WASTE MANAGEMENT FOR SUSTAINABLE DEVELOPMENT IN INDIA

Policy, Planning and Administrative Dimensions with Case Studies from Kanpur

Edited by Nonita T. Yap and Shailendra K. Awasthi
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I remain fully responsible for any shortcoming or oversight.

Nonita T. Yap
Principal Investigator, Editor
Anyone who has visited India recently cannot have failed to notice the tremendous challenges faced in its drive to develop its economy, especially the challenge of protecting the environment. The immense pressures of a growing population and the demand for ever-greater productivity in industry and agriculture have created problems of water, land and air pollution on a frightening scale. In areas of intensive growth, not only is the health of all living organisms put at risk, but the positive gains of development itself are also jeopardised. If development is to be sustainable, that is, if it is not to hurt the life chances of future generations, then ways and means must be found to control and eventually eliminate its harmful effects.

It was with this objective in mind that the environment was selected as one of the five themes of the CIDA-Shastri Project (CSP), along with gender, business, demography and the impact of science and technology. The CSP, launched in 1992, represents a partnership between CIDA, the Canadian International Development Agency, and the Shastri Indo-Canadian Institute (SICI), which since 1968 has fostered academic exchange between Canada and India. Ten projects featuring research collaboration between Canadian and Indian Universities have been selected; altogether, over two hundred faculty and graduate students are involved in the two countries. It is hoped that the projects will not only produce good analysis with beneficial results for policy, but also ongoing linkages between the participants leading to future cooperative efforts. Since environmental problems in particular represent global issues, the facilitation of a North-South dialogue and sharing of research through projects like the CSP may provide opportunities for meaningful solutions.

The collaborative efforts of the University of Guelph-HBTI research team in studying problems of industrial waste management, in Kanpur, India, demonstrate the potential inherent in such opportunities. The problems of the pollution of the Ganges River and their exacerbation resulting from the growth of industrial centres like Kanpur cry out for a solution. What the papers in this volume show is that a combination of expertise, both Indian and Canadian, and the employment of a multi-disciplinary approach involving scholars form both technological and social science disciplines can be extraordinarily fruitful.
During 1994-95 I have had the pleasure of visiting the research site and meeting many of the scholars involved and I have also attended the first seminar at which results were presented and discussed. The expertise, the enthusiasm and the effort forthcoming from all participants have been most impressive. Thus I would like to congratulate Dr. Nonita T. Yap of the University of Guelph and Dr. Shailendra K. Awasthi of Harcourt Butler Technological Institute on their great success in carrying out an excellent project and on the publication of these papers.

John R. Wood, President
Shastri Indo-Canadian Institute
Project Site: Kanpur
Source: (Bing Maps, 2017).

Project Site: Kanpur
Source: (Surveyor General of India, 1972).
INTRODUCTION

Like most participating governments at the 1992 United Nations Conference on Environment and Development (UNCED), the Government of India signed Agenda 21 UNCED’s Global Action Plan for Sustainable Development. Environmental protection is identified as a high priority in India’s 8th Five Year Plan as it actively pursues industrial development, its chosen route to national development.

For India the task of pursuing sustainability, i.e., pursuing an economic development path that can provide the basic needs of its huge and growing population without irreversibly draining the ecological capital on which this development is necessarily based, is particularly daunting. The Kanpur Research Project is predicated on the assumption that there remain in India opportunities for reconciling industrialisation and environmental sustainability. Sustainable development presupposes that some balance between economic growth and environmental stability can be created. While environmental sustainability does require less resource depletion, less energy use, and less waste generation, the trade-off between growth and environmental sustainability need not always be zero-sum. The ratio of industrial production and consumption to the level of environmental decline is not fixed. “Win-win” situations are possible through the use of technologies that reduce the waste intensity of production and consumption through greater closure of production systems and through full-life management of the production-consumption cycle.
Definition of Terms
“Technology” as used in the Kanpur Research Project refers to the mix of knowledge, organization, processes, machinery, tools, and human skills designed to increase the efficiency of productive activities. This broader definition of what constitutes technology evolved out of the analysis of the factors behind the widespread failure of the North-South technology transfer initiatives in agriculture, energy, and manufacturing in the last thirty years. Thus in transfer of technology literature, technology is analysed in terms of a superstructure- its code and invisible part, and a substructure, technique and organization – its social structure and visible part (ILO, 1988; OECD, 1993).

“Toxic substances” are substances, which cause acute or chronic health impacts on human, or animals, or which affect the growth of plants.

“Hazardous” is used in most legislation to refer to substances with the following characteristics: ignitability at a relatively low temperature, corrosivity (highly acidic or highly alkaline), reactivity (explodes or generates gases or fumes), toxicity, radioactivity, infectiousness, carcinogenicity, mutagenicity (causes genetic change thus affecting future generations), or teratogenicity (causes birth defects).

I. SUSTAINABLE DEVELOPMENT: DEFINITION AND IMPLICATIONS
The phrase “sustainable development” has gained widespread currency among politicians, industrialists, consultants and even scientists since 1986. Beyond the Brundtland definition of “meeting the needs of the present without threatening the ability of future generations to meet its own needs” there appears little agreement as to what the phrase implies for policy-makers, for business and for the consumer. There also appears little concerted effort to reach such an agreement. This has created scepticism such as that expressed Lele (1991) who observes that sustainable development is used as a “Metafix” that will unite everybody from the profit-minded industrialist and risk-minimizing subsistence farmer to the equity-seeking social worker, the pollution-concerned or wildlife-loving First Worlder, the growth maximizing policy-maker, the goal-oriented bureaucrat, and therefore the vote-counting politician (p. 613).
Indeed sustainable development is frequently interpreted as a way of having one’s cake and eating it too, an oxymoron in some peoples’ view. The Kanpur Research Project does not share the cynicism but does recognise that there is tension between the pursuit of development and environmental sustainability. It is a tension that would have to be resolved if we are to achieve the goal of sustainability. The proposal submitted for funding to the Shastri Indo-Canadian Institute stated:

Using waste management as a microcosm of the sustainable development problematic, the research is predicated on the following interrelated assumptions: First, there is a fundamental contradiction between environmental protection and economic development objectives that needs to be addressed if we are to seriously pursue sustainable development whether at the global, national, or community level. Second, minimization of this contradiction requires fundamental structural, conceptual and process changes in policy and planning institutions.

To be able to minimise the contradiction we need to understand its nature and sources. Such an analysis requires us to define two terms – “development” and “sustainability”. Both terms are complex and value-laden.

Those of us who are interested in pursuing sustainable development must start with three questions: development for whom?, sustainable over what area?, and for how long? We must be clear, at least to ourselves, who the beneficiaries are, where the appropriate spatial boundaries of concern lie, and what the appropriate time frame of analysis is. Development has to do with human goals, human aspirations and ideas of how things should be. It has been defined in a number of ways, including economic growth, industrialisation, empowerment, political participation, consumer choice and so on. The frequently heated discussions prior to and during UNCED in June 1992, in Rio de Janeiro, demonstrate the varying and frequently mutually contradictory answers to the question “development for whom?” Here lies one source of tension. There are divisions, real or apparent, along North versus South, global versus regional, national versus community, and, in some circumstances, along gender lines.
In addition to the political tension, there is a second, and perhaps more fundamental source of tension. Development goals – presented in Figure 1.1 for the purposes of this paper include food, clothing, shelter, education, health, leisure, identity and choice – are a human construct but the process of achieving the goals requires the interaction between the human system and the biophysical system.

The biophysical environment performs four functions essential in maintaining a particular quality of life: (a) supplier of resources, renewable and non-renewable, for the systems of production; (b) sink for the wasters of human activities; (c) source of life-support systems, specifically air, water, soil and the assimilative capacities provided by various ecological processes; and (d) material base for cultural and spiritual values. To make use of these environmental functions for development purposes we utilize the various forms of human organizations and technologies. This is the second source of tension. Technology can redress humanly defined environmental ‘shortcomings’ but it may not be costless. Each technological intervention has the potential for negatively impacting the biophysical environment and/or the human system.

The challenge of sustainable development may be pictured as one of achieving a balance in a “teeter totter” (Figure 1.2). Sustainability requires that balance be achieved between population and patterns of consumption on the one side and the mix of environmental functions on the other side, with technology as a non-rigid spherical pivot and the other human system variables as the bar. The more resilient the human system is, the more pliant the bar. The ability to achieve a balance, i.e., sustainability, depends on two conditions: (1) the use of technologies that are compatible with the human system variables and that make effective use of the environmental functions without violating the constraints; and (2) a socio-political system that makes the choice of such technologies feasible.

In the Kanpur Research Project, we examined both technological and human variables. The Project sought to define a public policy and planning framework that actively promotes the adoption of Low Waste Technologies (LWTs) through the following objectives:
Figure 1.1: Contribution of the Human and Biophysical Systems to the Development Process.
Source: (Yap, 1988)

ENVIRONMENTAL SYSTEM

Human System
- technology
- policy
- economic organization
- social organization
- political organization
- culture
- population

Biophysical System
- climatic systems
- water cycles
- biogeochemical cycles
- soil
- air
- water
- vegetative cover
- energy & raw materials for systems production
- spiritual & cultural support

Development Goals
- food
- clothing
- shelter
- education
- health
- leisure
- identity
- choice
Figure 1.2: Framework for Sustainable Development.
Source: (Yap, 1989)
The research activities included the following:

Under Research Objective 1:
(a) analysing the policy and legislate regime at the national and state level of governments that impinge on technology choices in waste management,
(b) analysing the mechanisms for intergovernmental coordination and areas of jurisdictional overlap and conflict, and
(c) evaluating the effectiveness of enforcement and monitoring systems.

Under Research Objective 2:
(a) developing a detailed profile of waste generation in Kanpur: nature and quantities of wastes, labour profile, market and competition of waste-intensive industries,
(b) developing case studies of selected industries to demonstrate technical feasibility and financial viability of LWT,
(c) reviewing the health impacts associated with waste chemicals, and
(d) examining the existing for a for multistakeholder consultation and collaboration, and improvements necessary for effective implementation of low waste strategies.

Under Research Objective 3:
(a) assessing the interest and capabilities of environmental and citizens’ groups in Kanpur
(b) assessing the experience of community-based initiatives in LWT, including in particular those that have involved women’s organizations
(c) examining the attitudes of municipal and health authorities towards the needs of women and the poor with respect to waste management, and
(d) assessing the basis of, and developing strategies for meeting these needs.

In effect we needed to:
(a) understand the decision environment of waste generators in Kanpur in relation to technology choice
(b) analyse how, and at what stage of the decision process (problem recognition, search, decision, implementation and monitoring) the existing policy and legislative regime and non-governmental organizations impinge on the technology choice of waste generators, and
(c) examine the ways by which instruments of policy and social organization may be rendered more effective and coherent in promoting the adoption of LWT for sustainability.

II. WHY THE FOCUS ON LOW WASTE STRATEGIES

Most of the resource depletion and environmental degradation problems of today are results of technology choices of yesterday. Addressing existing problems and minimising the creation of new ones clearly require a systematic shift to more resource efficient extraction, process and manufacturing technologies.

End-of-pipe (EOP) strategies, i.e., installation of scrubbers, containment lagoons, waste neutralization and treatment systems, deep well injection, engineered landfills, and incinerators, are based on a view of production as a linear and unidirectional process that inevitably generates waste. These are technologies introduced at the end of the production pipeline, to prevent waste from becoming pollution.
There are strong empirical and theoretical grounds to doubt the long-term effectiveness of EOP technologies. These technologies generally simply shift the environmental problem from one medium to another. Thus leachate contamination of groundwater from leaking dumpsites and toxic chemical emissions from state-of-the-art incinerators are not unexpected consequences. That EOP technologies are generally costly and do not add value to the product also puts in question their long-term affordability. This raises the more general problem of how to cope with the increasing quantity, toxicity, and diversity of industrial wastes that continue to be generated.

Low waste technologies refer to a wide range of production and process technologies of varying sophistication and cost. These technologies introduce feedback loops in the production and consumption cycle through good housekeeping practices, reuse, process modification, recycling, recovery, materials substitution, enhanced product durability, and minimal and standardised consumer packaging (Cf. Figure 1.3 and Table 1.1). They share one thing in common: they conserve material and/or energy inputs. LWTs include the biomethanation process advanced by the National Environmental Engineering Research Institute (NEERI) in dealing with liquid waste from distilleries, sugar refineries, fruit processing and tannery plants. It also includes the process developed by Bangalore engineer K.S. Shivaprasad for converting dry garbage to fuel pellets (Satchitanand, 1993).
Figure 1.3: Production-Consumption Cycle.
Table 1.1: Categories of Low Waste Approaches.

Source: (Yap, 1988).

<table>
<thead>
<tr>
<th>Category</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Good housekeeping</td>
<td>• easy implementation</td>
<td>• still have some waste to manage</td>
</tr>
<tr>
<td></td>
<td>• low investment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• short-term</td>
<td></td>
</tr>
<tr>
<td>2. Source segregation</td>
<td>• easy implementation</td>
<td>• may require some capital investment</td>
</tr>
<tr>
<td></td>
<td>• potential resource savings</td>
<td>• still have some waste to manage</td>
</tr>
<tr>
<td></td>
<td>• short-term</td>
<td></td>
</tr>
<tr>
<td>3. Process modification</td>
<td>• reduces both hazard and volume</td>
<td>• requires major R&amp;D effort</td>
</tr>
<tr>
<td></td>
<td>• moderate term</td>
<td>• generally not applicable industry-wide</td>
</tr>
<tr>
<td></td>
<td>• potential savings in production costs</td>
<td></td>
</tr>
<tr>
<td>4. Recycling</td>
<td>• potential savings in manufacturing costs</td>
<td>• may require some capital investment</td>
</tr>
<tr>
<td>(a) on-site</td>
<td>• moderate-term</td>
<td>• may not have wide impact across the industry</td>
</tr>
<tr>
<td>(b) off-site</td>
<td>• reduced liability for wastes</td>
<td></td>
</tr>
<tr>
<td>(i.e., through waste exchange)</td>
<td>• no capital investment</td>
<td>• liability remains with generator</td>
</tr>
<tr>
<td></td>
<td>• economy-of-scale for small generators</td>
<td>• subject to regulation</td>
</tr>
<tr>
<td></td>
<td>• potential savings in production costs</td>
<td>• vulnerable to market conditions</td>
</tr>
<tr>
<td></td>
<td>• receipts from recovered resource</td>
<td>• requires homogeneity of waste composition</td>
</tr>
<tr>
<td>5. Resource recovery</td>
<td>• potential savings in production costs</td>
<td>• requires capital investment</td>
</tr>
<tr>
<td></td>
<td>• vulnerable to market</td>
<td>• requires homogeneity of waste composition</td>
</tr>
<tr>
<td></td>
<td>• requires homogeneity of waste composition</td>
<td></td>
</tr>
<tr>
<td>6. Materials reformulation</td>
<td>• reduces hazard and volume</td>
<td>• requires major R&amp;D effort</td>
</tr>
<tr>
<td></td>
<td>• subject to product specifications and performance standards</td>
<td>• subject to product specifications and performance standards</td>
</tr>
<tr>
<td></td>
<td>• long-term</td>
<td>• long-term</td>
</tr>
<tr>
<td>7. Product substitution</td>
<td>• reduces hazard and volume</td>
<td>• requires major R&amp;D effort, capital investment, change in consumer habits</td>
</tr>
<tr>
<td></td>
<td>• long-term</td>
<td>• long-term, impacts many economic sectors</td>
</tr>
<tr>
<td>8. Enhanced product durability and use</td>
<td>• reduces throughput of raw materials for a given level of production and</td>
<td>• older plants and goods may be less energy-efficient</td>
</tr>
<tr>
<td></td>
<td>consumption</td>
<td>• may have serious economic and social impacts in the short-term</td>
</tr>
</tbody>
</table>
Low waste strategies are based on a recognition of technology as the crucial dimension in pollution control. Since all pollution comes from waste, a production or process technology that prevents or reduces the generation of waste has the potential to reduce pollution. In contrast to EOP technologies which are medium-specific, low waste strategies reduce releases to all media. LWTs add value as well as save resources and therefore have the potential for enhancing profitability at the level of the firm, income at the level of the household, and resource conservation at the level of the national economy. They provide financial returns through the reduction of resource inputs per unit of output, sale of secondary materials, reduced costs for storing, transport and disposal waste as well as reduced liability insurance. Since what leaves the plant premises as waste starts within the plan as an occupational hazard, LWTs also lead to a healthier work environment, and thus potentially increase workers’ productivity as well as reduce health costs. LWTs are indeed uniquely placed to integrate both environmental protection and economic development objectives.

The implication at the macroeconomic level is that environmental pollution can be delinked from economic development. If environmental degradation is expressed by the following equation,

\[
\text{Degradation} = \mathcal{f}(\text{W/GDP} \times \text{GDP/capita} \times \text{Pop})
\]

Where:
- Degradation = resource depletion and environmental pollution
- W/GDP = ratio of waste to Gross Domestic Product
- Pop = population

then reducing the waste to GDP ratio can be an effective way to reduce environmental degradation without necessarily sacrificing GDP growth, of course within the limits of thermodynamics.

**Empirical Evidence**

There is some empirical evidence for this delinking at both meso (i.e., at the level of industrial sectors or regions) and micro-economic level (i.e., at the level of the firm).

Experience in several countries in the Organization for Economic Cooperation and Development (OECD) shows that changing the energy structure and energy consumption patterns leads to a greater decrease in emissions of sulfur and nitrogen oxides than the installation of


desulphurisation and denitrification plants, both EOP technologies. From an examination of the correlation coefficient for the aggregated environmental impact index and the per capita GDP of several industrialised countries, Simonis (1994) reports that the correlation coefficient in 1985 was 0.31, a significant decrease from the 0.76 calculated for the period between the 1970s and early 1980s. In Sweden, Germany, France, and the United States, this was attributed primarily to a shift from “high volume production” to “high value production”.

At the microeconomic level, the environmental and financial benefits of increased “materials productivity” through the use of resource efficient technologies have been documented much more widely and the causality established more conclusively. The experience of 3M, Dupont, Dow Chemical, IBM as well as medium-sized firms in the U.S., Canada, and some European Union (EU) countries in the late seventies and eighties suggest that the amount of wastes reduced can be enormous, the cost recovery period brief, and the financial benefits to the firm substantive (Backman et al., 1989; De Hoo et al., 1992; Dorfman, 1991; Geiser, 1991; Huisingsh and Baas, 1991; Oldenburg and Hirschhorn, 1981; P2, 1994). More recent private sector initiatives are reported to be equally rewarding (See Yap and Heathcote in this volume).

Obviously the actual comparative cost-benefit profile for similar technology changes in equivalent industrial sectors in Low Consumption Countries (LCCs) will be different because waste disposal costs in these countries are frequently rendered insignificant by weak enforcement of legislation, and the argument for incorporating societal benefit in a firm’s “accounting” may not be part of local culture. As M.C. Mehta (1993), Advocate Supreme Court suggests in his commentary on the Ganga Action Plan, waste disposal costs are influenced by several factors including policy regime, market forces and the strength of grassroots politics (Sachitanand, 1993). However, the savings from reduced input costs could still be considerable (P2, 1994).

In an article in 1987 the head of Environmental Policies Division of the Federation of German Industries, summarized the benefits to German industry from the use of LWTs:

In the long-term, the development and introduction of low-emission technologies can also strengthen German industry’s competitive position, maintain jobs and create new export opportunities (Meller, 1986, p.37).
Analysis of the pattern of diffusion of LWTs over the last ten years helped define the hypotheses underlying the Kanpur Research Project, namely:

(1) LWTs can effectively integrate environmental protection and economic development objectives – they can provide win-win solutions, and
(2) Waste generators, whether firms or households, respond to several pressure points in relation to waste management practices – regulation, public pressure (public norms/culture), and financial incentives/disincentives, technological innovation. The government, religious authorities, the consumer, the community, scientists and engineers – are all potential agents of change.

III. WHY THE FOCUS ON POLICY AND PLANNING

Technology choices of waste generators are influenced by public policy. The constellation of pollution control policies put in place is frequently an outcome of a compromise among the different stakeholders – industrial producers, public policy makers and increasingly, public interest groups. Stakeholder conflict negotiation around environmental policy is based on a shared premise that the ratio of industrial production/consumption levels to the level of pollution is fixed. There is in short, an underlying assumption of a zero sum game.

There is theoretical basis for the argument that the ratio of the level of environmental degradation to the level of production and consumption is not fixed. Rather it is mediated by technology. The fundamental role of technology in the production process suggests that if pollution control policy is to be effective, it must target technology choice. Public policies must actively encourage a shift to technologies that close production-consumption loops. Because technology choice ultimately lies with the firm, policies aimed at changing corporate waste management practices must impinge systematically and consistently on the different variables that influence the decision-making of the waste generator. The state has a strong role to play in “nudging” the private sector to recognise and avail of the “win-win” opportunities.
The debate in pollution control policy continues to centre on policy instruments, specifically on the merits of command-and-control versus economic instruments. The command-and-control approach targets the control effort on pollutants. Market proponents assert that the decision whether or not to control a particular pollution problem is necessarily based on the costs of pollution control weighed against the economic benefits of production. Both command-and-control and market proponents fail to explicitly recognise that the link between production and pollution is mediated by technology.

In LCCs, there is a big implementation “deficit” in most areas of administration, not just in environmental protection. The reasons go beyond the government’s reliance on command-and-control approaches. Lack of expertise, lack of financial resources, meagre salaries, corruption, and bureaucratic apathy explain it equally. It deserves mentioning that claims regarding the greater effectiveness of market-based instruments over the command-and-control approach in controlling environmental pollution are not supported by empirical evidence. Research by the OECD concludes that economic regulations “have yet to live up to their theoretical advantage” (OECD, 1993).

Analysis of the experience in Singapore, Japan and South Korea offers useful insights. The Japanese experience shows that incorporation of cleaner processes into production is easier and cheaper during the setting up of new plants, and also that both “carrots and sticks” are necessary for the firms to adopt low waste strategies (ASEP Newsletter, 1994). Singapore has some 2,000 companies that generate hazardous wastes. About eighty percent of industrial hazardous wastes generated are reused, recycled and undergo resource recovery before disposal. Recovered materials such as silver from photographic wastes, and cupric and ferric chloride from the electronic industry are sold for reuse. These technology changes did not come about by relying on the goodwill of the private sector. The government of Singapore has a carefully designed and enforced hazardous waste management strategy that adheres to the following principles: (a) avoidance of intractable wastes, and (b) encouragement of waste minimisation and recycling (Austin and Koontz, 1993). In South Korea 70 percent of hazardous wastes are reportedly recycled (Jackson, 1991). What these three countries have in common is a strong interventionist state.
It has been argued that a “carrots and sticks” approach is not applicable in LCCs such as India, presumably because there are not enough “carrots” to go around and wielding a stick effectively implies a high administrative burden (ASEP Newsletter, 1994). The need however is not for new or additional “carrots” and “sticks”, but rather to redeploy existing ones. They have to be carefully targeted, timed, mutually consistent and consistently enforced. There is thus a need for strategic policy intervention and effective planning tools.

The experience in France, Germany and the Netherlands indicates that identifying the appropriate policy instruments demands more careful and sophisticated analysis even in High Consumption Countries (HCCs). For instance, the purpose of the pollution charge system – whether the charges collected go to the general government revenue or are recycled back to industries that adopt the desirable technical change – is to influence industry response. The actual pollution charge is also critical. If it is not very different from the cost of compliance, firms prefer to pay the charges and let the government do the clean-up. The Research and Development (R&D) subsidy programmes to promote the adoption of LWT have also had mixed results. The OECD concludes that for such programmes to be effective they must be (a) efficiently administered and coordinated with other incentive programmes; (b) adjusted to the specific characteristics and needs of the target industry; (c) administered with minimum encumbrances; and (d) made accessible to small-and medium-sized industries (Boegarts and Craemer et al., 1990; De Hoo and Dieleman, 1992).

A 1988 study of the Canadian experience in LWT reached exactly the same conclusions. There is no unique policy instrument that would encourage the adoption of LWTs across all industrial sectors. The effective policy instruments are those that are robust with regards to the scale of operations, size of industry, ownership, and location of markets. Both command-and-control (i.e., standards and emission limits), and economic instruments (i.e., financial incentives and waste charges) are needed. Waste generators will only see and use the “carrots” most effectively if the only other option available is the “stick” (Yap, 1988).

How may the appropriate mix of policy instruments be identified?
Decision Model Approach to Promoting LWT

The key to the effective promotion of low waste technologies lies in recognising that, in the final analysis, and regardless of whatever policy instruments are in place, the firm is the ultimate implementer of pollution control policy. It is the firm that decides whether or not to respond to existing or anticipated public policy, and how – comply with the policy, lobby for change, challenge any charge brought against it in court, or pay its way out of infraction penalties. In countries such as India where the state is administratively weak, the cost to the firm of non-compliance becomes insignificant. **It is therefore in the public interest that environmental protection be made consistent with the firm’s profit-seeking objectives.** This would lower the cost of enforcement.

Low waste technologies provide such opportunities.

Low waste strategies imply changes in the production or process technologies. The choice of technology is the exclusive prerogative of the firm. Understanding how the firm makes technology choices and identifying what variables influence its decisions are therefore essential in the search for effective, less intrusive, and less coercive policy instruments.

Figure 1.4 shows a heuristic model of the decision-making of the firm. Decision-making is viewed as an iterative process in four distinct stages: problem recognition, search for alternatives, decision, and implementation. The model pictures the firm as being influenced in its decisions by various pressure groups – the public, the media, labour, competition, formal and informal sources of authority. “Sources of authority” include the state and its instruments of policy as well as religious and ethnic organisations. All of these groups modify and constrain the firm’s profit-making goal.

Regulators have tended to assume that firms can be forced to change their behaviour through legal mechanisms and sanctions. Market advocates assume that firms decide primarily, if not exclusively, in response to economic factors. Empirical analysis of outcomes of environmental policies contradicts this “stimulus-response” approach to policy formation. The decision model which is the heart of the policy framework proposed here, suggests that all choice decisions are multi-criteria, and that there are diverse ways, direct and indirect, that the state can induce some desired changes in a firm’s behaviour.
Figure 1.4: Technology Choice Environment of the Firm.
Source: (Yap, 1988).
The decision of a firm to make changes in its production and process technologies occurs over time and proceeds through various stages. Changing the behaviour of the firm is thus itself a process. Public policy must seek to monitor and assist the firm throughout the process. Different needs arise at different points in the process. Public policy must be responsive to these needs.

For a shift to LWT to be considered, the firm has to recognise that there is a problem with its waste management practices. Experience in HCCs shows that this problem recognition can be triggered through (a) increased cost of energy and raw materials; (b) information on more efficient processes; (c) stringent government regulation or anticipation of regulation; (d) pressure from consumer, labour, media or community groups; (e) environmental audit requirements of financial institutions; and (f) increasing liability insurance.

Once a firm recognises the need to review its waste management practices, it will frequently need technical expertise to undertake the necessary R&D. The firm may have to undertake several process changes or adjust the scale of off-the-shelf LWT. Several technical and economic factors enter into the equation at this point. What and how much up-front costs are involved? How do these costs compare with the cost of non-compliance? How would the changes affect its competitive advantage? What are the implications on the quality and market acceptability of the product?, on the level of skill of the workforce and the quality of the work environment?, on production and delivery schedules?

Clearly then, if the government is to effectively encourage the adoption of low waste strategies by industry, it must analyse the firm's likely responses to these questions and design its instruments to “nudge” the firm through the problem recognition and search phases. The policy framework in Figure 1.5 shows the direct and indirect ways in which the state can move a firm through this process.

This conceptual framework guided the design of the Kanpur Research Project. It is used to analyse whether the existing policy and planning framework in India as they impinge on the waste management practices of selected Kanpur firms are consistent with the government’s pursuit of sustainable development.
Figure 1.5: Framework for Low Waste Pollution Control Policy.  
Source: (Yap, 1988).
PRELIMINARY FINDINGS OF THE KANPUR RESEARCH PROJECT

The papers in this volume describe the preliminary findings of the Kanpur Research Project. They are organised in four parts.

Part One presents background information on Kanpur and on the subject of low waste technologies. Cummings gives a brief description of Kanpur, the project site. Yap and Heathcote give an overview of the win-win opportunities presented by low waste strategies. LWTs are available in most industrial sectors but the extent of their adoption by industry remains low, even in OECD countries, with the outstanding exception of Japan and Germany. EOP technologies remain the preferred option of industry even where LWTs are available and affordable. The paper by Yap and Heathcote draws on country-specific studies to explore the reasons.

Part Two describes potential responses to environmental problems at the firm and community level. Misra, Awasthi and Trivedi analyse opportunities for win-win solutions in a paper mill. A similar analysis is done for a local dairy by Goyal, Awasthi and Trivedi. Singh, Trivedi and Awasthi describe opportunities to further integrate environmental goals with profitability in an edible oil processing plant. The potential for addressing an environmental problem through low waste technologies in a tannery is discussed by Misra, Trivedi and Awasthi.

Community-based responses are the subject of two papers coauthored by Kanpur-based community organisers, Prasad and Rahman. One paper reflects on the experience in organizing communities in neighbouring Jajmau around waste issues. What worked, what didn’t, and what lessons might be transferrable to communities like Kanpur? The second paper is on India’s mandal system. Can this form of community organising address modern urban environmental problems?

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1 This volume presents the work of researchers from at least five different disciplines in both social and physical sciences. Systematic editing efforts were made so that all papers would be useful to a reader from any discipline. Disciplinary diversity however was respected in terms of referencing style. The papers in Part Three follow the American Psychological Association (APA) style, i.e., endnotes, while the rest of the papers use the Modern Language Association (MLA) style, i.e., in-text citations.
such as waste management? The experiences discussed in the two papers provide strong grounds for optimism. They demonstrate the tremendous power that emerges from collective and organised community participation and action.

Part Three presents the policy and administrative context for waste management in India in general, and Kanpur in particular. Dwivedi describes and comments on the problems related to the efforts of the Government of India in pursuing sustainable development. He proposes an alternative policy framework that would guide governments in formulating policies for what the terms “environmentally sound and sustainable development” (ESSD). The intergovernmental relations relevant to industrial waste management in India and Kanpur are described by Jain, Dwivedi and Biswal. They argue that greater coordination among the different levels of government is needed if the waste management crisis is to be addressed effectively.

Achtell’s paper is narrower in both scope and focus. Achtell analyses the institutional impediments to the adoption of LWTs in India. Using extensive document review, interviews and participant observation, Achtell provides some useful insights, his use of anecdotes adding a nice touch to the picture he paints.

The final paper in Part Three, by Coates, focuses on municipal solid waste management. This is not directly relevant to the industrial waste management focus of the Kanpur Project, but compliments the picture drawn by Dwivedi, Jain, Biswal and Achtell. Some of Coates’ policy recommendations are interesting to juxtapose with Achtell’s observations. For example, Coates prescribes the computerisation of municipal solid waste management system at the municipal level as one way to improve system efficiency. Achtell on the other hand, questions how and to what extent the computerised database on LWT that has been developed and maintained by NEERI could be accessed by small and medium-sized firms.

The lessons learned from the research are summarised in three papers in Part Four. El-Tayeb, Cummings and Siddiqui enter the challenge of promoting LWT adoption through a different door. They examine the low waste strategies implemented in two Kanpur-based firms, a tannery and a dairy. They then calculate the financial costs and benefits to the firms with these changes. Their calculations provide unequivocal support for the hypothesis that low waste strategies can
improve the profitability of firms. The paper goes on to suggest detailed planning steps for evaluating the financial benefits to a firm using low waste strategies.

The second paper in the set abstracts a different lesson from the Kanpur Research Project. Based on her work with Kanpur-based firms, Howland looks at the planning implications for the effective transfer of low waste technologies in LCCs such as India. Howland’s observation and thoughtful analysis of the gap between implementation and planning is a very useful complement to the paper of El-Tayeb, Cummings and Siddiqui.

The final paper synthesises the preliminary research findings and examines the prospects of effective diffusion of low waste technologies in India. Applying the analytic framework discussed in this introduction, some policy recommendations are set out on how the Government of India can strategically integrate its pursuit of industrialisation with its commitment to sustainable development.

REFERENCES


PART ONE

BACKGROUND
INDUSTRIAL DEVELOPMENT OF KANPUR:  
A PROFILE

H. Cummings

INTRODUCTION

Background Geography
Kanpur lies in the north of India in the state of Uttar Pradesh (UP), the largest state by population in the country. The districts of Unnao in the north, Hamirpur in the south, Fatehpur in the east and Etawah and Farrukhabad in the west define the boundaries of Kanpur. On April 23, 1981 Kanpur was subdivided into Kanpur city and Kanpur dehat (village) (Indian Statistical Department, 1993). It is between Delhi, about 425 kilometres to the west and Calcutta about 1,000 kilometres to the east. The city is a major industrial centre of the north and used to be referred to in the past as the Manchester of Northern India. It is located on the banks of the Ganga in the centre of the Ganga plain, and is well connected to the rest of India via rail and road. Kanpur is on the Grand Trunk Road from the North West Frontier to Calcutta.

The climate of the city is subtropical monsoon and average temperatures range from a low of 19.5°C in January to a high of 35.6°C in May. It is 800 kilometres from the nearest sea coast. As in the case of the classical monsoon climate, almost 80 percent of the rain falls in the rainy months of mid-June, July, August and partly September. The April to June season is extremely hot and dry.

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1 This introductory section has benefitted extensively from S.N. Singh, Planning & Development of An Industrial Town, Mittal Publications, New Delhi, India, 1990. It has been updated as a result of our work in the city under the Project in 1994 and 1995.
The 1991 population of the city is approximately 2.4 million and includes 381 thousand who are determined to be in the “rural” portion of the city (KMC, 1994, p.1). Singh (1990, p.42) reports a 1971 population of 1.3 million, presumably referring to the urban portion of the district only. This suggests an annual rate of population growth of approximately 2.2 percent per annum from 1971 to 1991. Tiwari (1995) suggests that rates of population growth have progressively declined since 1931-1941, primarily as a result of the reduction in rates of immigration. There has been some growth in geographic area and population of the city over the years, through the annexation of neighbouring areas. The two original urban components of the city (Kanpur City and the Cantonment) were joined by five other urban centres (Rawatpur Station, Central Railway Colony, Armapur Estate, Northern Railway Colony and Chakeri) to form the Kanpur Urban Agglomeration.

History
Kanpur was declared as the district headquarters in 1801. It was a focus for industrial development from the beginning with indigo and cotton as well as tanneries mentioned in the period prior to 1850. By 1850, the city had added new communications (rail link to Allahabad) and public sector service facilities and the population had grown to over 100,000 (Singh, 1990, pp.9-35). Following the first war of independence (also known as mutiny) in 1857, a conscious policy to promote Kanpur as an industrial centre was developed. This was seen as an employment generation strategy which would reduce the tension in the areas around the city after the rebellion. The focus of the city on industrial development including tanneries, textiles, agricultural processing continued. Chemical and metal processing had been added to the city’s industrial base by the end of the century. The city remained best known for its textile and leather industries.

In the period up to the second world war, the city expanded at a rapid rate, eclipsing other northern cities and becoming the industrial development centre of the north by the 1940’s. Both the first and second world war efforts contributed to the growth of industry in the city as industries produced at full capacity to support the war effort. These were times of rapid growth in industrial employment in the city.
During the period from 1900 to 1945, industrial representatives and city officials recognised the particular needs of labour associated with the industrial development. They cooperated to construct labour colonies associated with the industries where improved housing and sanitary conditions for workers were the main objective. Although there is considerable reference to sanitary conditions and sewers for worker housing, there is little reference during this time to environmental concerns associated with the industrial development itself.

**Industry and Economy Today**

In the period from 1945 to today, the number of industries continued to increase while employment stabilised and then began to decline (Singh, 1990, pp.25-26). Despite these trends, we still find a city today where textile industry remains important but is facing increased competition from other countries and regions. Engineering and livestock-based industry follow in importance.

Although the textile industry is on the decline it remains supreme in terms of the number of employees and number of establishments. The majority of the workers are in the cotton mills. Leather and leather goods industries in the state of Uttar Pradesh are strongly concentrated in Kanpur (Singh, 1990, pp.57-60). The chemical and chemical products industries and the metal and metal-based industries are more recent additions to the industrial fabric of Kanpur. Both industrial groups were present from the turn of the century but have grown in significance in the post war years. Both are growing rapidly and providing some new jobs to replace some of those being lost in the textile sector.

The industries can be grouped into three categories with respect to their spatial location in the city. First, the old industrial complex, established prior to 1930, has now been surrounded by city growth. It includes an inner zone on the river front where large scale industries established in the late 1800’s and early 1900’s remind us of the British influence. This complex includes mainly textile mills and tanneries and approaches the edge of the Central Business District of Kanpur. Second, the pre-independence outlying industrial areas developed because of cheaper land, reduced congestion and lower land costs and taxes. It included defence industries, iron and steel works, chemical plants and aircraft industry. Third, the planned industrial estates are outlying organised industrial estates with smaller industries. Industries located here include: electrical, base metals, pints, agricultural implements and fertiliser (Singh, 1990, p.76).
With respect to the administration and management of Kanpur and area in 1995, the Kanpur Urban Agglomeration is approximately 300 square kilometres. A larger area including the city and surrounding area is under the management of the Kanpur Development Authority and includes 829 square kilometres (KMC, 1992, pp.1-2).

CONCLUSIONS

During the formative years of the development of the industrial complex of Kanpur, environmental conditions associated with industrial development were not a major concern. The people of Kanpur and area were concerned about finding jobs and the employers about profits. As the city grew in importance because of its industrial development, concerns for the health and wellbeing of workers came to be important. This was mainly reflected in attempts to improve the quality of available housing through the development of labour colonies.

Today, Kanpur Urban Agglomeration authorities are concerned about various aspects of environmental issues i.e., drinking water, sanitary conditions, drainage, environmental health, congestion (due to crowding and transportation), industrial, commercial and domestic waste, and workers health and safety to name a few. With respect to the waste produced by the industrial and commercial sector, a variety of approaches are important including the principles of reduction and recycling and the use of efficient waste management processes. One of the ways to deal with the waste management issue is through the use of low waste technology. Subsequent papers in the book outline various considerations in the implementation of sustainable development and the use of low waste technology for Kanpur industry.
REFERENCES


LOW WASTE INDUSTRIAL TECHNOLOGIES:
IF IT IS A LOW HANGING FRUIT,
WHY DOESN’T INDUSTRY PICK IT?

N.T. Yap and I. Heathcote

“Protecting the environment . . . is not a zero sum game. Many forms of pollution reflect underutilised or wasted resources.”

W. Esty, Associate Professor, Yale University 1994

“Win-win is a wonderful concept. It implies the economic oxymoron, a free lunch.”

F. Cairncross, Environmental Editor, The Economist 1994

INTRODUCTION

The industrial economy is essentially linear. Economic wealth is derived from the linear and unidirectional flow of resources. Many of the resource inputs are non-renewable. Wastes arise from each stage of this unidirectional flow, from the extraction and purification of raw materials, the manufacturing process, the utilisation of these goods, to the ultimate disposal of products at the end of their life cycle. Two serious problems have resulted from this linearity: (a) resource depletion, and (b) environmental degradation resulting from the wastes. International trade and aid have globalised the problems. Fundamental changes are required. Technologically there are two possibilities (Johansson, 1993):
creation, in a thermodynamic sense, of a closed industrial system which exchanges only energy (no material) with nature. Product flows return to and are fully reprocessed and recycled in the industrial system, and
(b) restructuring of industrial production to make it totally compatible with nature, using only renewable raw materials, “soft” technologies, and producing biodegradable products.

Low waste technologies (LWTs) are technical changes in this direction. These technologies introduce feedback loops through good housekeeping practices, reuse, process modification, recycling, recovery, materials substitution, enhanced product durability, minimal and standardised consumer packaging (Cf. Figure 1.3 in Introduction). LWTs may be grouped under eight categories (Cf. Table 1.1 in Introduction). The concept is described in the literature by several names: “non-waste technologies”, “clean(er) technologies”, “clean(er) production”. LWTs have the potential to provide financial returns through the reduction of resource inputs per unit of output, sale of secondary materials, reduced costs for storage, transport and disposal of waste as well as reduced liability insurance. By creating safer workplace environments worker health costs can arguably be reduced.

Objectives of the Paper
An analysis of the evolution and effectiveness of public policy response to the problem of industrial waste in Europe and in North America is important if Low Consumption Countries (LCCs) are to “leapfrog” some of the serious problems associated with industrialisation.

LWTs exist for a wide range of industrial sectors, but the extent of their adoption by industry remains low even in countries in the Organisation for Economic Cooperation and Development (OECD), with the outstanding exception of Japan and Germany. End-of-pipe (EOP) technologies remain the preferred option of industry even where LWTs are available and affordable. The question this paper seeks to answer is why? How can LWT adoption by industry be systematically and effectively promoted?
I. THE INDUSTRIAL WASTE PROBLEM AND END-OF-PIPE RESPONSES

Reliable quantitative data on industrial (and municipal) waste is difficult to obtain. However it is generally accepted that more than one billion tonnes of hazardous wastes are generated globally every year, with North America contributing about 30 percent (Jackson, 1991).

Public concern over industrial wastes has grown during the past three decades despite the fact that the link established between chemicals and human health problems is more correlative than causal. In the eyes of many among the public, the outbreak of Minamata disease in Japan in the late fifties, its occurrence in Ontario native communities in the mid-seventies, and the seal “kill” in the southern North Sea provided sufficient indications of the serious human and animal health threats posed by long-term exposure to certain chemicals. The short-term implications have been more readily accepted as a result of disasters such as the Torrey Canyon and Bhopal.

The ecological and health implications of chemical dispersion in the environment are complicated by several factors. First, very little is known about the toxicity of these chemicals. There are approximately 70,000 to 100,000 chemical compounds in commercial circulation with 2,500 new ones added every year (Freudenberg and Steinsapir, 1992). Inevitably these chemicals end up in the environment at some point in their life cycle. Less than 1 percent of chemical compounds
in commercial use have been adequately studied in terms of their toxicity (NRC, 1984). Second, the health impacts of chemicals have long lead times and hence causality is difficult to establish. Third, there remains inadequate understanding of how most of these chemicals flow through the environment and into the food chain. Finally, society’s chemical use is not only increasing in volume but also in diversity, complexity and in some use areas, in toxicity (NRC, 1984).

The conflict between environmentalists and industrial waste producers has generally been based on a shared premise that the ratio of industrial production to industrial pollution is fixed. The trade-off between production and pollution is inevitably a zero sum game. Consensus is not easy to achieve since the stakeholders represent fundamentally different positions on what constitutes acceptable environmental quality. Pollution control policy discussions involve balancing economic growth against pollution. The response of industry has typically been to add, at the end of the pipe, technologies that mitigate the environmental impacts of industrial processes and residuals – scrubbers, containment lagoons, waste neutralisation and treatment systems, deep-well injection, engineered landfills, and incinerators – or to rehabilitate sites after they have been polluted.

**Failure of EOP Responses**

In 1988 Barry Commoner evaluated 15 years of pollution control regulations in the United States. Reviewing annual Environmental Protection Agency (EPA) air and water quality data from 400 sampling stations, Commoner reported that environmental quality had barely improved in 80 percent of the test sites. In some sites it had even worsened. This despite clean up expenditures amounting to $100 billion in that fifteen-year period (Geiser, 1991). Also in 1988 the U.S. General Auditing Office estimated that there were between 130,000 and 425,000 contaminated waste sites in the U.S., although less than 1,500 are listed in the Superfund National Priorities List (Freudenberg and Steinsapir, 1992).

The notion of foresight or *Vorsorge* entered the public debate in Germany in the early seventies and became the foundation of German environmental policy since then (O’Riordan, 1994). This “precaution” principle with its ethical and economic implications likewise influenced the position of environmental groups in North America. ”Better to be roughly right in due time than to
be precisely right too late” became the theme of many environmental pressure groups that mushroomed in North America in the seventies. It did not however influence policy-making in North America to the extent it did in Germany and, increasingly in the European Union (EU) countries. Not until the emergence of grassroots community-based environmentalism in the U.S. and Canada in the late seventies did pollution issues enjoy the same prominence in the environmental policy agenda as wildlife conservation and nature preservation issues (Freudenberg and Steinsapir, 1992).

The evolution of the U.S. government policy is indeed instructive. No serious attention was given by the government to pollution prevention strategies until the eighties when opposition to the siting of waste disposal sites became more vehement and better organised at the community level. In 1986 the U.S. federal government allocated only $4 million on waste reduction out of its $16 billion environmental protection expenditures. That same year however, saw an influential report from the Office of Technology Assessment advocating a shift from pollution control to pollution prevention. A special office for Pollution Prevention was established in 1987 to guide the EPA programs.

By 1990 comprehensive waste reduction laws were enacted in several states and the U.S. Congress passed the Pollution Prevention Act (Geiser, 1991). In 1992 the U.S. government mandated federal defence research establishments to release and transfer “clean technologies”, presumably developed in these institutions during the cold-war era, to small- and medium-sized U.S. industries to improve their “global competitiveness”. The government has also used development assistance channels to fund LWT initiatives in Asia for the purposes of securing markets for U.S. environmentally-friendly technologies.

The consequences of the failure of EOP responses continue to unfold. Data reported under the U.S. Access to information legislation indicate that every year U.S. industries release more than 2.7 billion pounds of toxic chemicals into the atmosphere, including more than 300 million pounds of suspected carcinogens. According to the U.S. EPA, more than 90 percent of Americans have measurable quantities of suspected or confirmed carcinogens in their bodies (Freudenberg and Steinsapir, 1992).
The real economic costs of the failure to reduce the production, consumption and disposal of toxic chemicals are translating into clean-up costs estimated to be $10 billion for Germany and $1.5 billion for the Netherlands. Estimates in the U.S. range from $20 billion to $100 billion (Jackson, 1992).

II. INTEGRATING THE ENVIRONMENT AND THE ECONOMY

The failure of EOP responses was predictable. In 1977 Schultz had written:

If, for example, we assume that per capita living standards in the United States, improve from now on at only half the rate of the past century, the gross national product a hundred years from now, will still have risen by more than threefold… Only if pollution per unit of output is cut by two-thirds can we maintain current environmental performance, let alone improve it.

Schultz saw both policy and technology shifts as crucial:

In the long-run the future of society is going to hinge on the discovery and adoption of ever-improving technologies to reduce the environmental consequences of expanding production… The institutions and incentives of society have to be modified for a steady long-run effort. Reducing pollution has to become a paying proposition rather than just another battle against the regulators (emphasis and italics added) (1977, p.77).

Unfortunately these shifts have not come about. The 1970-1980 period was an era of what has been termed “resistant adaptation”, characterised by the failure of industry to internalise environmental issues in their business strategy (Walley and Whitehead, 1994). There were striking exceptions, the best known being the 3M Corporation which recognised in 1976 that pollution control compliance costs were threatening its profitability. It redirected its environmental control strategies to what are called “low waste technologies” or alternatively “clean technologies”. In the 15 years since 3M Corporation established its Pollution Prevention Pays Program (3P), it has reduced its waste generation by 50 percent – annually cutting down 126,000 tons of air emissions, 16,600 tons of sludge, more than 6.5 million litres of wastewater, 409,000 tons of solid and hazardous wastes, and an equivalent of 210,000 barrels of oil in energy consumption. The 3P Program has reportedly saved 3M Corporation more than $506 million from 1975 to 1990. Management believes a further 30 percent waste reduction is possible (Huisingh and Baas, 1991).
Other firms followed. The work of Royston (1980) publicised the early successes. Between 1989 and 1991 Texaco, using LWTs, achieved a 40 percent reduction in its air water and solid waste streams, and 58 percent reduction in toxic wastes. During the same period Georgia-Pacific achieved a 65 percent reduction in dioxins and a 34 percent reduction in chloroform emissions through materials substitution and processes (Harvard Business Review, 1994). By switching to a water-based solvent in coating medicine tablets, Ricker Laboratories (U.S.), a pharmaceutical plant, reduced its air pollution emissions by 24 tons a year, saving the plant $180,000 in pollution control equipment it would have needed to meet California’s environmental regulations. Broyhill Furniture Industries (U.S.) replaced a conventional spray-finishing operation with an electrostatic finishing system that applies a sensitising agent to furniture to attract finishing chemicals. Broyhill reduced its finishing and clean-up material costs by 20 percent leading to an annual savings of $150,000 (P2, 1994a; P2, 1994b).

In 1991 the cost and benefits of source reduction measures in twenty-nine organic chemical manufacturing plants in California, New Jersey and Ohio were analysed. The firms varied in size, products, processes, and markets. One hundred and eighty-one low waste initiatives were documented. The average reduction per waste stream was 71 percent, average increase in product yield 6.9 percent, average annual savings per initiative $351,000, average annual savings per dollar invested $3.92, average payback period 13.2 months, and average length of time to accomplish 8.2 months (Backman et al., 1989).

In Canada some of the most high-profile cases in recent years have come from the automobile manufacturing industry, as a result of a voluntary agreement signed between the Canadian Motor Vehicle Manufacturers’ Association (MVMA), Environment Canada and the Ontario Ministry of Environment and Energy (MVMA Project, 1994). The St. Thomas (Ontario) Assembly Plant of the Ford Company recently introduced a Total Fluids Management Unit Cost Billing Program providing economic incentives for the reduction of solvent use. The program uses a team approach whereby suppliers are paid on the basis of the number of vehicles rather than on chemical usage. The supplier provides full-time technical representatives in the customer’s facility.
(the Ford Company), develops operating and maintenance schedules, provides technical training, and participates in joint teams to achieve environmental and economic objectives. The program has resulted in reduced loadings of chromium (by 2,566 lbs./yr), nickel (by 991 lbs./yr), zinc (by 615 lbs./yr), and phosphate (by 8,425 lbs./yr). There was also an elimination of all solvent-based pre-cleaners (equivalent to about 120,000 lbs./yr of volatile organic compounds), reduced water consumption by 27 million gal/yr, and reduced metal-bearing paint sludge by 500,000 lbs./yr. While the costs of the program have been minimal, the annual savings are estimated at over U.S. $200,000.

Chrysler Canada Ltd. has also achieved success with LWT, winning recognition throughout the auto industry and securing the Essex County Waste Management Award of Merit three years in a row. Chrysler’s Pillete Road Truck Assembly Plant manufactures full size Dodge trucks, using hazardous and non-hazardous sealants in the assembly process. By expanding the use of reusable sealant totes with plastic liners, the plant eliminated sealants wasted in empty drums. Overall the program resulted in net savings of $50 a drum. Labour and additional costs associated with manually scraping the hazardous drums were also eliminated. Total annual savings for the plant are estimated at about U.S. $30,000.

General Motors of Canada Ltd. shifted to water-based paints for building and equipment maintenance, eliminating the use of naphthalene, toluene and xylene. The program has resulted in a reduction of 21,500 lbs. of solvent released during building refurbishment. It eliminated the need for special solvent-based storage facilities. The water-based paints cost more but spread further. Painting can now be done during daylight hours because the paint odour poses no health hazards to workers. The plant has also eliminated 100 percent of the grinding sludge, or swarf, created in the grinding and finishing of aluminum automotive transmissions. Previously landfilled, the swarf had 85 percent metal content and thus had potential value as feedstock. By introducing a simple defluidising unit into the process, the plant has saved $60,000 annually in reduced waste transportation and disposal costs. Now, 430 tonnes of aluminum grinding and 495 tonnes of iron/steel swarf are diverted from landfills and sent to a metal recycling operation.
Smaller operations are also demonstrating that LWT can yield financial benefits at low cost. Kelly Auto Body, an automotive serve and collision repair operation in Hamilton, Ontario found that minor housekeeping changes, and a capital expenditure of $12,000 spread over several years, resulted in significant savings. Process alterations included liquid masking (replacing paper and tarp), and the use of high-volume low-pressure paint sprayers. Liquid masking saved labour and improved quality. The low-pressure sprayer reduced paint costs, air emissions and filter changes. Savings also resulted from solvent collection and recycling (savings of $2,000 a year), bulk purchases of engine oil and antifreeze, and the use of recycled oil, antifreeze, tires, batteries, cardboard, containers and scrap metal.

Court Galvanizing Ltd. won the Ontario Waste Management Corporation’s 1992 Award of Merit for outstanding waste reduction activities. A conventional hot-dip galvanizing operation, Court introduced a sulfuric acid regeneration and rinse recovery system, reducing water use by 50 million litres a year. A separate recovery system removes iron and zinc from the sulfuric acid used in the galvanizing process and produces a ferrous/zinc sulfate by-product that can be used in the fertiliser industry. The system cost about $500,000 but has significantly reduced sewer use charges and sulfuric acid use. Acid disposal costs have been completely eliminated.

The experience of European firms is similar. A Swedish manufacturer of electrical light fixtures, under pressure from the government to reduce its volatile organic carbon emissions, converted to powder paints. The conversion cut down the painting costs by 50 percent and saved 204,000 Swedish Kronas (U.S. $29,000) in start-up costs for the combustion system it would have had to use. In Poland a medium-sized automotive-parts manufacturer introduced changes that cut down its heavy metal wastes production and water consumption. The investment of $17,800 was recovered in less than a month with annual savings of $223,000 (Backman et al., 1989). In the Netherlands the costs and benefits of LWT options generated and implemented through a government-funded, industry-university collaboration were analysed. Of the forty-five implemented options, twenty had benefit-cost ratios greater than 1 and nineteen were neutral (De Hoo and Dieleman, 1992).

Similar reports of enhanced profitability from LWT adoption among firms in LCCs are being added to the literature (P2, 1994a; P2, 1994b). The paper by El-Tayeb, Cummings and
Siddiqui in this volume document, in unusually careful detail, the profitability of low waste strategies adopted by some firms in Kanpur, India. The cost-benefit analyses of these changes, however, are rarely published. For instance, in India the financial benefits from the use of biomethanation process at the Central Distillery and Breweries Ltd. in Meerut and at the Government Medical College in Nagpur have not been reported. The benefits are presumed to be substantive since the process not only cuts down chemical inputs but also generates biogas for energy.

Reports such as these have led to intense interest among governments and environmentalists in clean production. Many draw on the credibility of sympathetic economists such as Harvard Business School Professor Michael Porter who had written that “strict environmental regulations do not inevitably hinder competitive advantage…indeed, they often enhance it” (Porter cited in Walley and Whitehead, 1994, p.48). The literature on the science, economic benefits and policy dimensions of clean production has increased significantly both in volume and rigour in the last six years.

III. DIFFUSION OF LWT

The adoption of LWTs has not always been driven by strict environmental regulations. In some cases it has been triggered by purely profit-seeking interest; in others it has been presented as a moral responsibility. Swire Pacific in Hong Kong had an environmental audit done. The audit showed sources of energy waste. Better energy management led to a savings of 7-10 percent of the energy bill, normally U.S. $260,000. As a cost-cutting measure, a fish canning plant in the Philippines started processing their press liquor to extract fish oil which they later refine for use in prawn feed, as a substitute for cod liver oil, and in other industries such as leather paints, to use as lubricants. The company proceeded to use some of the wastewater as raw material for producing fish sauce (Lirag, 1993). In Kanpur a tannery that systematically adopted process modifications and installed chrome recovery in its operations, stated at an interview with one of the authors (Yap) that
management introduced the changes because it sees environmental protection as a “moral responsibility”. The chemist at a Kanpur dairy who had been instrumental in introducing low waste changes in the plant, including establishment of a plant nursery to make use of discarded plastic bags, and sludge from the effluent treatment plant (see Howland’s paper in this volume) cited “love for flowers and a healthier workplace” as his main motivation.

**Country-specific Studies**

Some countries have put in place low waste technology programmes. Denmark, France, Germany and the Netherlands established “Cleaner Technology Programmes” in the early eighties. Sweden initiated a Cleaner Technology pilot project in 1987 and Norway, Austria and the United Kingdom in 1989. They have had varying effectiveness. What lessons can we draw from them?

**Netherlands (PRISMA):** Direct involvement of the government in cleaner production technologies started in the early 1970s (Craemer et al., 1990; De Hoo and Dieleman, 1992; Dorfman, 1991). A charge system for industrial wastewater was introduced along with the establishment of emission standards.

The National Environmental Policy Plan established waste reduction targets of 50-90 percent of the 1988 waste emissions by 2010. Waste generators are encouraged, with financial support from the government, to develop in-plant “Environmental Care” systems. If voluntary efforts fail, regulations would be introduced. Eighteen “Innovation Centres” in the different industrial regions of the country were established to transfer LWT to industrial firms.

This was the policy environment in which a two-year research project on low waste approaches, PRISMA, was launched in 1987 by the Netherlands Organisation of Technology Assessment (NOTA). It involved the Netherlands Organisation for Applied Scientific Research Centre for Technology and Policy Studies (TNO), Erasmus University Centre for Environmental Studies (ESM), and the Interfaculty Department of the University of Amsterdam (IVAM). Ten experiments were carried out in 10 companies in the Amsterdam and Rotterdam areas. The companies were selected from the food industry, electroplating, metalworking, public transport and chemical industry. The project was managed by NOTA with funding from the Ministry of Economic Affairs and the Ministry of Housing.
Under the supervision of the PRISMA researchers waste audits were conducted, waste reduction options investigated for technical and financial feasibility, and where appropriate, waste reduction programmes implemented. A detailed cost-benefit analysis was made for each option implemented. Policy studies were conducted by IVAM, ESM and TNO. Of the 164 options considered feasible, 45 were implemented within less than 1.5 years (De Hoo and Dieleman, 1992).

Sweden (LANDSKRONA): This research project, initiated in 1987, involved an environmental research organisation, TEM, within the University of Lund and seven small and medium-sized industrial firms in Landskrona (Backman et al., 1989). The goal was to explore the possible economic and environmental benefits of using systematic preventative approaches to reduce waste and risk. Funding was provided by the Foundation of REFORSK, the National Swedish Board for Technical Development (STU), the National Swedish Industrial Board (SIND) and the local authorities of Landskrona.

The firms were selected from the graphics, metal working and chemical industries. The project was launched with a workshop introducing the low waste concept and successful case studies to the executives of the participating firms. Detailed procedures were developed for each firm. In-plant discussions were held with individual firms to further clarify goals, procedures and timetables for the research. The procedure included undertaking a complete mass balance and developing production and process flow diagrams thus allowing for a comprehensive waste profile and audit to be done. The firms were encouraged to adjust this evaluation to their particular context. A detailed cost-benefit analysis was done on each implemented option, and the results shared with other firms in the sub-sector through conferences or workshops.

Perhaps one of the most valuable insights from the LANDSKRONA experiment was the indispensable role of a good waste audit in identifying opportunities for waste reduction. One of the highlights of this research was the work with a firm that manufactures lighting fixtures for interior and exterior applications. The wastes of concern were trichloroethylene (TCE) from degreasing operations, petroleum-based lubricating oils used in metal cutting and hydraulic pumps, chromates and phosphates, and solvent-based paints. In the process of searching for an alternative to TCE, the entire production process was examined. A switch from petroleum-based lubricants to
biodegradable oils emerged as a feasible alternative. Not only did this eliminate the use of non-biodegradable lubricant, it also totally eliminated the use of TCE, a hazardous waste. The biodegradable substitute is easily removable by a mild detergent.

**Denmark (KALUNDBORG):** The concept of closed loop systems has been extended beyond plant boundaries in Denmark (Ferro, 1994). Four major companies in Kalundborg experimented with a program of “industrial symbiosis”. At the centre is the town’s power plant. Some of the power plant’s waste steam is channelled to the nearby pharmaceutical plant for its fermentation process that produces insulin, and some to an oil refinery. Its excess heat provides energy for 5,000 households. Warm water from the power plant is used to warm fish tanks in which salmon and turbot are raised for export. The pharmaceutical company producing insulin delivers the sludge from its operations to local farmers, saving them $60 per acre of fertilizer costs. The oil refinery in turn delivers approximately one ton of gas per hour (that it would have “burned” off) to the power station, reducing its coal consumption by 30,000 tons per year. The oil refinery also sends its cooling and wastewater to the power plant, reducing overall water consumption. The final link in this symbiosis is a plasterboard factory which receives surplus gas from the refinery and gypsum from the power plant (a waste product of power plant sulfur dioxide scrubbers).

What these different programmes demonstrate is that the barrier to the adoption of LWTs is rarely technical. Paradoxically, just as LWTs are being vigorously promoted in LCCs by some development assistance agencies, a “backlash” appears to have developed, at least in North America, against the whole notion of “win-win” scenarios. Voices are beginning to be heard from the academic and professional community who challenge what they described as the “Pollyanna” view (Walley and Whitehead, 1994; Harvard Business Review, 1994; Passent, 1994; Van den Broek, 1994). If LWTs are technically feasible and demonstrably more cost-effective than EOP technologies why have they not been widely adopted? Why is a backlash emerging?
IV. BARRIERS TO DIFFUSION

This strongest barriers are non-technical and may be grouped under four categories: (a) attitudinal (b) financial (c) organisational and (d) systemic.

Attitudinal
There is widespread ignorance or scepticism among waste generators of the potential financial benefits of low waste approaches. Waste management is generally assigned to middle level managers who tend to avoid the risks of unfamiliar technologies. Many also do not wish to be seen by higher management as not having done their jobs adequately. Some of the waste management routines become sacrosanct through the years and any change can be perceived as a threat in the workplace (Yap, 1988). This reluctance to change is especially true for small firms (Cote, 1995).

Recent debate on the plausibility of win-win scenarios suggest that corporate environmental policies continue to be driven by compliance, rather than a genuine interest in minimising the environmental impacts of plant operations.

In LCCs there is very little incentive for industries to recognise the environmental impacts of their operations. The enforcement of pollution control legislation is very weak, and penalty for violation, low. The problem is compounded by the fact that in many LCCs interest in industrial waste issues among pressure groups such as labour unions and mass-based organisations is relatively recent. Most non-governmental organisations in LCCs have been and continue to be more concerned with rural resource management issues (Jain, 1995; Yap, 1990). Labour unions remain concerned primarily with job security and wage levels.

Financial: Perceived and Real
Because capacity in LWTs in a sense is an intangible asset, it is not likely to be given great value in the typical cost benefit analysis done by a firm considering investment options. This disinterest becomes justifiable where the LWT capacity is in the knowledge content of technology because then the expertise becomes “portable”. Where the cost of waste disposal or non-compliance is
insignificant, investment in LWT appears unnecessary. Where firms are already complying with government regulation using EOP technologies, the full cost of existing waste management practices is underestimated. Many of the costs are frequently lost or scattered in maintenance or operation ledgers (Yap, 1988). Small firms in particular, do not have the time or money. Recent work in Nova Scotia suggests that time may be the biggest impediment to change in small firms (Cote, 1995).

Most of the low waste strategies, i.e., good housekeeping practices, process modifications, materials substitution (see Introduction in this volume), involve post investment technical change. Developing in-house capacity therefore makes greater demands on industry. To be able to make the necessary incremental equipment or process changes over time, there must be mastery of the existing production/process technology. This “endogenous” capacity may be low. Risk capital is not readily available. The costs of accessing information on LWT, evaluation the different technical options, and/or adapting existing LWT can be significant. The costs are particularly onerous if not outright impossible to bear for small and medium-sized firms (Craemer et al., 1990; Yap, 1993).

Organisational/Informational
At the level of the firm, one of the major barriers to a full exploration of LWT opportunities lies in the fragmentation of production activities. Waste management is not seen as every plant employee’s business. There is also resistance to scrutiny by outside experts because of confidentiality concerns. At the level of the industrial sector there is a lack of systematic, reliable and easily accessible source of information on the technical feasibility and financial opportunities of LWT. Firms who have successfully adapted low waste strategies are understandably unwilling to share information since LWTs give them cost advantage over their competition. This is particularly true for process modifications since they are not patentable. In LCCs concerns about corporate taxes further inhibit firms from officially acknowledging the profitability of low waste strategies.

Respect for the confidentiality concerns of industry has led to information dissemination materials such as brochures and pamphlets which are too general in nature. Because the application of technology is almost always location-specific, such publicity materials are rarely effective, except where the changes involved are good housekeeping and materials substitution. They are general but informative lessons.
The situation in LCCs is further complicated by the diversity of the major industrial waste generators in terms of scale, ownership and location of market. This implies different sets of constraints to technological innovations in each sector. The constraints will not be technical since proven LWTs exist for all these sectors although modifications may be needed in terms of scale and even design. These modifications demand endogenous capacity which is low in LCC institutions, whether government, industry or universities.

Export-oriented sectors such as textiles and electronics, are medium to large-scale operations. They are frequently controlled by foreign-based transnational corporations (TNCs) or as joint ventures, and are likely to enjoy a different policy regime than that for the domestic market such as metal finishing, foundry, and pulp and paper. The export-oriented sectors may resist any technological innovation on the ground that the additional costs will impact their international competitiveness.

Those producing for the domestic market differ in size. Metal-finishing firms are typically small family-owned operations, foundries are medium-scale, while pulp and paper manufacturing firms tend to be large operations. The financial and technical ability to innovate is virtually non-existent for the metal-finishing industry and minimal for the foundry. Technological innovations in the pulp and paper industry frequently require massive capital outlay as the experience in Canada shows (Yap, 1988), although they are proving necessary for competitiveness.

The study by Achtell (in this volume) of the institutional impediments to LWTs in India cites “bureaucratic dysfunction” and high administrative turnover as militating against effective transfer and sharing of information on LWTs among stakeholders (Achtell, 1995).

Systemic
A short and rigid compliance period, and requirements for “best practicable or available technology” – pervasive features of government pollution control policies under pressure from environmental groups – effectively favour the use of off-the-shelf, EOP technologies. A limited evaluation of the
success of the PRISMA Project (vide supra) in defusing “clean technologies” concluded that the focus on solving acute environmental problems led to a reactive, effect-oriented environmental policy. Industry inevitably chooses to implement off-the shelf EOP solutions since they are more familiar and accessible. This incentive for EOP technologies is reinforced where subsidies provided for capital cost do not specify “clean technologies” (Craemer et al., 1990).

Weak enforcement and insignificant penalties, pervasive in most LCCs, reduce the cost to industry of non-compliance. The full cost of environmental degradation is thus not included in the cost of production.

Another systemic barrier to LWT is the strong vested interests of the environmental (waste management) industry in EOP approaches. Pollution control regulations have been developed around these technologies. The “environmental industry” is product-, not process-oriented. The search for and adoption of LWT involves a process of interaction between the firm and the “expert”. The environmental industry has invested heavily in developing technologies to “capture” and manage wastes. Many waste management firms have specialised in developing EOP technologies, i.e., wastewater treatment, industrial sewage treatment, engineered landfills, incinerators. When consulted by industry or government, they are likely to offer what they are familiar with and good at (Oldernburg and Hirschhorn, 1987). Given the pivotal role of the environmental industry to the diffusion of LWT, winning this industry over to LWT from their EOP thrust is crucial. Shifting from a volume-based to a value-based billing system for environmental consulting services, similar to Ford’s Total Fluids Management Unit Cost Billing Program (vide supra) may facilitate this “conversion”.

These barriers can be analysed in terms of the decision-making environment of the firm (see Figure 1.4 in the Introduction). What they tell us is that the “triggers” to the problem recognition phase are weak because of inconsistent, if not confused policy signals, weak enforcement of regulation, and weak or non-existent pressure groups from the community. The search activity of those firms who recognise that a problem exists is hampered by lack of information on feasible and cost-effective alternatives and financing.
CONCLUSIONS

Overcoming these barriers requires the participation of all stakeholders – government, industry, public interest groups, and consumers.

Attitudinal
A report on the LANDSKRONA Project observed that by first focusing on and demonstrating the technical feasibility of one or two key areas of production, corporate management becomes more receptive to the investment of time and resources to undertake a more comprehensive audit (Backman et al., 1989).

Education of consumers and environmental public interest groups is also needed. The education must be geared towards understanding not only of the seriousness of the industrial waste problem but also of the complexity of the search for effective and sustainable solutions. Environmentalists must be made to see that it is in the public interest not only that waste producers recognise the environmental problems their operations are creating, but also to be sympathetic to the firm’s search for cost-effective solutions. Stringent regulations, firm and short compliance periods are politically rewarding but have not proven effective or sustainable in the long-term.

The establishment of criteria for, and indicators of, “clean production” such as ISO 14000 and Eco-labelling is a step in the right direction but their overall effectiveness in reducing environmental degradation is likely to be limited. They may be a powerful incentive in international trade but have limited impact in terms of influencing consumer decisions in LCCs since these programmes presume a high level of mass education and effective demand to be truly effective in changing corporate behaviour.

Organisational/Informational
Databanks of case studies of successful LWT adoption are clearly necessary. The LANDSKRONA researchers conclude that the most valuable resource they offered to the firm is a compilation of detailed studies of successful LWT application (Backman et al., 1989). Industry-specific databases on LWT case studies such as that being developed in India should be expanded and disseminated. The database on LWT experts established by the United Nations Environment Programme should be systematically updated and expanded.
Financial

Subsidy for LWT Research and Development (R&D) is crucial in promoting the diffusion of these technologies, particularly for small- and medium-sized firms. Lessons from the OECD in this regard indicate that the application process and qualification criteria for such subsidy programmes must be simplified (Barnett, 1993; OECD, 1985; OECD, 1993).

Systemic

It has been suggested that the environmental industry could play more of a positive role if they could bill on a different basis, i.e., a certain percentage of savings from LWT introduced (Cote, 1995). The experience of Japan in promoting the “greening” of small and medium enterprises is relevant particularly to countries in the process of industrialising. Japan relied heavily on a combination of “carrots and sticks”. The most important lesson from the Japanese experience is that enforcement of environmental regulations is crucial in triggering industries to look for solutions. However it should not be overlooked that Japanese compliance deadlines allowed flexibility in the choice of technologies and the search for cost-effective strategies (ASEP Newsletter, 1994). Obviously forcing companies to pay the real cost of waste management and environmental degradation would go a long way in “triggering” problem recognition. This however may not be acceptable in the current political and economic climate.

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PART TWO

RESPONSES TO THE PROBLEM
INTEGRATING ENVIRONMENT AND ECONOMY IN THE PAPER INDUSTRY: USE OF LOW WASTE TECHNOLOGIES

M. Misra, S.K. Awasthi and R. K. Trivedi

INTRODUCTION

The paper industry in India ranks among the top twenty polluting industries in the country (Ansari, 1994). The industry uses a variety of raw materials and chemical inputs including agricultural residues, forest residues, waste paper, lime, caustic soda, dyes and other chemical for the paper making process. It is an energy and capital-intensive industry. The component of energy cost in papermaking constitutes between 20 and 40 percent of the total cost of production (Rao, 1985). When considering the economics of paper production, energy is considered the major economic factor after labour, land and capital costs (Raghuveer et al., 1985).

In the paper making industry, previous waste minimisation efforts in India have included collecting the effluent from the paper machine and treating it with bleach for decolourisation and alum for flocculation and sedimentation. The clear overflow is used for pulp washing in the bleach plant. The underflow pulp slurry is processed further and used as filler in duplex board manufacturing, thus saving pulp as well as water (ITT, 1994). Other efforts have included the recovery and recycling of fibres. Dissolved air flotation permits fibre recovery and recycling back to the pulp section for pulp washing (Central Pollution Control Board, 1986). Recycling in a German paper mill resulted in a reduction of the water requirements per ton of paper from 20 to 9.1 m3 (Ben Aim, 1989). Recycling is also being practiced in other countries, such as Thailand and France. The German experience demonstrates that there is potential at most stages of paper production for fibre recovery and reuse of the remaining water.
I. THE STUDY FIRM

For the purposes of the study, a paper mill in Kanpur, which manufactures Duplex paper using waste paper as a raw material, was identified. The plant is situated in Kanpur dehat (southwest of the city), and is a small sized operation. The plant has a capacity to process 40 tons of waste paper per day. The process consumes 118 m³ of water per ton of paper produced, and approximately 85 m³ of wastewater results. In general, the water requirement for paper mills processing waste paper as a raw material ranges from 100 to 150 m³ per ton of paper (Central Pollution Control Board, 1986). The capital investment of the firm is Rs 150 million. The firm employs 175 workers: 50 skilled workers, and the rest, who are unskilled, work on a contract basis. The labour force is drawn from the rural population living near the firm. The average wage for employees is Rs 30 per day. The unit has a turnover of approximately Rs 140 million/annum (Kushwaha, 1995).

II. METHODOLOGY

Several visits to the plant site and the administrative offices were made in order to collect data. Interviews were conducted with top executives of the plant including the General Manager, persons in charge of plant production and effluent treatment and disposal, and with employees working on the shop floor. These interviews enhanced the investigators’ understanding of the firm’s manufacturing process, resource requirements and waste generation. Data required to complete the process descriptions and a material balance was gathered from interviews, literature review and site visits. A diagram illustrating the duplex paper manufacturing process is shown as Figure 2.1.
Figure 2.1: Duplex Paper Manufacturing Process.
III. MANUFACTURING PROCESS

For making Duplex paper, the raw materials are prepared and refined in two separate streams. One stream is for the top layer (white layer) and the other is for the bottom layer (grey layer).

The raw materials used for the paper’s top layer include white cuttings and white used copies. For the bottom layer, corrugated paper, newsprint and other waste paper are used.

The white paper waste is fed into the pulper (pulping section) in pre-determined quantities, along with water, steam and bleaching powder. The material from the pulper is transferred to the poucher where the pulp is washed for two hours to remove residues. The wastewater generated at this stage is taken to the effluent treatment plant (ETP). The washed pulp is collected in Chest No. 1 and sent to the turbo centricleaner where solids and mud are separated. The pulp is then transferred to a thickener. Overflow from the thickener is reused for making pulp in the pulper section. To render the pulp uniform and homogeneous it is transferred to a beater. The next step is called Chest No. 3, which is blending stock preparation unit where dyes, talc and chemicals such as rosin, alum and titanium dioxide are mixed with the pulp in order to impart the desired properties to pulp, which will ultimately be used for making the top layer of Duplex paper.

Simultaneously, the pulp required to make the bottom layer of the duplex paper is prepared and transferred to Chest. 4, known as the machine chest. The final pulp from both machine chests is collected in separate head boxes and transferred to the paper machine. The pulp passes over a moving wire mesh and loaded to the synthetic felt screen. Large volumes of wastewater are generated in this section. After this process, the resulting sheet of paper is transferred to the Mona Glad (MG) section where the paper sheet is transferred to a dryer for final drying which reduces the moisture content to approximately 0.06 percent. Finally, the finished paper is cut and packed for marketing.
IV. MATERIAL BALANCE OF THE PLANT

A material balance representing the whole plant process is shown in Figure 2.2. The balance was made on the basis of 40 tons of waste paper being processed and used as raw material. The quantities of the various streams entering and leaving the individual process units are shown in tons. The material balance reveals that processing 40 tons of waste paper results in the production of 34 tons of Duplex paper and uses approximately 4,000 m$^3$ of water.

V. WASTE GENERATION

Investigation of the manufacturing process reveals that the most obvious waste streams are generated in the pulping section, poucher (washing section), and paper machine section of the paper manufacturing plant. The volumes of waste generated from each section of the plant, its composition, and the present mode of disposal are presented in Table 2.1. From the waste streams identified in the manufacturing process, several are significant in terms of their volume, the financial loss resulting from fibre quantities leaving in the waste stream, and/or their environmental impact. These are:

1. liquid effluent from the paper machine section (2796 m$^3$)
2. thickener rejects
3. boiler ash and turbo rejects, and
4. sludge from the effluent treatment plant.
Figure 2.2: Material Balance of the Paper Mill.
Table 2.1: Waste Generation and Management in the Paper Mill.

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>State</th>
<th>Quantity</th>
<th>Assessed Cost (Rs)</th>
<th>Present Use</th>
<th>LWT Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effluent from pulper</td>
<td>Liquid</td>
<td>36 m³ Water, 90 kg Fibre,</td>
<td>595</td>
<td>To ETP</td>
<td>Recycle</td>
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<tr>
<td>(washing)</td>
<td></td>
<td>240 kg Solid (Mud, Plastic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poucher (washing)</td>
<td>Liquid</td>
<td>80 m³ Water, 150 kg Fibre,</td>
<td>825</td>
<td>To ETP</td>
<td>Recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>750 kg Mud</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbo Rejects</td>
<td>Solids (Iron</td>
<td>270 kg Fibre, 120 kg Mud</td>
<td>30</td>
<td>Landfilling</td>
<td>Fibre recovery/recycle</td>
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<td></td>
<td>Clips &amp; Plastics)</td>
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</tr>
<tr>
<td>Thickener Rejects</td>
<td>Liquid</td>
<td>570 kg Fibre, 160 kg Mud</td>
<td>3,125</td>
<td>Recycle to Centricleaner</td>
<td>Fibre recovery</td>
</tr>
<tr>
<td>Paper Machine Section</td>
<td>Liquid</td>
<td>2,796 m³ Water, 3.6 T Fibre</td>
<td>19,800</td>
<td>Reuse in Pulper for bottom layer, Pulper &amp; Washing &amp; finally to ETP</td>
<td>Energy recovery &amp; recycle</td>
</tr>
<tr>
<td>Floor (Plant) Washing</td>
<td>Liquid</td>
<td>20 m³ Water (10 kg Fibre)</td>
<td>55</td>
<td>To ETP</td>
<td>Recycle</td>
</tr>
<tr>
<td>Boiler Ash</td>
<td>Solid</td>
<td>19.2 T</td>
<td>N/A</td>
<td>Landfilling</td>
<td>Brick mfg.</td>
</tr>
<tr>
<td>Sludge from ETP</td>
<td>Solid</td>
<td>1.67 T</td>
<td>N/A</td>
<td>Landfilling</td>
<td>Greyboard mfg.</td>
</tr>
<tr>
<td>MG Section Vapours</td>
<td>Solid</td>
<td>21.7 m³</td>
<td>N/A</td>
<td>Emissions</td>
<td>Good Hskpg.</td>
</tr>
<tr>
<td>Packaging</td>
<td>Solid</td>
<td>N/A</td>
<td>N/A</td>
<td>Sold</td>
<td></td>
</tr>
</tbody>
</table>


VI. PRESENT WASTE MANAGEMENT PRACTICES

In the plant under study recycling and recovery of the fibre are being practised to some extent. Fibre recovery is affected by having a Krofta unit near the paper machine. This unit employs a flotation method to recover fibres which are returned to the pitch section (Tank) for re-introduction to the pulp stream. The only other identified low waste technology (LWT) currently in place is recycling of process water.

The major liquid waste stream coming from the paper machine section (which contains about 3.6 tons of fibre) however, is not currently being used for the recovery of fibre or energy. This waste stream goes directly to the ETP. The unit uses rice husks as a fuel to generate steam. About 19 to 20 MT per day of fly ash is generated as waste from the boiler house. Handling of this solid waste poses a serious problem as it contributes to an unsafe work environment. Presently the ash is disposed of as land filling material. The firm has a regular effluent treatment plant: a clarifier and settling tank. The sludge removed from the ETP is land filled at different sites.

VII. PROBLEM IDENTIFICATION

After analysing the various waste streams and the present waste management practices of the unit, the liquid effluent was identified as the most significant waste from an economic as well as an environmental point of view (Figure 2.3). Therefore, this waste stream was selected as the focus for involving the use of LWT, specifically resource recovery and recycling. It was suggested that the investigation aim at treating the paper mill effluent waste by coupling anaerobic and aerobic digestion processes to recover energy in the form of methane gas and use this gas as a fuel by the firm. Reuse of the resulting water (in the pulping section) would also be possible. It was observed that this proposal had the potential to reduce the concentrations of pollution parameters in the effluent, including total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) to sufficiently low levels.
Figure 2.3: Generation of Wastewater from Paper Machine Section.
XII. WASTE MINIMISATION PROPOSALS AND ECONOMY

The waste volume produced from any process can be minimised only if the conversion efficiency of raw materials to products is maximised. In the case of paper manufacturing, the recovery of more valuable materials from waste streams as well as for recycling of comparatively less expensive resources such as water provides such opportunities. A resource recovery approach was applied to the centricleaner, thickener and paper machine sections of the paper mill. Two categories of options were identified: Category A which were more apparent and could be readily implemented, and Category B for which implementation would be suggested only after further investigation of their technical and economic viability.

Category A Options

Reduction Of Fibre Losses: (a) Introduction of a method for preventing fibre loss. It can be seen from the material balance that 180 kg of fibre is lost from the centricleaners, along with mud and other deposits. The installation of a high pressure fibre saver is recommended to prevent this fibre loss. The fibre loss from the thickener is approximately 720 kg. The fibre saver could also recover this material.

(b) Use of double felt. The use of felt in the paper machine reduces the paper’s water content from 60 percent to 20 percent. The loss of fibre with this expressed water is staggering: between 1.0 and 1.5 tons/day. The use of double felt is suggested in order to reduce the problem of press picking which occurs due to the presence of fine materials. It is expected that following double felt installation, the number of paper breaks would be reduced. It would also reduce the load on the couch decker, and consequently pulp reprocessing costs would decrease (Gupta, 1994).
Water Recycling: While acknowledging that there is some effort being made by the plant management to recycle some process water and thus decrease the total volume used, additional measures may be adopted that would result in further water use reductions.

(a) Installation of a separate tank and pump for edge cutting nozzles: Paper breakage caused by pressure variations in the edge cutting nozzles decreases system efficiency. Installation of a separate tank and pump reduce this breakage, and make the edge cutting operation more uniform (Gupta, 1994).

(b) Installation of a screw press for pulp dewatering: Installing a screw press for pulp dewatering would extract more water in the press section. This would have the effect of reducing the load on the dryers, and would ultimately reduce the firm’s steam requirement.

(c) Installation of a multiplex filter: A significant problem preventing more extensive water recycling in the paper industry is the TS content of used process water. Installation of a multiplex filter is predicted to result in a reduction of the TSS in process water to below 30 ppm, making it suitable for recycling. The filtered water can be reused for felt showers, thus reducing fresh water consumption (Gupta, 1994).

In addition, housekeeping suggestions that would decrease unnecessary paper breakage and identify leaks have been made to the firm. The benefits accruing to the firm from adopting these LWT suggestions are not yet available as implementation has not yet occurred.

Category B Options
This category has a high potential for waste minimisation, and could provide multiple benefits to the firm. It has the potential to produce energy (in the form of methane gas) which may be used as fuel, and at the same time could reduce pollution and produce water of a quality suitable for recycling in the plant. The investigated option in this category was the anaerobic-aerobic treatment of paper mill waste.
IX. MATERIALS AND TECHNIQUES

Effluent Sampling

The combined waste stream resulting from mixing the individual waste streams prior to their treatment in the ETP was sampled by the investigators. The sample was done every eight hours (i.e., once during each shift) and six samples were collected in total.

Characterisation of the Waste

Six samples were analysed following standard methods given in the literature (Rand, 1976) for the following parameters: TS, TSS, TDS, pH, COD and BOD. The range in composition of the waste samples is presented in Table 2.2.

Table 2.2 Characteristics of Combined Effluent

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids</td>
<td>13,478 – 14,558 mg/l</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>9,276 – 9,516 mg/l</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>4,436 – 4,804 mg/l</td>
</tr>
<tr>
<td>pH</td>
<td>8.0 – 8.5</td>
</tr>
<tr>
<td>Chemical Oxygen Demand</td>
<td>10,102 – 10,880 mg/l</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand</td>
<td>5,500 – 6,050 mg/l</td>
</tr>
</tbody>
</table>

Variations are attributed to changing manufacturing conditions, inefficiencies of process equipment, paper breakage due to power failures (leading to fibre loss and subsequent increase in the effluent’s solids content) and the use of chemical methods of analysis.

The following analytical grade chemicals were used for waste stream characterisation: potassium dichromate, sulphuric acid, silver sulphate, ferroin indicator, ferrous ammonium sulphate, mercuric sulphate, phosphate buffer solution, magnesium sulphate, calcium chloride solution, ferric chloride, manganese chloride, alkali iodide azide, starch indicator and sodium thiosulfate.
Experimental Set-Up

A schematic diagram of the apparatus uses for the anaerobic and aerobic studies are presented in Figure 2.4 and Figure 2.5.

Apparatus Used for Anaerobic Study

The apparatus used for the anaerobic study consisted of a constant temperature water bath fitted with a thermometer and a relay. Aspirator bottles having 500 mL capacity were used as digesters for the slurry and gas samplers were used to collect the gas formed during the anaerobic process. The water bath was fitted with a stirrer for maintaining uniform temperature to within ±1°C. To take gas samples for analysis, a glass ‘Tee’ was fitted in the quarter inch tubing, which allowed the gas formed to be collected in the gas samplers using a water displacement technique.

Apparatus Used for Aerobic Study

The apparatus used for the aerobic study consisted of a 6.5 mm tubing into which an orifice plate with orifice diameter 2.5 mm was fitted with a flange coupling. On the upstream side of the orifice, a valve was fitted to admit air from a compressor, and on the downstream side a distributor was attached to supply air to aerate the sample. The pressure drop across the orifice metre, an indicator of the aeration rate, was measured using a mercury manometer (Echman, 1950).

X. PROCEDURE

Anaerobic Study

The slurries, prepared with a pre-determined ratio of effluent total solids content to digested slurry of cow dung were charged to the aspirator bottles. Cow dung slurry was added to provide the bacteria required for the anaerobic digestion process. The bottles were sealed and connected to a gas sampler through a glass ‘Tee’. The amount of gas produced was recorded daily and analysed for its methane and carbon dioxide content. The solid content in the slurries were kept in the ratio of 1:0.5, 1:1 and 1:2 and the digestion temperature was maintained at 37 ± 1°C. The temperature of digestion was chosen in order to promote maximum activity of the mesophyllic bacteria. At the end of the run, the slurry remaining was again analysed for the same pollution parameters following the same methods as before. This permitted an estimate to be made of the percent reduction in these parameters achieved by the anaerobic digestion process.
Figure 2.4: Anaerobic Digestion Apparatus.
Figure 2.5: Aerobic Digestion Apparatus.
Aerobic Study

Air from a constant pressure chamber of a compressor was introduced through a valve and used to aerate the sample resulting from the anaerobic study. The aeration was run a number of times varying: (i) the aeration rate, and (ii) the time of aeration. After the aeration process the sample remaining was again analysed for its pollution parameters. This permitted an estimation of the total reduction and percent reduction in the pollution parameters achieved by coupling the two processes (anaerobic and aerobic).

XI. RESULTS AND DISCUSSION

Results are presented in Table 2.3 and Table 2.4. The results are based on two trials for each ratio of the solids content. The variation in the values obtained may be attributed to inadequacies introduced in the maintenance of constant temperature, frequent power failures, and use of chemical methods of analysis.

From Table 2.3 it can be seen that the maximum reduction in pollution parameters was achieved with a solids: cow dung ratio of 1:1. The volume of gas generated and its composition are shown in Table 2.5 and Table 2.6 respectively. It can be seen from these Tables that the maximum amount of gas (1.299 L on average), and the highest methane fraction (87 percent) were achieved from samples having the same ratio of solids 1:1. The quantity of gas produced per litre of sample was 8.66 litres, containing on average 85 percent methane.
Table 2.3: Reduction in Pollution Parameter after Anaerobic Digestion of Effluent.

<table>
<thead>
<tr>
<th>Sample Ratio</th>
<th>Parameter</th>
<th>Initial Conc’n</th>
<th>Final Conc’n</th>
<th>Conc’n Reduction</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 : 0.5</td>
<td>TS</td>
<td>10,300 – 10,900</td>
<td>9,100 – 9,280</td>
<td>1,410</td>
<td>11.7 – 14.8</td>
</tr>
<tr>
<td></td>
<td>TDS</td>
<td>7,780 – 8,200</td>
<td>6,976 – 7,264</td>
<td>870</td>
<td>10.3 – 11.4</td>
</tr>
<tr>
<td></td>
<td>TSS</td>
<td>2,464 – 2,756</td>
<td>1,952 – 2,188</td>
<td>540</td>
<td>20.6 – 20.7</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>8.0 – 8.5</td>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>COD</td>
<td>9,976 – 10,408</td>
<td>7,904 – 8,288</td>
<td>2,096</td>
<td>20.3 – 20.8</td>
</tr>
<tr>
<td></td>
<td>BOD</td>
<td>5,574 – 5,800</td>
<td>1,750 – 2,010</td>
<td>3,827</td>
<td>65.3 – 68.6</td>
</tr>
<tr>
<td>1 : 1</td>
<td>TS</td>
<td>9,454 – 10,080</td>
<td>7,170 – 7,398</td>
<td>2,468</td>
<td>23.9 – 26.6</td>
</tr>
<tr>
<td></td>
<td>TDS</td>
<td>7,172 – 7,356</td>
<td>5,560 – 5,996</td>
<td>1,486</td>
<td>18.5 – 22.4</td>
</tr>
<tr>
<td></td>
<td>TSS</td>
<td>2,420 – 2,556</td>
<td>1,468 – 1,544</td>
<td>982</td>
<td>39.3 – 39.6</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>7.5 – 8.0</td>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>COD</td>
<td>7,568 – 7,840</td>
<td>5,668 – 5,918</td>
<td>1,910</td>
<td>24.5 – 25.1</td>
</tr>
<tr>
<td></td>
<td>BOD</td>
<td>4,950 – 5,550</td>
<td>1,050 – 1,110</td>
<td>4,170</td>
<td>78.8 – 80.0</td>
</tr>
<tr>
<td>1 : 2</td>
<td>TS</td>
<td>8,804 – 9,316</td>
<td>7,444 – 7,740</td>
<td>1,468</td>
<td>15.4 – 16.9</td>
</tr>
<tr>
<td></td>
<td>TDS</td>
<td>6,784 – 7,056</td>
<td>5,580 – 5,724</td>
<td>1,268</td>
<td>17.7 – 18.8</td>
</tr>
<tr>
<td></td>
<td>TSS</td>
<td>2,076 – 2,204</td>
<td>1,824 – 2,056</td>
<td>200</td>
<td>8.5 – 10.1</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>7.0 – 7.5</td>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>COD</td>
<td>4,984 – 5,320</td>
<td>3,484 – 3,520</td>
<td>1,650</td>
<td>30.0 – 35.2</td>
</tr>
<tr>
<td></td>
<td>BOD</td>
<td>2,100 – 2,500</td>
<td>1,000 – 1,100</td>
<td>1,250</td>
<td>52.4 – 56.0</td>
</tr>
</tbody>
</table>

NOTE: All values are in mg/l except pH
Table 2.4: Reduction in Pollution Parameter after Aerobic Digestion of Effluent.

<table>
<thead>
<tr>
<th>Sample Ratio</th>
<th>Parameter</th>
<th>Initial Conc'n</th>
<th>Final Conc'n</th>
<th>Conc'n Reduction</th>
<th>Percent Reduction</th>
<th>Total Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 : 0.5</td>
<td>TS</td>
<td>9,100 – 9,280</td>
<td>8,564 – 8,884</td>
<td>396</td>
<td>4.3</td>
<td>16.8 – 18.4</td>
</tr>
<tr>
<td></td>
<td>TDS</td>
<td>6,976 – 7,264</td>
<td>6,594 – 6,766</td>
<td>440</td>
<td>6.1</td>
<td>15.2 – 17.4</td>
</tr>
<tr>
<td></td>
<td>TSS</td>
<td>1,952 – 2,188</td>
<td>1,956 – 2,048</td>
<td>68</td>
<td>3.2</td>
<td>20.6 – 25.6</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>COD</td>
<td>7,904 – 8,288</td>
<td>7,416 – 7,524</td>
<td>626</td>
<td>7.7</td>
<td>25.6 – 27.7</td>
</tr>
<tr>
<td></td>
<td>BOD</td>
<td>1,750 – 2,010</td>
<td>1,200 – 1,520</td>
<td>500</td>
<td>26.0</td>
<td>73.8 – 78.4</td>
</tr>
<tr>
<td>1 : 1</td>
<td>TS</td>
<td>7,170 – 7,398</td>
<td>6,912 – 7,212</td>
<td>222</td>
<td>3.0</td>
<td>26.6 – 28.4</td>
</tr>
<tr>
<td></td>
<td>TDS</td>
<td>5,560 – 5,996</td>
<td>5,544 – 5,904</td>
<td>54</td>
<td>0.9</td>
<td>19.8 – 22.6</td>
</tr>
<tr>
<td></td>
<td>TSS</td>
<td>1,468 – 1,544</td>
<td>1,282 – 1,494</td>
<td>178</td>
<td>11.8</td>
<td>49.0 – 51.5</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>COD</td>
<td>5,668 – 5,918</td>
<td>5,256 – 5,322</td>
<td>499</td>
<td>8.6</td>
<td>30.5 – 32.1</td>
</tr>
<tr>
<td></td>
<td>BOD</td>
<td>1,050 – 1,110</td>
<td>600 – 760</td>
<td>400</td>
<td>37.0</td>
<td>86.3 – 87.9</td>
</tr>
<tr>
<td>1 : 2</td>
<td>TS</td>
<td>7,444 – 7,740</td>
<td>7,196 – 7,356</td>
<td>316</td>
<td>4.1</td>
<td>18.3 – 21.0</td>
</tr>
<tr>
<td></td>
<td>TDS</td>
<td>5,580 – 5,724</td>
<td>5,276 – 5,324</td>
<td>352</td>
<td>6.2</td>
<td>22.2 – 24.5</td>
</tr>
<tr>
<td></td>
<td>TSS</td>
<td>1,824 – 2,050</td>
<td>1,780 – 1,908</td>
<td>106</td>
<td>5.4</td>
<td>14.0 – 14.4</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>COD</td>
<td>3,484 – 3,520</td>
<td>3,290 – 3,468</td>
<td>123</td>
<td>3.5</td>
<td>33.9 – 34.8</td>
</tr>
<tr>
<td></td>
<td>BOD</td>
<td>1,000 – 1,100</td>
<td>750 – 890</td>
<td>230</td>
<td>21.9</td>
<td>64.2 – 64.4</td>
</tr>
</tbody>
</table>

NOTE: All values are in mg/l except pH. 

\(^1\)Total of anaerobic and aerobic processes
Table 2.5: Gas Production from the Anaerobic Digestion Process.

<table>
<thead>
<tr>
<th>Digestion Period</th>
<th>Gas production [Litres]</th>
<th>Sample Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Weeks]</td>
<td>1 : 0.5</td>
<td>1 : 1</td>
</tr>
<tr>
<td>One</td>
<td>0.045 – 0.049</td>
<td>0.060 – 0.062</td>
</tr>
<tr>
<td>Two</td>
<td>0.370 – 0.378</td>
<td>0.545 – 0.549</td>
</tr>
<tr>
<td>Three</td>
<td>0.758 – 0.782</td>
<td>1.230 – 1.244</td>
</tr>
<tr>
<td>Four</td>
<td>0.776 – 0.784</td>
<td>1.288 – 1.310</td>
</tr>
</tbody>
</table>

Digestion Temperature: 37°C

Table 2.6: Gas Composition (Anaerobic Digestion).

<table>
<thead>
<tr>
<th>Sample Ratio</th>
<th>CH₄</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 : 0.5</td>
<td>80 – 84</td>
<td>18</td>
</tr>
<tr>
<td>1 : 1</td>
<td>85 – 89</td>
<td>13</td>
</tr>
<tr>
<td>1 : 2</td>
<td>79 – 83</td>
<td>19</td>
</tr>
</tbody>
</table>

Energy Recovery

On applying the optimal experimentally determined conditions of digestion, the following energy recovery equation from the paper mill effluent can be derived:

One Litre of Effluent = 8.66 L of gas, having 85 percent CH₄
~ 7.36 L of CH₄
= 7.4 L of methane (CH₄) per litre of effluent

The total average volume of effluent from the paper mill is 2796 m³/day. Thus the total average volume of methane gas generated would be: 20,580 m³/day
The calorific value of methane gas is 35,800 KJ/m³ (Peavy, 1986). Thus the total quantity of energy produced from the digestion is: \(7.36 \times 10^8\) KJ. Natural gas has a calorific value of: 37,300 KJ/m³ (Peavy, 1986). The gas produced from digestion would be equivalent to:

\[
\frac{7.36 \times 10^8 \text{ KJ}}{37,300 \text{ KJ/m}^3} = 1.97 \times 10^4 \text{ m}^3 \text{ of natural gas}
\]

or \(\frac{7.36 \times 10^8 \text{ KJ}}{19,000 \text{ KJ/kg}}\) (Calorific value of coal)

\[= 38,736 \text{ Kg or } \sim 38.74 \text{ metric tonnes of coal}\]

Therefore, the digestion process could potentially generate enough methane gas on a daily basis to replace 38.74 tonnes of coal.

The paper mill currently uses rice husk as a fuel for the boiler. The fuel equivalence of rice husk is one tonne husk to 0.48 tonnes of coal (James and Rao, 1992). Therefore 80.7 tonnes of rice husk could potentially be replaced by daily methane generation. The steam requirement at capacity operation is 8 tonnes/hour over 24 hours/day. This amounts to 192 tonnes of steam per day. The requirement of coal or rice husk is based on industry estimates that one tonne of coal produces four tonnes of steam. Therefore 192/4 = 48 tonnes of coal daily (capacity operation), which is equivalent to 48/0.48 = 100 tonnes of rice husk is required each day. If a comparison of the coal/rice husk requirement for steam generation and available equivalent energy from gas generated during couple anaerobic/aerobic digestion is made, it can be concluded that about 80 percent of the coal requirement can be met from internal resources (gas recovery).

The literature (Gupta and Awasthi, 1990) reports that the most favourable temperature from the activity of methane forming bacteria is 38°C. This is within one degree of 37°C, which was chosen as the temperature for anaerobic digestion. The optimal temperature for anaerobic digestion of wastewater with a slurry concentration in the ration of 1:1 has been found to be 35°C with accuracy of ±1°C (James and Rao, 1992).
CONCLUSIONS

The Indian paper industry treats its effluent mostly by end of pipe technology. LWT efforts have been restricted to fibre recovery and water recycling. The present case study differs from other technical literature in that it explicitly gives an approach for substitution of LWT in the paper industry. The methodology included a literature search and interviews with personnel to analyse the entire manufacturing process and identify where effluent is being generated. A material balance, when applied to the process, assists in quantifying wastes. Careful observation and analysis of the waste, and estimating the value of the useful and recoverable materials from the waste stream helps in assigning the cost to the waste stream and estimating the losses which the unit incurs on a daily basis. These steps could pave the way for substitution of LWT in the plant. The recovery of by-products from waste requires an assessment of the economic viability of the proposal and the development of technology for the recovery. This approach represents how environment and economy can be integrated using LWT.

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INTEGRATING ENVIRONMENT AND ECONOMY:  
THE CASE OF A DAIRY INDUSTRY

K. Goyal, S.K. Awasthi and R.K. Trivedi

INTRODUCTION

Due to an abundant supply of raw milk, the dairy industry in India has grown rapidly and has bright prospects. According to recent Food and Agriculture Organisation (FAO) estimates, Indian milk production has increased by 4 percent in the last three years, in contrast to a decline of 2 percent in world milk production. In 1990, India lagged behind the Soviet Union and the United States in annual milk production with 54.9 million tonnes. Today it ranks second in the world with 60.8 million tonnes, after the U.S. with 70 million tonnes (No author, 1995a). This increase was due to the better prices offered to farmers coupled with the adoption of improved technology for production and distribution. The role of the organised sector is steadily growing in milk production and in milk processing. The anticipated reductions in production subsidies and import tariffs in Europe and the U.S. should increase the competitiveness of India’s dairy export. The value of Indian dairy industry products is expected to rise from Rs 26,000 crore in 1990 to Rs 47,500 crore in 1995, reaching Rs 85,000 crore by 2000 A.D. (No author, 1995a).

Since a large portion of the Indian population is vegetarian, milk occupies an important position in the list of edible commodities. Nearly half of the volume of milk produced is consumed as fluid milk (about 25,089 thousand tonnes which corresponds to 45.7 percent of the total milk production consumed as liquid milk, with nearly 34 percent used as skim milk or butter milk) (Thompkinson, 1995). The production of dried milk and related products has become an
increasingly important subsector of the dairy industry. During the late 1960s, the total annual production of dried milk and related products in India was in the order of 30,000 tonnes. Since then, this figure has increased to 155,000 tonnes in 1990 (including 60,400 tonnes of baby food) and presently stands at 200,000 tonnes of annual production from 14 licensed milk product factories (Thompkinson, 1995).

Annual milk production data in the Indian states is shown in Table 3.1.

<table>
<thead>
<tr>
<th>State</th>
<th>1992-93</th>
<th>1993-94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>3,103</td>
<td>3,950</td>
</tr>
<tr>
<td>Bihar</td>
<td>3,360</td>
<td>3,450</td>
</tr>
<tr>
<td>Gujarat</td>
<td>3,546</td>
<td>3,795</td>
</tr>
<tr>
<td>Haryana</td>
<td>3,715</td>
<td>3,740</td>
</tr>
<tr>
<td>Karnataka</td>
<td>2,590</td>
<td>2,662</td>
</tr>
<tr>
<td>Kerala</td>
<td>1,889</td>
<td>5,012</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>4,102</td>
<td>4,250</td>
</tr>
<tr>
<td>Punjab</td>
<td>5,583</td>
<td>6,045</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>3,468</td>
<td>3,775</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>10,649</td>
<td>11,000</td>
</tr>
<tr>
<td>West Bengal</td>
<td>3,023</td>
<td>3,400</td>
</tr>
</tbody>
</table>

Kanpur has several small dairies in the unorganised sector located within densely populated areas of the city. It also has one large dairy in the organised sector, which processes 75,000 to 100,000 litre of milk per day.
Since fresh milk has a short life and the distances between the producer and the consumer have increased over time, the preservation of milk and its safe supply to consumers has become a matter of concern for producers, policy planners and managers alike. Sour milk, or milk otherwise wasted, has the potential to degrade receiving water quality through the addition of high Biochemical Oxygen Demand (BOD) loads. This study explores the possibility and cost-effectiveness of substituting Low Waste Technology (LWT) for End-of-Pipe (EOP) technology in the dairy industry.

The facility under study is the Parag Dairy, a cooperative buffalo milk processing operation in Kanpur. It is the largest milk processing unit in Kanpur, and is situated in Nirala Nagar, on the southern side of Kanpur city. The Parag Dairy manufactures a number of products including different grades of milk, butter and ghee. Occasionally, several minor or special products are made in quantities according to market demand. The dairy employs about 400 unionised employees and operates over three eight-hour shifts a day. A total of 75,000 to 100,000 litres per day of milk are processed (Agarwal, 1994). The amount processed varies according to the season, but liquid milk makes up at least 90 percent of the product. Product mix is decided using feedback from distributors about market demand. After seeing a financial loss in the past year, the dairy is currently operating at a profit.

I. THE PROCESS

Milk Collection
At the village level, the Parag Dairy has established milk collection centres known as “Societies” which collect milk directly from the farmers. The Society allows farmers to sell their milk without losing money to middlemen. Each Society has 30 to 40 member farmers and a Secretary is chosen from among these members to be responsible for the collection and testing of raw milk.

Dairy trucks make two daily stops at each of the 300 villages or Societies. The milk is transported to the dairy in metal jugs. Villages which are farther than 40 kilometres from the dairy transport milk to a chilling centre. The milk is chilled in order to slow bacterial action and reduce the risk of souring before it continues to the dairy.
**Milk Processing**

The various operations involved in the processing of milk and milk products include chilling, centrifuging, sediment removal, cream separation, pasteurisation and sterilisation, homogenisation, butter churning, ghee production, packing, handling and storage. The process flow diagram for processing liquid milk and manufacturing other milk products is presented in Figure 3.1.

Raw milk, as received, is chilled to 4°C in a refrigerated bulk tank using chilled water. Chilling arrests enzyme activity and microbial growth. Chilled milk can be stored for four to five hours in a holding tank while awaiting pasteurisation. The dairy has two pasteurisers, one with a capacity of 10,000 L/hr and the other 5,000 L/hr. The units heat milk to 73°C for 15 seconds. This heat is transferred to incoming milk by heat exchange across plates in the regeneration units of the pasteurisers.

Cream separation is achieved by the centrifugal action resulting from churning at 6,000 rpm to separate the fat or cream layer of the milk. Milk having various fat contents [i.e., full cream, “toned” (2 percent fat), skimmed, etc.] results from this stage. The products are then homogenised to create a uniform consistency and ensure that fat globules do not rise to form a cream line. Cream separation and homogenisation is an intermediate process of pasteurisation. The pasteurised milk is then ready for storage in a holding tank and for packaging (bagging). The bagged milk is stored for a maximum of 12 hours at 10°C before distribution.

**Processing of Butter and Ghee**

Cream removed from the cream separator is churned into white butter in a rotating churn which is cooled continuously with chilled water. White butter is removed and used for ghee production or salt and colour are added to it to make yellow butter (table butter). The yellow butter is packaged in various sizes and sold in the market. White butter is transferred on a stainless steel trolley from the churn to the melting unit for melting and prestratification, water (about 10 percent of the initial volume) is drained from the unit. Any residual fat in the water is recovered by adding chilled water. The remaining stratum, consisting of fat, scum and 5 percent water, goes to the ghee boiler where it is maintained at 110°C and then to a filter where it is filtered to separate the fat from the scum and ghee residue. The fat thus obtained is known as ghee and is a marketable product. Ghee residue contains denatured proteins and is waste which is presently transported to the effluent treatment plant (ETP).

Other dairy products are paneer (cheese), milkcake, flavoured milk, lassi, (a milk drink consisting of curd, sugar and spice), mattha (salted skimmed curd diluted with water), and shrikhand (a concentrated mixture of sugar and dewatered curd). The processes and inputs for all dairy products are shown in Table 3.2.
Figure 3.1: Process Flow Diagram (Dairy Plant).
II. WASTE GENERATION AND TREATMENT

The volume of wastewater generated by sources such as utility, processing and cleaning procedures, shows a close relationship to water consumption volumes. The Parag Dairy generates 300m$^3$ of wastewater daily for treatment in its ETP. Included in the wastewater are product rejects, chiefly from the paneer section, material lost during transfer, liquid drained from the butter churn, sour milk after fat removal [the dairy is allowed waste losses of 1 percent fat and 1 percent solids non-fat (SNF) of the total volume of milk], ghee residue and laboratory chemicals.

The typical waste streams from different unit operations are summarised in Table 3.3. The waste streams are combined prior to entering the ETP, which has a design capacity of 700m$^3$/day. The plant has all of the conventional primary treatment steps including collection, aeration and settling tanks. The solid waste produced by the dairy includes ETP sludge, packing materials (polyfilms, glass, plastic tubs, bottle caps, jute and kraft paper bags), some losses of input materials, and skim milk powder (SMP).

The dairy is conscientious in seeking to reduce its waste volume and toxicity. Some LWTs are currently being used successfully. Most wastes generated from the main production lines are
<table>
<thead>
<tr>
<th>Input</th>
<th>Products</th>
<th>Operation</th>
<th>By-products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw milk Polypack</td>
<td>Milk</td>
<td>Receiving, Weighing, Testing, Chilling, Pasteurisation</td>
<td>Cream</td>
</tr>
<tr>
<td></td>
<td>Full cream milk (6% fat, 9% SNF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toned milk (3% fat, 8.5% SNF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skimmed milk (no fat, 8.5% SNF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cream Colour Common salt</td>
<td>Yellow butter (80-80.5% fat, 15% water, 2.5% curd, 2% SNF, 0.5% salt)</td>
<td>Churning, Packing</td>
<td>Butter Milk (sometimes used as Mattha)</td>
</tr>
<tr>
<td>White butter</td>
<td>Ghee or clarified butter (100% fat)</td>
<td>Melting, Prestratific’n, Boiling, Filtration, Packing</td>
<td></td>
</tr>
<tr>
<td>Milk Citric acid</td>
<td>Paneer (5% fat, 8.5% SNF)</td>
<td>Coagulation</td>
<td></td>
</tr>
<tr>
<td>Milk Sugar</td>
<td>Milk cake</td>
<td>Boiling</td>
<td></td>
</tr>
<tr>
<td>Toned milk Sugar Cardamom extract</td>
<td>Flavoured milk (3% fat, 8.5% SNF)</td>
<td>Sterilisation, Boiling</td>
<td></td>
</tr>
<tr>
<td>Milk Sugar Kewara extract</td>
<td>Lassi</td>
<td>Curdling, Mixing</td>
<td></td>
</tr>
<tr>
<td>Buttermilk Salt Spices</td>
<td>Mattha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk Sugar Flavour</td>
<td>Shrirkhand</td>
<td>Curdling, Hanging</td>
<td></td>
</tr>
</tbody>
</table>
either recovered as by-products and sold, or are used elsewhere in the plant (i.e., the fat recovered from sour milk and butter milk is sold, and citric acid is reused for coagulation in the paneer section). The dairy has developed a (horticultural) plant nursery which uses a number of process by-products including ETP sludge, which is used for plant bedding and waste polyfilm, which is used as plant containers or pots. The dairy’s waste streams, their quantities and the current strategies to manage the wastes are presented in Table 3.4.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Waste Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk receiving</td>
<td>Sour milk</td>
</tr>
<tr>
<td></td>
<td>Cleaning In Place (CIP) water</td>
</tr>
<tr>
<td></td>
<td>Can &amp; floor washing water</td>
</tr>
<tr>
<td>Chilling and storage</td>
<td>CIP, floor washing, milk</td>
</tr>
<tr>
<td>Pasteurisation</td>
<td>CIP, floor washing, milk</td>
</tr>
<tr>
<td>Milk packing</td>
<td>CIP, milk</td>
</tr>
<tr>
<td>Storage, floor washing</td>
<td>CIP, trace of SMP</td>
</tr>
<tr>
<td>Butter manufacturing</td>
<td>CIP, buttermilk</td>
</tr>
<tr>
<td>Ghee manufacturing</td>
<td>Ghee residue, CIP, floor washing</td>
</tr>
<tr>
<td>Cheese manufacturing</td>
<td>CIP, floor washing, cheese whey</td>
</tr>
<tr>
<td>Steam generation</td>
<td>Heating fuel residue</td>
</tr>
</tbody>
</table>
### Table 3.4: Waste Management Practices and LWT Opportunities.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Waste Stream</th>
<th>Daily Quantity</th>
<th>State</th>
<th>Current Disposal Practice</th>
<th>LWT Possibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Handling Losses</td>
<td>1,000 L</td>
<td>Liquid</td>
<td>ETP</td>
<td>Good housekeeping</td>
</tr>
<tr>
<td>2</td>
<td>Water</td>
<td>300m³</td>
<td>Liquid</td>
<td>ETP</td>
<td>Recycling</td>
</tr>
<tr>
<td>3</td>
<td>Skimmed sour milk</td>
<td>2,000 L</td>
<td>Liquid</td>
<td>ETP</td>
<td>Protein recovery</td>
</tr>
<tr>
<td>4</td>
<td>Buttermilk</td>
<td>6,000 L</td>
<td>Liquid</td>
<td>Used for product manufacturing</td>
<td>-----</td>
</tr>
<tr>
<td>5</td>
<td>Ghee residue</td>
<td>6 kg</td>
<td>Solid</td>
<td>ETP</td>
<td>1. Fat recovery 2. Candy production</td>
</tr>
<tr>
<td>6</td>
<td>Paneer whey</td>
<td>400 L</td>
<td>Liquid</td>
<td>ETP</td>
<td>Soft drink ingredient</td>
</tr>
</tbody>
</table>

### III. MATERIAL BALANCE

Preparation of a material balance for the plant aided in the identification and quantification of unspecified waste losses, and is thus a mandatory step for waste minimisation. In the case of the Parag Dairy, it was observed that although the company’s waste management system is good, further attention to waste management strategies is both possible and advisable. The material balance appears as Figure 3.2.
**Figure 3.2: Material Balance (Dairy Plant).**

<table>
<thead>
<tr>
<th>Input</th>
<th>Unit Operation</th>
<th>Output/by-products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw milk 100 000 L milk</td>
<td><strong>Receiving</strong></td>
<td>2000 L sour milk</td>
</tr>
<tr>
<td>98 000 L</td>
<td><strong>Chilling &amp;</strong></td>
<td>200 L sour milk</td>
</tr>
<tr>
<td>98 000 L</td>
<td><strong>Pasteurization</strong></td>
<td>250 L milk</td>
</tr>
<tr>
<td>87 450 L</td>
<td><strong>Cream separation</strong></td>
<td>100 L milk, 10 000 kg cream, 50 L butter product</td>
</tr>
<tr>
<td>87 400 L</td>
<td><strong>Homogenization</strong></td>
<td>1000 L milk for other milk products</td>
</tr>
<tr>
<td>86 400 L</td>
<td><strong>Storage</strong></td>
<td>400 L milk</td>
</tr>
<tr>
<td>86 400 L</td>
<td><strong>Bagging</strong></td>
<td>(a) 10 000 L full cream milk, (b) 40 000 L toned milk, (c) 36 000 L skim milk</td>
</tr>
</tbody>
</table>
IV. POTENTIAL FOR ADDITIONAL LOW WASTE TECHNOLOGIES

This study sought to further reduce the pollution load from the dairy and to demonstrate the technical feasibility and financial viability of the application of additional LWTs. Two waste streams are possible candidates for additional by-product recovery. Skimmed sour milk could be used in casein production and ghee residue could be employed in the manufacture of sweets. Other LWT categories that might be investigated are good housekeeping and waste stream segregation. Some LWT opportunities, with the associated current waste loss rates and recovery potentials, have been identified in Table 3.4.

V. PROBLEM IDENTIFICATION

This paper describes an attempt to recover casein from sour milk. Casein is a valuable product which has several industrial applications (Cf. Table 3.5).

On the basis of the information presented in Table 3.5, it is clear that the recovery of casein has the potential to generate income for the unit, while at the same time reducing the organic load on the effluent discharged from the plant. This approach therefore appears to be a viable proposition for reducing dairy waste.

VI. METHODOLOGY

The methodologies for collecting information included a literature survey, plant visits and interviews. Interviews were conducted with the General Manager, Plant Manager, administrative staff and shop floor staff. A combination of these techniques was used to form a description of the
manufacturing process and identify the various waste streams. A material balance aided in quantifying waste streams, and costs were assigned to these streams on the basis of market rates obtainable for materials being carried in them.

Dairy effluent inevitably contains free fat. The recovery of free fat and removal of suspended solids using dissolved air flotation is common practice in India, and helps to improve process efficiency and lower capital costs. Another treatment option favoured in India for its cost and energy effectiveness is anaerobic digestion (Central Pollution Control Board, 1993).

VII. MATERIALS
The materials used in development of the technology for this proposal were skimmed sour milk and various acids and solvents such as sulphuric acid, hydrochloric acid, sodium hydroxide, boric acid, hexane, cupric oxide, and indicators.

Sample Collection
Samples of skimmed sour milk (fat was reduced to 0.1 – 0.3 percent by centrifuge at the dairy) were collected twice a day to correspond with the twice-daily receipts of raw milk. The total twenty samples included in the analysis were collected over at ten day period. The tests were conducted using standard methods (ASTM, 1968a). Total solids, suspended solids, total dissolved solids, BOD, and chemical oxygen demand (COD) were determined by standard methods (Rand, 1976). Specific gravity and acidity were measured by methods given in the literature (Webbs, 1974).

Preparation of Protein
Five aliquots of milk were measured from each of the twenty samples. The aliquots, in equal volumes of 150 mL each, were collected in conical flasks and maintained at 30°C, 40°C, 50°C, 60°C and 70°C using a constant temperature water bath. Two acids, hydrochloric and sulphuric, at two concentrations each, 10 percent and 20 percent, were used. A known volume of acid was added to
the samples to maintain a pH of 4.6 (i.e., the pH value of the isoelectric point of casein). The samples were stirred continuously to achieve complete precipitation. The precipitate was filtered through muslin cloth and washed three times with water. After washing, the samples were dried at temperatures ranging from 40°C to 50°C in a drying oven and then found using a mortar and pestle. The protein powder thus obtained was further analysed to assess its quality. A flow diagram of the process for making casein using the selective precipitation technique is presented in Figure 3.3.

Characterisation of Protein
The resulting dried samples were characterised for their moisture percentage, fat content, acidity and protein content. Moisture percentage was determined by standard methods (Rand, 1976). The method used to determine the fat content in the samples was direct extraction by petroleum ether (ASTM, 1968b). The protein content of the samples was determined by estimating the nitrogen content using the Kjeldahl procedure, and multiplying this amount by 6.38 as applicable for the total organic and ammonia nitrogen (ASTM, 1968a). The acidity of the sample was determined by the method given by the American Society for Testing and Materials (1968b).

VIII. RESULTS AND DISCUSSION

Composition of Raw Milk
Milk consists of 85 to 90 percent water and 11-15 percent total solids (Webbs, 1974). The latter comprises fat and SNF portions. The fat of buffalo milk varies from 7 to 7.40 percent and the SNF from 9 to 10 percent. The typical composition of buffalo milk is given in Table 3.6.

Average Composition of Sour Milk Samples
The average composition of the twenty skimmed sour milk samples is presented in Table 3.7.
Figure 3.3: Casein Preparation (Dairy Plant).
Table 3.6: Composition of Buffalo Milk.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>82.76</td>
</tr>
<tr>
<td>Fat</td>
<td>7.36</td>
</tr>
<tr>
<td>Protein</td>
<td>3.60</td>
</tr>
<tr>
<td>Lactose</td>
<td>5.48</td>
</tr>
<tr>
<td>Ash</td>
<td>0.78</td>
</tr>
<tr>
<td>Solids in fat</td>
<td>9.86</td>
</tr>
<tr>
<td>Total solids</td>
<td>17.24</td>
</tr>
</tbody>
</table>

Table 3.7: Average Composition of Milk Samples.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parameter</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>5 - 6</td>
</tr>
<tr>
<td>2</td>
<td>Fat content</td>
<td>0.1% - 0.2%</td>
</tr>
<tr>
<td>3</td>
<td>Solids non-fat</td>
<td>7.0% - 8.5%</td>
</tr>
<tr>
<td>4</td>
<td>Specific gravity</td>
<td>1.02 – 1.10</td>
</tr>
<tr>
<td>5</td>
<td>Acidity</td>
<td>0.36% - 0.48%</td>
</tr>
</tbody>
</table>

Pollution Parameters of Sour Milk Samples

The results presented in Table 3.8 are based on ten samples analysed by the investigators. The recovered samples were characterised by analysing the for acidity, moisture, fat and nitrogen contents. Results are presented in Table 3.9.
Table 3.8: Pollution Parameters of Skimmed Sour Milk.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parameter</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>5 - 6</td>
</tr>
<tr>
<td>2</td>
<td>Total solids</td>
<td>74.12 – 84.17 g/L</td>
</tr>
<tr>
<td>3</td>
<td>Total dissolved solids</td>
<td>69.67 – 78.42 g/L</td>
</tr>
<tr>
<td>4</td>
<td>Total suspended solids</td>
<td>4.45 – 5.74 g/L</td>
</tr>
<tr>
<td>5</td>
<td>Biochemical oxygen demand</td>
<td>1,400 – 4,500 mg/L</td>
</tr>
<tr>
<td>6</td>
<td>Chemical oxygen demand</td>
<td>21,024 – 50,000 mg/L</td>
</tr>
</tbody>
</table>

Table 3.9: Sample Characteristics.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Temp. [°C]</th>
<th>Acid Conc°</th>
<th>Moisture [%]</th>
<th>Total Fat [%]</th>
<th>Nitrogen Content [%]</th>
<th>Acidity [mL of 0.1 N NaOH]</th>
</tr>
</thead>
<tbody>
<tr>
<td>With H$_2$SO$_4$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>10%</td>
<td>12.0</td>
<td>0.20</td>
<td>12.22</td>
<td>10.0</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>10%</td>
<td>11.0</td>
<td>0.13</td>
<td>12.50</td>
<td>12.0</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>20%</td>
<td>8.3</td>
<td>0.18</td>
<td>13.32</td>
<td>10.0</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>20%</td>
<td>8.2</td>
<td>0.14</td>
<td>12.60</td>
<td>12.4</td>
</tr>
<tr>
<td>With HCl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>10%</td>
<td>8.0</td>
<td>0.10</td>
<td>11.8</td>
<td>8.6</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>10%</td>
<td>8.3</td>
<td>0.12</td>
<td>12.8</td>
<td>8.0</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>20%</td>
<td>9.5</td>
<td>0.14</td>
<td>10.2</td>
<td>8.4</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>20%</td>
<td>10.0</td>
<td>0.17</td>
<td>12.9</td>
<td>6.1</td>
</tr>
</tbody>
</table>
**Effect of Temperature and Acid Concentration on Protein Precipitation**

The results obtained using hydrochloric and sulphuric acids are given in Table 3.10 and Table 3.11 respectively. Protein yield was calculated from the formula (Dee Snell and Ettre, n.d.):

\[
\text{Percent Protein Content} = 6.38 \times \text{Nitrogen Content} \times \text{Precipitate Yield}
\]

The results are based on four experimental trials. The variability in the results can be ascribed to variation in operating parameters (time, temperature, pH) and to the variability in samples. From Table 3.10 it can be seen that with hydrochloric acid, the maximum protein yield for both acid concentrations is achieved at 60°C (on average 4.7 percent yield using 10 percent acid and 4.4 percent yield using 20 percent acid). From table 10.11 it can be seen that the maximal yields using sulphuric acid occurred at 30°C (4.8 percent yield using 10 percent acid and 4.7 percent yield using 20 percent acid). It is therefore concluded that for protein preparation, 10 percent sulphuric acid at 30°C is the optimal temperature/concentration combination for precipitation under atmospheric conditions, giving a maximum average yield of 4.8 percent. As 30°C is approximately room temperature, casein preparation under these conditions would not require any additional inputs of heat energy.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Temp. (°C)</th>
<th>pH</th>
<th>Yield [%]<strong>1</strong> (using 10% Acid)</th>
<th>Yield [%]<strong>1</strong> (using 20% Acid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>4.6</td>
<td>0.23 – 0.36</td>
<td>1.9 – 2.0</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>4.6</td>
<td>3.2 – 3.3</td>
<td>2.6 – 3.3</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>4.6</td>
<td>3.3 – 3.4</td>
<td>3.5 – 4.5</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>4.6</td>
<td>3.8 – 5.5</td>
<td>3.9 – 4.8</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>4.6</td>
<td>3.8 – 4.7</td>
<td>3.7 – 4.7</td>
</tr>
</tbody>
</table>

**1** Percentage based on 100 mL samples
### Table 3.11: Effect of Temperature on Protein Yield Using Sulphuric Acid.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Temp. (°C)</th>
<th>pH</th>
<th>Yield [%]* (using 10% Acid)</th>
<th>Yield [%]* (using 20% Acid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>4.6</td>
<td>4.3 – 5.3</td>
<td>4.2 – 5.1</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>4.6</td>
<td>3.0 – 4.9</td>
<td>2.4 – 3.7</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>4.6</td>
<td>3.2 – 4.3</td>
<td>3.3 – 3.8</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>4.6</td>
<td>3.4 – 4.3</td>
<td>3.0 – 3.1</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>4.6</td>
<td>3.1 – 3.5</td>
<td>3.1 – 3.2</td>
</tr>
</tbody>
</table>

*Percentage based on 100 mL samples

### IX. ECONOMIC VIABLITY OF THE LWT PROPOSAL

Recovery of casein from sour milk has been identified as an option for implementation at Parag Dairy, Kanpur. The equipment required to carry out casein recovery, with approximate costs, is described in the following calculations which address the economic viability of the proposal. Information presented in Table 3.12 is based on the unit processes involved in the experimental work conducted by the investigators. Prices were decided in consultation with local plant fabricators.

### ASSUMPTIONS

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of milk processed</td>
<td>75,000 L/day (approximately 75,000 kg)</td>
</tr>
<tr>
<td>Water used</td>
<td>2.50 lakh L/day</td>
</tr>
<tr>
<td>Sour milk</td>
<td>2 percent of total volume</td>
</tr>
<tr>
<td>Working days</td>
<td>300 per annum</td>
</tr>
</tbody>
</table>

### PROFITABILITY ASPECT

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of casein produced</td>
<td>50 kg/day</td>
</tr>
<tr>
<td>Rate</td>
<td>Rs 50 per kg</td>
</tr>
<tr>
<td>Value of sales</td>
<td>300 days/yr x 50 kg/day x 50 Rs/kg = 7.50 lakh/yr</td>
</tr>
</tbody>
</table>

### RAW MATERIALS & CHEMICALS CONSUMED

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid consumption</td>
<td>6.6 L/day (H2SO4) = 13 kg/day</td>
</tr>
<tr>
<td>Annual consumption</td>
<td>13 kg/day x 300 days/yr = 3.9 metric tonnes/yr</td>
</tr>
<tr>
<td>Cost of acid</td>
<td>@ Rs 4,000/T = Rs 0.16 lakh</td>
</tr>
<tr>
<td>Packing material &amp; chemicals</td>
<td>Rs 0.32 lakh</td>
</tr>
<tr>
<td>Total cost of raw materials</td>
<td>Rs 0.48 lakh</td>
</tr>
</tbody>
</table>
POWER CONSUMPTION

<table>
<thead>
<tr>
<th>Load required</th>
<th>20 HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load factor</td>
<td>50%</td>
</tr>
<tr>
<td>Power consumption</td>
<td>$20\text{ HP} \times 0.746 \text{ KWH} \times 0.50 \text{ (local power factor)} \times 300 \text{ days/yr} \times 16 \text{ hrs./day} = 35,808 \text{ KWH/yr}$</td>
</tr>
<tr>
<td>Cost of power</td>
<td>@ Rs $2.50/\text{KWH} = \text{Rs} 0.90 \text{ Lakh}$</td>
</tr>
</tbody>
</table>

REPAIRS & MAINTENANCE

Estimated at Rs 10,000 per annum

SALARY & WAGES

Annual Rs 1.92 Lakh (for 7 persons employed)
Rs 16,000/month total for one supervisor, three skilled and three unskilled workers

MARKETING & ADMINISTRATIVE EXPENSES

Estimated at 10 percent of sales, or Rs 0.75 Lakh per annum at 100 percent capacity.

DEPRECIATION

An annual depreciation rate (following the WDV method) of 25 percent on equipment and 10 percent on building costs has been used in all calculations.

SUMMARY

The total production costs (100 percent capacity operation) are presented in Table 3.13.

PROJECT COSTS

<table>
<thead>
<tr>
<th>Land</th>
<th>No additional costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>Rs 2.00 Lakh</td>
</tr>
<tr>
<td>Plant &amp; Equipment</td>
<td>Rs 3.00 Lakh</td>
</tr>
<tr>
<td>Escalation &amp; Contingencies</td>
<td>Rs 0.50 Lakh</td>
</tr>
<tr>
<td>Preoperative Expenses</td>
<td>Rs 0.10 Lakh</td>
</tr>
<tr>
<td>Margin Money for Working Capital</td>
<td>Rs 0.40 Lakh</td>
</tr>
<tr>
<td><strong>Total Project Costs</strong></td>
<td><strong>Rs 6.00 Lakh</strong></td>
</tr>
</tbody>
</table>
Table 3.12: Estimated Costs of Equipment for Protein Recovery.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Capacity</th>
<th>Approximate Cost Rs Lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Precipitation Tank with FRP(^1) lining or PVC(^2) Tank</td>
<td>10,000 L</td>
<td>0.40</td>
</tr>
<tr>
<td>2. Pump with 1 HP motor</td>
<td></td>
<td>0.04</td>
</tr>
<tr>
<td>3. Acid Tank (PVC)</td>
<td>5,000 L</td>
<td>0.15</td>
</tr>
<tr>
<td>4. Plate &amp; Frame Filter Press (PVC)</td>
<td>500 L, 18” x 18” x 2”</td>
<td>0.20</td>
</tr>
<tr>
<td>5. Washing Tank (PVC/FRP)</td>
<td>6,000 L</td>
<td>0.20</td>
</tr>
<tr>
<td>6. Tray Dryer, electrically operated with 50 trays</td>
<td>10 HP</td>
<td>0.70</td>
</tr>
<tr>
<td>7. Pulveriser with motor</td>
<td>5 HP</td>
<td>0.50</td>
</tr>
<tr>
<td>8. Bag stitching machine</td>
<td>2 No.</td>
<td>0.04</td>
</tr>
<tr>
<td>9. Weighing Scale, Dial type</td>
<td>1 No. 50 Kg</td>
<td>0.10</td>
</tr>
<tr>
<td>10. Laboratory Equipment &amp; Instrumentation</td>
<td></td>
<td>0.20</td>
</tr>
<tr>
<td>11. Erection &amp; Commissioning Fees</td>
<td></td>
<td>0.45</td>
</tr>
<tr>
<td><strong>APPROXIMATE TOTAL</strong></td>
<td></td>
<td><strong>Rs 3.00</strong></td>
</tr>
</tbody>
</table>

\(^1\) Percentage based on 100 mL samples

\(^2\) Polyvinyl Chloride
Table 3.13: Cost of Production at 100 Percent Capacity.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Expense Item</th>
<th>Amount (Rs Lakh/annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw Materials &amp; Chemicals</td>
<td>0.48</td>
</tr>
<tr>
<td>2.</td>
<td>Power</td>
<td>0.90</td>
</tr>
<tr>
<td>3.</td>
<td>Repairs &amp; Maintenance</td>
<td>0.10</td>
</tr>
<tr>
<td>4.</td>
<td>Salary &amp; Wages</td>
<td>1.92</td>
</tr>
<tr>
<td>5.</td>
<td>Depreciation</td>
<td>0.90</td>
</tr>
<tr>
<td>6.</td>
<td>Interest on Money Borrowed$^1$</td>
<td>0.60</td>
</tr>
<tr>
<td>7.</td>
<td>Marketing &amp; Administration</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>TOTAL ESTIMATED PRODUCTION</td>
<td>5.70</td>
</tr>
<tr>
<td></td>
<td>VALUE OF PRODUCTION</td>
<td>7.50</td>
</tr>
<tr>
<td></td>
<td>OPERATING PROFIT</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td>NET CASH GENERATION$^2$</td>
<td>2.70</td>
</tr>
</tbody>
</table>

$^1$15% interest rate on capital expenditures (Rs 3.0 Lakhs) and working capital (Rs 1.0 Lakhs)

$^2$ Sum of gross operating profits and depreciation
Sensitivity Analysis

To predict the effects of fluctuations in raw materials and product prices, a sensitivity analysis was completed (Table 3.14). From the analysis, it was concluded that the operating profit and net cash generation remained within limits of project viability (i.e., had positive values for each tested change).

From these calculations, it is apparent that the proposal is economically viable. The payback period for the proposal is less than three years, which is by all standards within reasonable limits, and the firm could afford the implementation of the proposal.

Table 3.14: Sensitivity Analysis.

<table>
<thead>
<tr>
<th>Costs &amp; Revenues [Rs Lakhs]</th>
<th>Effects of Increasing Production Costs by:</th>
<th>Effects of Decreasing Sales Price by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>Production</td>
<td>5.81</td>
<td>5.98</td>
</tr>
<tr>
<td>Sales</td>
<td>7.50</td>
<td>7.50</td>
</tr>
<tr>
<td>Operating Profit</td>
<td>1.69</td>
<td>1.52</td>
</tr>
<tr>
<td>Net Cash Generation</td>
<td>2.64</td>
<td>2.47</td>
</tr>
</tbody>
</table>
CONCLUSIONS

This study indicates potential for LWTs in the dairy industry. Suggestions include the preparation of soft drinks, candy and protein products (casein) from waste milk which is currently lost with the effluent. The potential for production of industrial grade casein to improve the profitability of the plant has been demonstrated in the current study. The study thus presents a strong case for adopting low waste technology in order to reduce the pollution load and provide financial benefit to the firm.

REFERENCES

INTEGRATING ENVIRONMENT AND ECONOMY IN VEGETABLE OIL REFINERIES

V. Singh, R.K. Trivedi and S.K. Awasthi

INTRODUCTION

India contributes about ten percent to total world oilseed production, with a cultivated area of approximately 26 million hectares (12-13 percent of the country’s total cropped area) and an annual production of 21 million tonnes (Agarwal, 1994). India has the distinction of being the country with the largest area in the world under oilseed cultivation, producing ten important oilseed varieties (Agarwal, 1994). However, in production, India stands in fourth place after the United States, China and Brazil. This is mainly due to a low productivity per hectare (about 50 percent of the world average) (Shah, 1995).

Vegetable oils contain substances essential to the human diet and the oils are ingredients in many food items. The oils are also an important raw material in the manufacture of soaps, paints, cosmetics, lubricants, textiles, leather and pharmaceuticals. Vegetable oils and oil cakes are two major oilseed products separated by crushing or solvent extraction. Edible oil production in India is, at present, only just sufficient to meet indigenous requirements. The annual per capita consumption of edible oils has increased rapidly from four kg in 1960 to about seven kg in 1994 (see Table 4.1), mainly due to an improved standard of living (Agarwal, 1994). However, the present level of consumption is still only half of the world average (14-15 kg), and far below that in developed countries, as shown in Table 4.2.

The edible oil industry plays an important role in the Indian economy. It provides direct employment to about half a million people, and indirect employment to about 14 million people (Agarwal, 1994). About 1,000 processing plants including oil refineries and units for solvent extraction and vanaspati production are currently operating throughout the country (Solvent Extractor’s Association of India, 1994).
Table 4.1: Oilseeds Scenario: Global vs. Indian (Million Tonnes).

Source: (Oil World Statistics, 1994).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>93-94</th>
<th>92-93</th>
<th>91-92</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Crushing of oilseeds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) World total</td>
<td>186.0</td>
<td>187.0</td>
<td>189.0</td>
</tr>
<tr>
<td></td>
<td>(b) India</td>
<td>19.8</td>
<td>18.6</td>
<td>16.8</td>
</tr>
<tr>
<td></td>
<td>(c) Percent*</td>
<td>10.5</td>
<td>9.9</td>
<td>8.9</td>
</tr>
<tr>
<td>2.</td>
<td>Production of oils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) World total</td>
<td>86.3</td>
<td>83.4</td>
<td>84.1</td>
</tr>
<tr>
<td></td>
<td>(b) India</td>
<td>7.2</td>
<td>7.0</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>(c) Percent</td>
<td>8.3</td>
<td>8.4</td>
<td>7.7</td>
</tr>
<tr>
<td>3.</td>
<td>Consumption of oils &amp; fats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) World total</td>
<td>87.0</td>
<td>85.1</td>
<td>83.8</td>
</tr>
<tr>
<td></td>
<td>(b) India</td>
<td>7.3</td>
<td>7.0</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>(c) Percent</td>
<td>8.4</td>
<td>8.2</td>
<td>8.2</td>
</tr>
<tr>
<td>4.</td>
<td>Imports of oils &amp; fats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) World total</td>
<td>28.23</td>
<td>26.90</td>
<td>26.65</td>
</tr>
<tr>
<td></td>
<td>(b) India</td>
<td>0.24</td>
<td>0.22</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>(c) Percent</td>
<td>0.85</td>
<td>0.82</td>
<td>1.58</td>
</tr>
<tr>
<td>5.</td>
<td>Export of oils &amp; fats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) World total</td>
<td>28.16</td>
<td>26.86</td>
<td>26.62</td>
</tr>
<tr>
<td></td>
<td>(b) India</td>
<td>0.14</td>
<td>0.15</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>(c) Percent</td>
<td>0.50</td>
<td>0.56</td>
<td>0.34</td>
</tr>
</tbody>
</table>

*Percentage of India’s share in the world total.
Table 4.2: Per Capita Consumption of Vegetable Oils (kg/yr).
Source: (Shah, 1995).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Country</th>
<th>91-92</th>
<th>90-91</th>
<th>89-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>USA</td>
<td>31.6</td>
<td>31.1</td>
<td>30.5</td>
</tr>
<tr>
<td>2.</td>
<td>Canada</td>
<td>27.9</td>
<td>27.2</td>
<td>26.4</td>
</tr>
<tr>
<td>3.</td>
<td>Germany</td>
<td>27.9</td>
<td>27.5</td>
<td>26.9</td>
</tr>
<tr>
<td>4.</td>
<td>UK</td>
<td>26.9</td>
<td>26.4</td>
<td>25.7</td>
</tr>
<tr>
<td>5.</td>
<td>France</td>
<td>19.0</td>
<td>18.7</td>
<td>16.9</td>
</tr>
<tr>
<td>6.</td>
<td>Australia</td>
<td>19.3</td>
<td>19.2</td>
<td>17.4</td>
</tr>
<tr>
<td>7.</td>
<td>New Zealand</td>
<td>14.8</td>
<td>14.8</td>
<td>12.9</td>
</tr>
<tr>
<td>8.</td>
<td>China</td>
<td>6.5</td>
<td>6.3</td>
<td>6.0</td>
</tr>
<tr>
<td>9.</td>
<td>India</td>
<td>6.9</td>
<td>6.4</td>
<td>6.4</td>
</tr>
<tr>
<td>10.</td>
<td>Japan</td>
<td>18.5</td>
<td>18.1</td>
<td>18.3</td>
</tr>
<tr>
<td>11.</td>
<td>Pakistan</td>
<td>12.2</td>
<td>12.0</td>
<td>11.7</td>
</tr>
</tbody>
</table>

Kanpur is the second most important centre in northern India (after Delhi) for the vegetable oil trade. Both raw and refined oils, which are produced by the oil mills solvent extraction plants, are traded. About 55 to 60 oil mills of various sizes and capacities are operational in Kanpur. There are five edible oil refineries in and around Kanpur with a total production capacity of about 300 MT of refined oils per day.

As does any other industry, the vegetable oil industry contributes to the overall pollution problems of Kanpur city. In this industry, the major pollutants include spent nickel catalyst and oil spillage. In the past, this industry has focused on controlling pollution through end of pipe (EOP) treatments (Central Pollution Control Board, 1994). Currently, an effluent treatment plant (ETP) is the method chosen to reduce effluent pollution parameters to the levels set by the Central Pollution Control Board, before the stream is released to the city’s drainage system.
Recently, the concept of clean technology or low waste technology (LWT) has been recognised as having potential for improving industrial waste management. Efforts have been made by some industries to adopt cleaner technologies. Studies describing waste volume reduction, waste recycling, reuse and by-product recovery are well documented in several industries (Kulkami, 1994) including the vegetable oil sector (Cambrian Engineering, 1991). One of the vegetable oil units in Kanpur, M/S Hindustan Vegetable Oil Corporation Limited (HVOC) was selected as the subject of the current investigation, in order to explore the possibilities of using LWT for pollution control.

HVOC (Kanpur) is one unit of a Government of India undertaking. The refined and hydrogenated oil producing unit, built in 1936, is situated in the heart of Kanpur city. The plant is characterised by high energy consumption (four hundred kg of coal are used per tonne of *vanaspati* produced) and high process losses (from 6 percent to 8 percent oil losses) (NEERI, 1994). The unit has the highest oil processing capacity in the state of Uttar Pradesh. Production capacity is 100 MT/day *vanaspati*, 125 MT/day refined oil and 1.5 MT/day washing soap, produced as a by-product. Three hundred and forty seven regular workers are employed along with 15 administrative and supervisory staff. The unit has an annual turnover of between Rs 50-60 million. For the purposes of the current investigation, the overall process of converting raw materials to finished products has been studied as a series of unit operations. Unit processes have been analysed, their waste streams quantified, and efforts have been made to discern possible areas of application for LWT in the plant. This has been done without losing sight of the necessity of sustainability, as seen by the firm.

I. THE PROCESS

In India, the edible oils are consumed in three forms: as raw oil, and as processed refined liquid oil and solid *vanaspati* (or vegetable *ghee*). The main objective of refining is to make the oil palatable by removing free fatty acids (FFA) and undesirable impurities such as seed fragments, tissue pigments and odoriferous compounds (Table 4.3).
Refining also maintains the moisture content and levels of insoluble impurities and volatile matter, together known as MIV. The four main stages in the refining process are degumming, neutralisation, bleaching and deodorisation.

Degumming is done in order to remove phosphatides and gummy material. The second stage, neutralisation, renders the acidic oil neutral in pH by removing the fatty acids and other impurities either chemically, using caustic soda or by physical methods. The oil is then bleached to remove undesirable colouring. Finally, deodorisation is carried out at high temperature and very low pressure to remove odours left by the chemicals after neutralisation and bleaching. The refined oils are also hydrogenated to make Vanaspati, a solid product that simulates butter fat (ghee). Hydrogenation is carried out in the presence of a nickel catalyst. Consumption of vanaspati has decreased recently, mainly due to increased health consciousness in the Indian population, and the availability of a good variety of refined liquid oils in the Indian market.

II. METHOD AND IDENTIFICATION OF WASTE STREAMS

Several visits to HVOC’s plant and administrative office were made in order to study the process and collect other relevant data. Interviews with the plant’s General Manager, Assistant General Manager, Production Manager, Maintenance Manager and shop floor staff were conducted. Analytical work, carried out in the quality control laboratory of the plant, characterised waste composition and volume. A literature search was used to gather information on the manufacturing process and waste streams. The following LWT approaches have been adopted by the vegetable oil processing industry:

- recycling wastewater for washing floors and reaction vessels
- by-product recovery, for example acid oil and laundry soap, and
- replacing batch neutralisation with continuous neutralisation.
Table 4.3: Crude Vegetable Oil Composition.

<table>
<thead>
<tr>
<th>Component</th>
<th>Desired/Undesired</th>
<th>Characteristic</th>
<th>Process for Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triglycerides</td>
<td>Desired</td>
<td>Essential for body growth</td>
<td></td>
</tr>
<tr>
<td>Free fatty acids</td>
<td>Undesired</td>
<td>Decrease smoke point and forms poisonous lead soaps</td>
<td>Neutralisation</td>
</tr>
<tr>
<td>Mucilaginous</td>
<td>Undesired</td>
<td>Cause high refining loss, Settle out in storage</td>
<td>Degumming</td>
</tr>
<tr>
<td>Phosphatides</td>
<td>Undesired</td>
<td>Cause high refining loss, Settle out in storage</td>
<td>Degumming</td>
</tr>
<tr>
<td>Pigments</td>
<td>Undesired</td>
<td>Cause dark</td>
<td>Bleaching</td>
</tr>
</tbody>
</table>

At HVOC, awareness of LWTs was promoted by a consultant’s report (Cambrian Engineering, 1991). Implementation of the suggestions made in the report is proceeding slowly, with the one accomplishment being the installation of a continuous neutralisation unit. The process flow diagram (Figure 4.1) describes the process steps in the production of refined oil and vanaspati. By examining the process steps, the investigators were able to identify the waste generating steps, and the nature of waste generated.
Figure 4.1: Flow Diagram of Edible Oil Manufacture at HVOC, Kanpur.
Source: (HVOC).
III. MATERIAL BALANCE

Material and energy balances are important requirements for any waste minimisation programme, since they make it possible to identify and quantify previously unrecognised losses or emissions. A material balance representing the process at HVOC is presented in Figure 4.2. The balance is made on the basis of 100 tonnes per day crude vegetable oil processing, and assumes that the raw oil contains 1 percent free fatty acids, 0.05 percent moisture and 0.2 percent inerts. The figures are based on information supplied by the firm’s management and investigations carried out by the researchers. The handling losses, including spillage and overflowing of tanks are based on staff reports. Gums, soap stock, spent earth and spent nickel catalyst were weighed for one batch of oil. Drums and buckets were used to measure the volumes of liquids and slurries. Spent earth and catalyst were weighed in gunny sacks. The quantity of wash water was estimated based on volumes entering the ETP.

An energy balance of the plant was not possible, due to the poor energy management system of the company, and a lack of information available for each section. However, the plant management has been requested to start an energy management programme, with energy audit initiatives.

IV. WASTE MANAGEMENT

Following the identification, characterisation and quantification (material balance) of waste streams, the whole waste management system of HVOC can be depicted, as shown in Table 4.4. From this Table it is evident that several waste streams (gums, soap stock, spent earth and spent catalyst) attract special attention because they have oil as a constituent, and therefore represent financial loss of product. The present waste management system at HVOC is not able to command a good price for these waste streams. Therefore, a critical evaluation of the sources of waste generation, and the results of a search for possibilities to implement LWT is now presented.
Figure 4.2 Material Balance.
Source: (HVOC).

<table>
<thead>
<tr>
<th>Input Streams</th>
<th>Unit Operations</th>
<th>Output Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil (100 MT)</td>
<td>Crude Oil Receipts</td>
<td>Handling Losses (100 Kg) A₁</td>
</tr>
<tr>
<td>H₂PO₄ (50 Kg), Water (1000 Kg)</td>
<td>Degumming</td>
<td>Gums (1250 Kg) B</td>
</tr>
<tr>
<td>NaOH 40% (450 Kg)</td>
<td>Neutralization</td>
<td>Soap Stock (3650 Kg) C₁</td>
</tr>
<tr>
<td>Salt (500 Kg), Hot Water (18.2 MT)</td>
<td>Washing</td>
<td>Wash Water (18 MT) F₁</td>
</tr>
<tr>
<td>Bleaching Earth, Activated Carbon</td>
<td>Drying Bleaching</td>
<td>Moisture (1300 Kg)</td>
</tr>
<tr>
<td>Filter Aid (30 Kg)</td>
<td>Filtration</td>
<td>Spent Earth with Oil (3.08 MT) D₁</td>
</tr>
<tr>
<td>Nickel Catalyst (100 Kg)</td>
<td>Hydrogenation</td>
<td>Spent Catalyst with Oil (200 Kg) E</td>
</tr>
<tr>
<td>NaOH 40% (90 Kg), Salt (100 Kg), Hot Water (8.5 MT), Activated Earth (225 Kg)</td>
<td>Post Refining</td>
<td>Soap Stock (750 Kg) C₂, Waste Water (8 MT) F₂, Spent Earth (320 Kg) D₂</td>
</tr>
<tr>
<td>Citric Acid (50 Kg), Open Steam (80 MT)</td>
<td>Deodourisation</td>
<td>Odour and Fatty Matter (100 Kg) G</td>
</tr>
<tr>
<td>Packing Material</td>
<td>Packing</td>
<td>Spilled Oil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Product</td>
<td></td>
<td>Unaccounted Losses Of Oil (100 Kg) A₂</td>
</tr>
</tbody>
</table>

95.10 MT

Unaccounted Oil and Water is Due to Monitoring and Analytical Errors.
Table 4.4: Waste Streams and their Management at HVOC, Kanpur.

<table>
<thead>
<tr>
<th>Waste</th>
<th>Nature</th>
<th>Major Characteristics</th>
<th>Quantity</th>
<th>Current Fate</th>
<th>Scope for LWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gums</td>
<td>Sludge</td>
<td>Phosphatides, Neutral Oil</td>
<td>12.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Solid/Acid Oil</td>
<td>Recovery of Phosphatides &amp; Oil</td>
</tr>
<tr>
<td>Soap Stock</td>
<td>Paste</td>
<td>Basic Soap, Neutral Oil</td>
<td>44.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Acid Oil/Soap ETP</td>
<td>Recovery of Neutral Oil</td>
</tr>
<tr>
<td>Wash Water</td>
<td>Liquid</td>
<td>Water having basic pH</td>
<td>80.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ETP</td>
<td>Recycle for Soap Making</td>
</tr>
<tr>
<td>Spent Earth</td>
<td>Solid</td>
<td>Spent Earth with Oil</td>
<td>34.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Sold</td>
<td>Recovery of Oil</td>
</tr>
<tr>
<td>Spent Nickel</td>
<td>Sludge</td>
<td>Nickel Catalyst</td>
<td>2.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Sold</td>
<td>Recovery of Oil and Nickel</td>
</tr>
<tr>
<td>Deodourisation</td>
<td>Liquid</td>
<td>Fatty Acids, Odouriferous Compounds</td>
<td>1.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Mixed with Acid Oil</td>
<td>Recovery of Constituents</td>
</tr>
<tr>
<td>Distillate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deodourisation</td>
<td>Solid</td>
<td>Impurities</td>
<td>3.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Sold</td>
<td></td>
</tr>
<tr>
<td>Filter Residue</td>
<td>Liquid</td>
<td>Oil</td>
<td>1.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ETP</td>
<td></td>
</tr>
<tr>
<td>Packing Spillage</td>
<td>Liquid</td>
<td>Oil</td>
<td>n.a.</td>
<td>ETP</td>
<td>Recycle for Oil Recovery</td>
</tr>
<tr>
<td>Floor Washings</td>
<td>Liquid</td>
<td>Water having basic pH</td>
<td>n.a.</td>
<td>ETP</td>
<td></td>
</tr>
<tr>
<td>Spent Water</td>
<td>Liquid</td>
<td>Water having Acid pH</td>
<td>200.0&lt;sup&gt;b&lt;/sup&gt; ETP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>from Acid Oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging</td>
<td>Solid</td>
<td>Metal &amp; Plastic</td>
<td>n.a.</td>
<td>Sold</td>
<td></td>
</tr>
<tr>
<td>Oxygen from Electrolysis</td>
<td>Gas</td>
<td>Oxygen</td>
<td>n.a.</td>
<td>Sold</td>
<td></td>
</tr>
<tr>
<td>Boiler Ash</td>
<td>Solid</td>
<td>Ash &amp; Coal</td>
<td>n.a.</td>
<td>Sold</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Kg / tonne of <em>vanaspati</em> or refined oil
<sup>b</sup>Kg / 100 tonnes product
Sources of Waste Generation

On the review and inspection of the plant, the following have been identified as the main technical causes which contribute to wastes generation at different stages:

A. Poor housekeeping
   - leaking taps/valves/flanges
   - spillage
   - overflowing tanks
   - manual transportation of materials

B. Operational and maintenance negligence
   - unchecked water / steam consumption
   - unnecessary running of equipments
   - lack of preventative maintenance
   - sub optimal maintenance of process conditions
   - ritualistic operation

C. Poor raw material quality
   - purchase of crude oil with a high content of impurities
   - purchase of low quality (low efficiency) bleaching earth and nickel catalyst
   - poor quality of other process chemicals
   - improper storage of raw materials

D. Poor process / equipment design
   - mismatched capacity of equipment
   - batch process operation
   - maintenance prone design (high maintenance requirements)
   - adoption of avoidable process steps i.e., settling and several washings
   - outdated equipment
E. Poor layout
- unplanned ad hoc expansion
- bad material movement plant

F. Outdated technology
- use of conventional chemical refining methods

Some managerial factors contributing to the waste problem are:

G. Managerial
- management has limited power to suggest remedies to the causes mentioned above (D, E, and F)
- a strong labour union\(^1\) prevents some efforts, specifically regarding A and B above, and
- management is losing interest in addressing waste problems because government tax policies\(^2\) are negatively affecting their competitiveness.

**Costs of the Waste Streams**
In order to assess the profit potential of the waste streams, it is first necessary to assign costs to them. The following are cost components of the waste streams (direct and indirect):
- cost of neutral oil (crude oil) contained in the wastes
- manufacturing cost of materials in waste (including labour costs)
- cost of product in waste
- cost of waste treatment to be in compliance with regulatory requirements
- cost of waste disposal
- cost of waste transport
- cost of maintaining the work environment, and
- cost of due to waste cells
A cost assessment of the various waste streams at HVOC was undertaken. A ranking by the assessed cost identified soap stock, spent earth, spent catalyst, gums and spillage as wastes requiring further study for LWT potential.

V. WORKABLE LWT OPPORTUNITIES

Among the nine waste streams identified at HVOC, the streams which need the utmost attention to address their recovery value are soap stock, spent earth, spent nickel catalyst, gums and oil spillage losses. These waste streams will now be further described, along with their potential for recovery.

Soap Stock
This waste stream is generated in the neutralisation step and is an essential output of the vegetable oil refining unit. It has two major components: soap and neutral oil. Theoretically, the soap should be the only output, but in the process of separating the soap from the rest of the oil, some quantity of neutral oil remains in the soap. At HVOC, batch process neutralisation is used, and the soap is separated from the oil by a settling process. This is a three stage process. The soap stock separated from the various stages, and its major constituents are presented in Table 4.5.

From Table 4.5 it is clear that even in the final stage (Stage III) of separating the neutral oil, the non-separable oil is about 55 percent of the total fatty matter, which results in a lowering of the value of the stream for soap conversion.
Table 4.5: Soap Stock and its Constituents.

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Stage I Neutraliser</th>
<th>Stage II Washer</th>
<th>Stage III Karaha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fatty Matter (TFM), [%]</td>
<td>53.4</td>
<td>43.3</td>
<td>36.4</td>
</tr>
<tr>
<td>Free Fatty Acid (FFA), [%]</td>
<td>35.3</td>
<td>39.8</td>
<td>44.8</td>
</tr>
<tr>
<td>Combined Fatty Matter (CFM), [%]</td>
<td>18.8</td>
<td>17.2</td>
<td>16.3</td>
</tr>
<tr>
<td>[% of TFM]</td>
<td>35.3</td>
<td>39.7</td>
<td>44.8</td>
</tr>
<tr>
<td>Neutral Oil Content (NOC), [%]</td>
<td>34.5</td>
<td>26.1</td>
<td>20.1</td>
</tr>
<tr>
<td>[% of TFM]</td>
<td>64.4</td>
<td>60.3</td>
<td>55.2</td>
</tr>
<tr>
<td>Ratio Neutral Oil: Soap</td>
<td>1.84</td>
<td>1.52</td>
<td></td>
</tr>
</tbody>
</table>

The net loss attributable to unrecovered neutral oil is about Rs 26,000 per day. Improved recovery rates can be accomplished by process modification with installation of additional equipment. A continuous neutralisation unit with a 50 TPD capacity (using centrifugal separation), has already been installed at HVOC and once trial runs are completed, the outcome will be obvious. Based on interviews with Shri Ram Foods and Fertilisers Ltd. (1995), it is expected that the neutral losses will be reduced substantially by this modification. It was concluded (based on interviews) that further work on this particular aspect of waste management using LWT has little importance presently.

**Spent Earth**

The waste material ranking second in order of value is spent bleaching earth. The uncovered value of the oil and spent earth is about Rs 21,000/day. This waste material is currently sold to a local soap manufacturer who specialises in making black soap (popularly known as NIROL soap), at a price of Rs 1,500/MT. This waste stream was identified as having potential for LWT investigation by the current study. The management at HVOC has also expressed concern about this waste stream and the financial loss it represents.
Spent Catalyst
Spent nickel catalyst generated in the hydrogenation step falls in third in order of value. However, since it is a hazardous material, it cannot be disposed of like the spent earth. Currently it is being removed by soap and catalyst manufacturers at a very low rate. The catalyst also has high potential for LWT application, in terms of recovering both the oil and the nickel metal. Due to limitations in resources and time, this work was not pursued by the investigators.

Gums
The gums separated during the degumming process are a source of phosphatides, which are valuable oleochemicals. The recovery of phosphatides from these gums is a workable proposition for HVOC and could be accomplished on-site. However, capital investment is required and therefore phosphatide recovery has not been considered as a focus in this study.

Spillage
Oil spillage is visible to anyone visiting or working at HVOC. The spillage of oil is mainly due to poor housekeeping. Therefore, measures that control and minimise oil spillage at every step of the process are required. A dedicated team of workers along with supervisory staff could be designed for this task. Some innovative suggestions such as rewards to workers and staff for suggestions and measurable reductions, and their involvement in making decisions were made to management. However, being a government undertaking, policy decisions come from the corporate office. Therefore, the implementation of these suggestions may take time.

Others
Deodoriser distillates are contained in the total waste stream at HVOC. The distillates contain a substantial quantity of oleochemicals, which can find good industrial applications.
VI. TARGETED RESEARCH FOR IMPLEMENTATION

Out of the workable LWT opportunities identified, the recovery of oil from spent earth, was selected for further research to explore the possibility of implementation.

The activated earth and carbon (bleaching earth) has a high absorption capacity. During the bleaching operation it not only adsorbs undesirable colouring matter, but also a certain amount of oil. Oil retention can range from 20-40 percent of the spent earth’s weight, depending on the filtration technique used. After its use, the bleaching earth is normally loaded with oil, water, and leachable heavy metals. The environmentally friendly and cost effective disposal of spent bleaching earth is the objective of this research. The technical feasibility of suggested disposal methods will be judged based on the following criteria:

• the kinds of impurities
• the percentage and quality of oil
• the time gap between recovery of oil and the generation of spent earth
• ecological aspects, and
• safety and hazards (spent earth can self ignite).

The utilisation of spent earth has been explored in the past (Zschau, 1994) for:

(a) fuel
(b) cementation furnaces
(c) brick-making
(d) soil improvement
(e) extraction
(f) regeneration
(g) addition to animal food
(h) uses in biogas digesters, and
(i) soap making.
From this list, in-house methods such as recovery of the oil by extraction and soap making have been studied by examining their technical feasibility in terms of the facilities available in the existing plant. In addition, the preferred solution should dispose of the defatted earth without any pollution risk. Oil recovery from spent earth has been attempted using the methods presented below. A consideration of the economic feasibility of the solutions has also been undertaken and is discussed in Section IX.

VII. METHODOLOGY

Solvent Extraction with Petroleum Solvents
Oil was recovered from spent bleaching earth using hexane as a solvent. Solvent extraction is the most technically feasible method as it is already being practised around the world for the commercial recovery of oil from oil bearing materials. The extraction is not difficult on a laboratory scale. On the plant scale, however, palletisation and safe handling of defatted earth have posted some difficulties (Garg, 1995). The recovered oil is inedible and has a high free fatty acid content and a dark colour. Most of the solvent is recovered.

The extraction of oil from the spent earth along with the prepressed oil cake, a by-product of the oil milling industry, is being examined. An advantage of this solution is that the defatted clay may be used as a soil enhancer, along with the organic fertiliser provided by the defatted oil cake. The operating parameters, recovery and quality of oil extracted are described in Table 4.6. It can be seen that on the laboratory scale, the recovery of oil may be as high as 98.5 percent. At full scale, 95 percent recovery has been reported (Shri Ram Foods and Fertilisers Ltd., 1995).
<table>
<thead>
<tr>
<th>Extraction Method</th>
<th>Experimental Optimum Conditions</th>
<th>Process Chemicals</th>
<th>% Recovery of total oil present in spent earth$^1$</th>
<th>Characteristics of oil colour$^1$ (Lovibond 1” cell)</th>
<th>FFA %$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvent extraction</td>
<td>5 - 6 hour steaming</td>
<td>Hexane double the amount of bleaching earth in W/V ratio (Recyclable)</td>
<td>96.6 – 99.5</td>
<td>22.5</td>
<td>11.1</td>
</tr>
<tr>
<td>Extraction by supercritical CO$_2$</td>
<td>8,000 psi 60°C</td>
<td>Supercritical CO$_2$</td>
<td>96.1 – 98.7</td>
<td>22.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Aqueous extraction with Na$_2$CO$_3$</td>
<td>1 hour stirring at 95 - 100°C</td>
<td>5% Na$_2$CO$_3$ solution in equal amount of bleaching earth and H$_2$SO$_4$</td>
<td>14.7 – 15.3</td>
<td>20.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Aqueous extraction with NaOH</td>
<td>1 hour stirring at 95 - 100°C</td>
<td>NaOH, 1/5$^{th}$ to the amount of earth and H$_2$SO$_4$</td>
<td>54.6 – 56.8</td>
<td>20.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Saponification</td>
<td>3 hours 100-120°C</td>
<td>NaOH @ 10% of earth, NaCl</td>
<td>113.0 – 117.3$^2$</td>
<td>22.1</td>
<td>10.0</td>
</tr>
<tr>
<td>Pressure extraction by autoclave</td>
<td>2 hours stirring at 200°C, 220 psi</td>
<td>NaOH 2% by weight of earth</td>
<td>73 – 75.4</td>
<td>20.1</td>
<td>6.0</td>
</tr>
</tbody>
</table>

$^1$Results are the averages over three trials  
$^2$Indicates total soap yield (oil plus alkali material)
Extraction with Aqueous Sodium Carbonate
An aqueous solution of sodium carbonate (Na₂CO₃) was mixed and heated to 95°C. This temperature was maintained for one hour while stirring. The recovery of fatty matter achieved was very low, as is evident from the results presented in Table 4.6.

Extraction with Aqueous Sodium Hydroxide
An aqueous solution of sodium hydroxide (NaOH) was mixed and heated to 95°C, then stirred for one hour at this temperature. The fatty matter recovered on splitting yielded good results, shown in Table 4.6. This process may be utilised at HVOC, as the infrastructure for carrying out the process already exists in the plant.

Pressure Extraction
Splitting of the oil present in spent earth at high temperature and pressure yields an acid oil. The results of the experiments carried out in the laboratory are encouraging. However, additional equipment would be required on-site at HVOC for recovery to be accomplished in this way.

Soap Making
The spent earth purchased from HVOC is currently being used to make a poor quality washing soap. The process is simple, however, experienced workers are needed to successfully carry out the recovery of oil in this way. HVOC is already making washing soap on-site, and they have all the necessary infrastructure.

Therefore, technical viability exists for the recovery of oil from the spent earth, by one of the extraction methods, or by using the resource for by-product (soap) manufacture.
VIII. RESULTS

The results presented in Table 4.6, Table 4.7 and Table 4.8 represent the outcomes of three experimental trials for each of the recovery procedures. The range in reported values was within two percent. These variations are attributable to sampling procedures, variations in experimental operating parameters, quality of extraction chemicals, the time of extraction and of exposure of the sample, the ratio of solvent to earth, and the temperature and pressure adopted for extraction. Oil characteristics were evaluated following Indian Standard procedures (Bureau of Indian Standards, 1988).

Of the five extraction methods, solvent extraction is the most promising. Further work was done with this procedure to determine the relationship of selected conditions to percent recovery of oil. The storage period (before extraction) and the time of extraction were varied. Table 4.7 and Table 4.8 present the recovery rates during these trials. It may be inferred that the storage period plays a role in the quality of extracted oil (in terms of its FFA content and colour). The recovery rates decreased slightly. The investigators concluded that oil extraction from the spent earth should be done as early as possible. Table 4.8 presents the recovery rates obtained during selected recovery times.

IX. ECONOMIC FEASIBILITY

Economic viability is an important parameter in selecting a LWT option. A cost analysis of the technology is an important step to be undertaken before its adoption. All cost considerations, i.e., cost of hardware, working capital cost, operational and maintenance costs, shut down costs as so forth, must be included in the total costing of the technological option. The savings, in terms of inputs (raw materials and energy), operational costs, increased yield of end products, and a reduction in environmental maintenance costs represent the economic attractions of LWT for industry.
Table 4.7: Oil Quality and Recovery from Stored Spent Earth.

<table>
<thead>
<tr>
<th>Storage Period</th>
<th>% Recovery of Oil [%]</th>
<th>FFA [%]</th>
<th>Colour Lovibond 1/4” cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 hours</td>
<td>27.2</td>
<td>6.3</td>
<td>20.0 3.9 4.0</td>
</tr>
<tr>
<td>2 days</td>
<td>26.5</td>
<td>7.6</td>
<td>20.0 6.1 6.6</td>
</tr>
<tr>
<td>3 days</td>
<td>26.2</td>
<td>7.6</td>
<td>20.0 6.1 6.6</td>
</tr>
<tr>
<td>4 days</td>
<td>26.0</td>
<td>7.6</td>
<td>20.0 7.0 4.0</td>
</tr>
<tr>
<td>5 days</td>
<td>25.8</td>
<td>7.9</td>
<td>20.2 7.0 6.9</td>
</tr>
<tr>
<td>9 days</td>
<td>25.5</td>
<td>8.5</td>
<td>20.6 7.0 6.9</td>
</tr>
<tr>
<td>13 days</td>
<td>25.5</td>
<td>10.0</td>
<td>22.2 6.1 5.1</td>
</tr>
</tbody>
</table>

Table 4.8: Variations in Extraction Time Using Hexane.

<table>
<thead>
<tr>
<th>Time of Extraction</th>
<th>Recovery Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 hours</td>
<td>21.0</td>
</tr>
<tr>
<td>4 hours</td>
<td>25.8</td>
</tr>
<tr>
<td>5 hours</td>
<td>26.0</td>
</tr>
<tr>
<td>6 hours</td>
<td>26.0</td>
</tr>
</tbody>
</table>

The costs and savings associated with the oil recovery methods on which actual experimental work was carried out under this project are depicted in Table 4.9.

The required capital investment in terms of plant machinery and other infrastructure. For calculating the operating costs, the costs of raw materials, labour, utilities (power, steam, water, fuel) and costs for interest paid on additional capital investments have been considered.
Table 4.9: Economic Viability of Oil Recovery from Spent Earth.

<table>
<thead>
<tr>
<th>Process</th>
<th>Capital Investment Rs Thousands</th>
<th>“A” Operating Cost of Spent Earth Rs/MT</th>
<th>“B” Recovery/ Saving Oil Rs/ MT</th>
<th>Sale of Deoiled Earth Rs/ MT</th>
<th>“B-A-C*” Net saving Rs 000s/MT</th>
<th>Saving per Year Rs 000s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction with Petroleum Solvent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) In-house</td>
<td>1,000</td>
<td>1,000</td>
<td>3,750</td>
<td>----</td>
<td>1.250</td>
<td>1,275</td>
</tr>
<tr>
<td>(b) Outside</td>
<td>----</td>
<td>800</td>
<td>3,750</td>
<td>1,000</td>
<td>2.450</td>
<td>2,499</td>
</tr>
<tr>
<td>Aqueous Extraction with NaCO₃</td>
<td>----</td>
<td>500</td>
<td>600</td>
<td>----</td>
<td>(1.40)</td>
<td>----</td>
</tr>
<tr>
<td>Aqueous Extraction with NaOH</td>
<td>----</td>
<td>1,000</td>
<td>2,250</td>
<td>----</td>
<td>(0.25)</td>
<td>----</td>
</tr>
<tr>
<td>Autoclave</td>
<td>100</td>
<td>800</td>
<td>3,000</td>
<td>----</td>
<td>0.70</td>
<td>714</td>
</tr>
<tr>
<td>Soap Making</td>
<td>----</td>
<td>2,000</td>
<td>4,500</td>
<td>----</td>
<td>1.00</td>
<td>1,020</td>
</tr>
</tbody>
</table>

*C: Additional operational cost of spent earth @ Rs 1,500/MT
The cost of administrative overhead has not been considered. The estimation of recoveries is based on the percentage of oil and other products recovered from spent earth, with net savings being the recovered value minus operational costs. Prices assigned to the recoverable materials are the prevailing market prices provided by HVOC management.

Assumptions were:
- 300 working days each year
- 3.4 MT of spent earth produced every day, and
- spent earth being approximately 27 percent oil by weight.

The calculations summarised in Table 4.9 are based on the processing of one MT of spent earth. The quantities of oil and soap are the percentage recovery figures previously presented in Table 4.6.

Out of the five options tried and evaluated for the recovery of oil from spent earth, solvent extraction is the most profitable option. The major investment for the firm would be for the main extraction equipment, since other infrastructure and utilities already exist in the plant (HVOC). However, the other option (to have a contract with an off-site solvent extraction unit) is more attractive as it offers a better utilisation of the firm’s resources. The solvent extraction unit currently processing prepressed oil cake will have the option to get processed spent earth along with the oil cake. The de-oiled cake is used as an organic fertilizer, therefore it is reasonable to expect that the de-oiled spent earth will command a similar price. Soap making from spent earth and oil recovery by the autoclave procedure are also appropriate, technically feasible and economically viable options. All the infrastructure and facilities required by these procedures currently exist in the plant, and therefore no additional expenditure would be required to implement these methods. The other methods are not attractive enough in terms of their economic benefits to consider implementing them.
X. IMPLEMENTATION OF CASE STUDY FINDINGS

The case study of HVOC has been able to draw management’s attention by identifying waste streams in terms of their volume and the financial losses they represent. However, even after having the benefits of the suggested LWT demonstrated, management is not eager to implement any of the suggestions. The chief explanation for this attitude is that the plant is currently running far below capacity, due to low sales. Management is therefore preoccupied with boosting their sales and production levels.

CONCLUSIONS

The case study of an edible oil refinery has been able to identify LWT options that integrate environmental and economic considerations. A detailed study of LWT options for handling the identified waste management problems has revealed that soap stock, spent earth and spent nickel catalyst are the key waste streams having potential for resource recovery. The unit’s losses of neutral oil contained in soap stock should be reduced by the newly installed continuous neutralisation equipment. The recovery of oil from spent earth has the potential to provide additional income to the firm. It is hoped that this additional income would be used to make further improvements to environmental conditions at the firm.

ACKNOWLEDGEMENTS

Investigators are thankful to the management and staff of M/S Hindustan Vegetable Oil Corporation Limited, Kanpur and the administration of Harcourt Butler Technological Institute for their cooperation and support provided in carrying out this study.
We are grateful to Shastri Indo-Canadian Institute and the Canadian International Development Agency for providing financial support without which this study would not have been possible.

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INTEGRATING ENVIRONMENT AND ECONOMY:
THE CASE OF THE TANNING INDUSTRY


INTRODUCTION

The leather industry, as both a major source of industrial pollution and an economically important sector, is one of four industries selected for detailed study of the implementation of low waste technology (LWT). The Jajmau area of Kanpur is situated at the southern side of the city, along the bank of the river Ganga. A recent survey revealed that there are 151 registered small and large tanneries in Jajmau (District Industry Centre, 1992). In addition to this number, there may be a few unregistered units discharging their effluents directly into the river Ganga, thus creating environmental problems of dangerous proportions.

The number and capacities of Kanpur tanneries are presented in Table 5.1. The sheer number of these facilities warrants concerted efforts to reduce environmental damage to the river and city. At the beginning of the twentieth century, the level of management skills in local tanneries was not high and administration of the tanning industry was done by the Indian Government. Today, however, Kanpur is an important centre for the production of export quality and other superior varieties of leather.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Size</th>
<th>Number</th>
<th>Capacity (Hides/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Large</td>
<td>17</td>
<td>500 - 800</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
<td>30</td>
<td>300 - 500</td>
</tr>
<tr>
<td>3</td>
<td>Small</td>
<td>45</td>
<td>100 - 500</td>
</tr>
<tr>
<td>4</td>
<td>Cottage</td>
<td>50 - 60</td>
<td>&lt; 100</td>
</tr>
</tbody>
</table>

Table 5.1: Number and Capacities of Kanpur Tanneries.
Source: (Central Leather Research Institute, 1994).
Tanning is an imprecise science and consumes large quantities of water (approximately 40 litres of water per kilogram of hide processed). Table 5.2 and Table 5.3 present estimates of the total liquid and solid wastes currently generated by the industry in Kanpur. It is estimated that approximately 52,000 hides are processed every day in Jajmau, with the hides having an average weight of 35 kg.

I. THE CASE STUDY FIRM

The current study is based on work with one Jajmau tannery. Super Tannery (India) Ltd. was selected for investigation based on the management’s interest and offers of cooperation. Table 5.4 presents employment data drawn from the Super Tannery facility, a well-equipped, modern tannery in Kanpur. Super Tannery started production in 1953 with a capacity of 9,000 hides/annum. An effluent treatment plant was installed in 1984. The current capacity of the unit is 1,000 hides/day, with an annual turnover of Rs 230 million and 1,400 employees. Super Tannery uses both vegetable and chrome tanning processes to produce finished leather. Both processes use cow and buffalo hides as a raw material. Out of the 1,000 hides/day capacity, about 600 hides/day are processed by chrome tanning and 300-400 hides/day by vegetable tanning.
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Operation</th>
<th>Total Volume (m³/day)</th>
<th>Avg pH</th>
<th>Total Solids (mg/L)</th>
<th>Suspended Solids (mg/L)</th>
<th>BOD (mg/L)</th>
<th>Current Practices</th>
<th>LWT Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soaking (veg/cr)</td>
<td>188</td>
<td>9.3</td>
<td>21,200</td>
<td>2,590</td>
<td>1,610</td>
<td>ETP</td>
<td>Reduce Quantities</td>
</tr>
<tr>
<td>2</td>
<td>Liming (veg/cr)</td>
<td>164.5</td>
<td>12.7</td>
<td>48,400</td>
<td>10,330</td>
<td>10,000</td>
<td>ETP</td>
<td>Recover</td>
</tr>
<tr>
<td>3</td>
<td>Deliming (veg/cr)</td>
<td>114.9</td>
<td>8.0</td>
<td>5,870</td>
<td>1,390</td>
<td>1,520</td>
<td>ETP</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Tanning (veg/cr)</td>
<td>392.8</td>
<td>5.8</td>
<td>31,800</td>
<td>3,510</td>
<td>19,290</td>
<td>Recycling &amp; Recovery</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Samming (cr)</td>
<td>36.2</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>ETP</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Bating (cr)</td>
<td>377.3</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>ETP</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Rechroming (cr)</td>
<td>90.0</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>Chrome Recovery</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Suspender (veg)</td>
<td>78.9</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>ETP</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Washing (veg)</td>
<td>125.0</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>ETP</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Fat liquoring &amp; dyeing</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>Some Recycle, ETP</td>
<td>More Recycling</td>
</tr>
</tbody>
</table>

veg: Vegetable tanning cr: Chrome tanning ETP: Effluent Treatment Plant n.a.: not available

Table 5.2: Liquid Waste Generated from Kanpur Tanneries.
Source: (Super Tannery, 1993)
Table 5.3: Solid Wastes Generated from Kanpur Tanneries.
Source: (Super Tannery, 1993).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Operation</th>
<th>Total Waste (Tons/day)</th>
<th>Nature</th>
<th>Current Practices</th>
<th>LWT Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trimming (cr+veg)</td>
<td>5.0</td>
<td>Head pieces, hooves, tails, trimmings, etc.</td>
<td>Glue manufacture, animal feed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fleshing (cr)</td>
<td>9.0</td>
<td>Extra meat and adipose tissue</td>
<td>Vegetable fleshing for glue making</td>
<td>Utilisation of chrome fleshing</td>
</tr>
<tr>
<td>3</td>
<td>Shaving (cr)</td>
<td>0.9</td>
<td>Shaving dust</td>
<td>Leather board</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Splitting (cr)</td>
<td>4.2</td>
<td>Grain and flesh side cuttings</td>
<td>For low quality leather processing</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Tanning &amp; drying (veg)</td>
<td>36.03</td>
<td>Non-tannin brown powder</td>
<td>Fuel</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ETP</td>
<td>n.a.</td>
<td>Sludge</td>
<td>Landfill &amp; fertilizer</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Boiler</td>
<td>n.a.</td>
<td>Ash</td>
<td>Landfill</td>
<td></td>
</tr>
</tbody>
</table>

veg: Vegetable tanning   cr: Chrome tanning   n.a.: not available
Table 5.4: Employment Data, Super Tannery, Kanpur.
Source: (Super Tannery, 1993).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Category</th>
<th>Total Number of Employees</th>
<th>Average Wage (Rs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Administrative Staff</td>
<td>130</td>
<td>n.a.</td>
</tr>
<tr>
<td>2</td>
<td>Skilled Workers</td>
<td>180</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>Semi-skilled Workers</td>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>Unskilled Workers</td>
<td>400</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>Casual Labourers</td>
<td>600</td>
<td>contract basis</td>
</tr>
</tbody>
</table>

II. DATA COLLECTION

The methodology adopted in the study includes data gathered during personal interviews with the production and administrative staff of the firm. Information on manufacturing processes and estimation of waste stream volumes is based on literature review and the observations of the investigators.

III. THE MANUFACTURING PROCESS

Leather processing is done in two main steps: lime yard operations and tan yard operations.
**Lime Yard Operations**
In the lime yard section, raw buffalo hides are trimmed to remove hooves, tails, and head pieces. The trimmed hides are then soaked in water to remove dirt, salt, blood, manure and proteins. Liming, which results in dehairing and swelling of the hide, is the next operation in this section. Liming is followed by fleshing to remove adipose tissue, fat glands and muscle from the hide. The hides are then delimed using ammonium chloride (NH₄Cl) and water.

**Tan Yard Operations**
After liming, the hides undergo bating using enzymes and other bating agents. The hides are then treated with sodium chloride (NaCl) and sulfuric acid (H₂SO₄) for pickling. After bating and pickling, the hides are tanned with vegetable or chromium tanning solutions, in ratios that depend on the end use of the leather and the market demand. Vegetable tanning uses vegetable tanning agents such as *babul* bark powder and *barra*, while chrome tanning uses basic chromium sulphate. After chrome tanning the hides are basified (rendered alkaline) using sodium bicarbonate. The hides are known as wet blue after this step because of their pale blue colour. After the wet blue stage, a variety of finishing operations are performed, including fat liquoring, padding, buffing, splitting and shaving, etc. The steps in chrome and vegetable tanning are presented in Figure 5.1 and Figure 5.2 respectively (see also Appendix 4 in El-Tayeb et al. in this volume).

**IV. DESCRIPTION OF WASTE STREAMS**
Waste generation is an integral part of the tanning process. A pictorial depiction of the liquid effluent and solid waste generation during the tanning process appears in Figure 5.3. In India much work has been accomplished by the Central Leather Research Institute (CLRI) on cleaner technology development (reduction, reuse and recycling of process wastes). Indian tanneries are becoming aware of these developments and the opportunities they present in terms of environmental and economic benefits.
Figure 5.1: Process Flow Diagram (Chrome Tanning).
Figure 5.2: Process Flow Diagram (Vegetable Tanning).

Diagram description:
- Raw Hides → Trimming
- Trimmings → Soaking → Lime fleshing → Scudding & screening → Selected hides → Deliming
- Deliming → Waste water
- Lime fleshing → Waste water
- Soaking → Liming
- Liming → Waste water
- Knives → Fleshing
- Fleshing → Waste water
- Water/NH·Cl
- Deliming → Waste water
- Scudding & screening → Selected hides
- Selected hides → Deliming
- Deliming → Waste water
- Knives → Fleshing
- Fleshing → Waste water
- Water/NH·Cl
- Light tan liquor
- Suspending → Waste water
- Tanning → Waste water
- Tanning → Waste water
- Tanning → Waste water
- Heat
- Drying → Solid waste
- Drying → Waste water
- Water In chambers
- Setting → Rolled hides
- Evaporation
- ETP
- Vegetable tan leather


Figure 5.3 Waste Arising from Tanning Process.
Source: (Van Vliet, 1994).

- **One ton raw hide** gives **200 kg leather**
- **50 cubic meters liquid effluents**
- **120 kg** Raw trimmings
- **100 kg** Trimmings & shavings
- **115 kg** Blue shavings
- **70 to 230 kg** Fleshings
- **2 kg** Buffing dust
- **22 kg** Trimmings
- **2 kg** Buffing dust

**UNTANNED**
- **120 kg** Raw trimmings
- **100 kg** Trimmings & shavings

**TANNE**
- **115 kg** Blue shavings
- **70 to 230 kg** Fleshings

**DYED/FINISHED**
- **2 kg** Buffing dust
- **22 kg** Trimmings

Solid wastes & by-products:
- **COD** 235-250 kg
- **BODS** c 100
- **Suspended solids** c 150
- **Chromium** 5 – 6
- **Sulphide** c 10
Work done on cleaner production in India and worldwide is described in the literature (Rajamani et al., 1994). Work done for utilisation of leather by-products is illustrated in Figure 5.4. Both solid and liquid wastes are generated during hide and leather processing. A detailed analysis of each stream is presented below.

**Solid Waste**

In the trimming operation, hooves, tails and headpieces are separated from the hides. These trimmings are a potential source of protein, and can be used for glue and other products.

Waste hair and flesh (fleshings) are generated during the liming and fleshing operations. The fleshings are of two types: fleshings from hides in the vegetable tanning stream and those from hides in the chrome tanning stream. Fleshings from the vegetable process are non-toxic and are suitable for glue conversion and the production of an animal feed supplement. The fleshings from the chrome tanning stream contain residual sulphides (from liming) and are therefore not suitable for glue making or feed. There is very little market for these ‘chrome fleshings’ and most of this material is discarded in the open land area of the tannery. Chemicals from the discarded fleshings can leach into surface and ground waters, and the solid material also attracts vulture, flies and other pests to the work environment.

Waste *babul* bark and other vegetable materials from the vegetable tanning section is dried to a dark brown coloured powder on roads and streets and in open yards. Indeed, its appearance identifies the presence of the vegetable tanning industry. After drying, this powder can be used for fuel and therefore has a market value. Splits (the less desirable side of the split hide) are valuable solid ‘wastes’ and are used in manufacturing a lower quality of leather. Shavings dust, another by-product of the finishing process, is utilised by the leather board industry.

Finally, a large volume of sludge is generated by the operation of the facility’s effluent treatment plant (ETP). Boiler ash represents another solid waste. The sludge and ash are currently land filled or used as fertiliser.
Figure 5.4: Technological Options for By-product Utilisation.
**Liquid Waste**

Liquid waste (wastewater) is generated in both the lime yard and the tan yard sections. The characteristics of these wastewater streams are presented below:

Wastewater Stream I: The largest volume of wastewater is generated during hide soaking. This stream contains high levels of solids, blood, manure, soluble protein and salts and is drained directly to the ETP.

Wastewater Stream II: The second largest source of wastewater (in terms of volume) is the liming operation. Residual liming chemicals such as lime and sodium sulphide (Na₂S) render this stream highly alkaline. This waste stream typically contains soluble proteins, suspended solids, hair and high BOD and is also currently drained to the ETP.

There are LWT opportunities for this wastewater, including recycling it to the liming bath. Another option is the recovery of dissolved sulfides. This practice, although documented in other countries (Yi and Tian, 1987; No author, 1992) has not been widely adopted in India since liming chemicals are inexpensive.

Wastewater Stream III: This waste stream is generated during the deliming stage, where hides are delimed with NH₄Cl to remove the chemically and mechanically deposited lime. This effluent is also drained to the ETP.

Wastewater Stream IV(a): Spent chrome liquor is generated in the chrome tanning section. This material has a green colour and an offensive odour. Similar wastewaters are also generated during the rechroming stage (the second stage of chrome tanning). In Super Tannery, spent chrome liquor is processed to recover a solid chromium compound. The remaining liquid is drained to the ETP.

Wastewater Stream IV(b): This stream is generated in the vegetable tanning section. Some of the water from the vegetable tanning pits is reused. The acidic wastewater from the suspender and washing operations is drained to the ETP.
Wastewater Stream V: Forty percent of the water remaining in the hides is removed by samming. This stream also drains to the ETP.

Wastewater Stream VI: In the fat liquoring and dyeing sections, hides are processed with fat liquor, water, and dye solutions in order to improve their physical properties (elasticity, softness, and so forth). After these operations, the resulting alkaline, coloured spend liquor is drained to the ETP.

Staff of the Super Tannery estimate that their total water requirement is approximately 1,600 m$^3$/day. Of this, it is possible to account for 1567.6 m$^3$/day as wastewater. A total of 55.13 tons/day of solid wastes are also produced.

The total quantities and characteristics of wastes have been presented in Table 5.2 and Table 5.3, and include current waste management practices and LWT possibilities.

Material balances for chrome tanning and vegetable tanning are presented as Figure 5.5 and Figure 5.6 respectively. The quantities of raw materials, chemical inputs, wastes and finished products are based on processing a total of 1,000 hides per day.

V. PROBLEM IDENTIFICATION

Process analysis and construction of material balances identifies important waste and by-product streams. The liquid waste streams and fleshings from the chrome tanning process were identified as waste streams having potential for LWT. Among LWT options, the reduction of effluent volume has great potential for the firm. In most of the firm’s unit operations the consumption of water is higher than the standard norms (Rajamani et al., 1994).
Figure 5.5: Material Balance (Chrome Tanning).

<table>
<thead>
<tr>
<th>Input</th>
<th>Unit Operation</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.6 T solid &amp; 4m³ moisture</td>
<td>Raw hides</td>
<td>(B) for 600 hides</td>
</tr>
<tr>
<td>Knives</td>
<td>Tanning</td>
<td>3T Trimmings</td>
</tr>
<tr>
<td>Water 126m³</td>
<td>Soaking</td>
<td>112 m³ wastewater</td>
</tr>
<tr>
<td>Water 186m³, Lime 1.56 T, Na₂S 0.69 T</td>
<td>Liming</td>
<td>98.7 m³ wastewater</td>
</tr>
<tr>
<td>Knives</td>
<td>Fleshing</td>
<td>4.5 T fleshing</td>
</tr>
<tr>
<td>Water 242.7m³, Enzymes (CN/A)</td>
<td>Deliming</td>
<td>67.2 m³ water, 4.4 T solid (lime, NH₄Cl, Na₂S)</td>
</tr>
<tr>
<td>NH₄Cl 2.7 T Water 121m³</td>
<td>Bating</td>
<td>(377.3 m³) wastewater, deliming &amp; bating</td>
</tr>
<tr>
<td>BCS 7.2 T Water 121.3 m³</td>
<td>Tanning</td>
<td>90 m³ wastewater</td>
</tr>
<tr>
<td>m/c</td>
<td>Samming</td>
<td>(36.2 m³) wastewater as moisture removal</td>
</tr>
<tr>
<td>m/c</td>
<td>Splitting</td>
<td>4.2 T solid wastewater + 14.6 m³ moisture</td>
</tr>
<tr>
<td>m/c</td>
<td>Shaving</td>
<td>0.9 T shaving dust + 14.6 m³ moisture</td>
</tr>
<tr>
<td>BCS 7.2 T Water 121.3 m³</td>
<td>Rechroming</td>
<td>90 m³ wastewater</td>
</tr>
<tr>
<td>Dyes 1m³ Fat liquor 1 T</td>
<td>Dyeing &amp; fat liquoring</td>
<td></td>
</tr>
<tr>
<td>Heat</td>
<td>Drying</td>
<td>38.1 m³ water evaporated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.25 T leather</td>
</tr>
</tbody>
</table>
Figure 5.6 Material Balance (Vegetable Tanning).

<table>
<thead>
<tr>
<th>Input</th>
<th>Unit Operation</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw hides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knives</td>
<td>Tanning</td>
<td>2T Trimmings</td>
</tr>
<tr>
<td>(14.0) ton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water 84 m³</td>
<td>Soaking</td>
<td>75 m³ wastewater</td>
</tr>
<tr>
<td>(12.0) ton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water 124 m³</td>
<td>Liming</td>
<td>65.8 m³ wastewater</td>
</tr>
<tr>
<td>Lime 1.5 T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knives</td>
<td>Fleshing</td>
<td>3.6 T lime fleshing</td>
</tr>
<tr>
<td>(81.3) ton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄CL 2.02 T</td>
<td>Deliming</td>
<td>47.76 m³ waste tan liquor</td>
</tr>
<tr>
<td>Water 80 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veg. tanning 12.13 T</td>
<td>Suspender</td>
<td>47.76 m³ waste tan liquor</td>
</tr>
<tr>
<td>Water 80 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veg. tanning 12.13 T</td>
<td>Tanning pits</td>
<td>151.29 m³ waste liquor</td>
</tr>
<tr>
<td>Water 168 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veg. tanning 12.13 T</td>
<td>Tanning drums</td>
<td>151.29 m³ waste liquor</td>
</tr>
<tr>
<td>Water 168 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water 80 m³</td>
<td>Washing</td>
<td>151.29 m³ waste liquor</td>
</tr>
<tr>
<td>Heat</td>
<td>Drying</td>
<td>125 m³ waste water</td>
</tr>
<tr>
<td>(13.95) ton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leather</td>
<td></td>
<td>98.7 m³ vapours</td>
</tr>
</tbody>
</table>
Handling and treatment costs of effluents could be lowered by reducing the volume of liquid effluents from the liming, soaking and washing steps. The recovery of valuable materials from one waste stream is already being practised at the case study firm. A chromium recovery plant installed with technical assistance from the CLRI and an Indo-Dutch cooperative project is functioning well. The recovery of sulphide, as mentioned earlier, is not economically attractive.

Fleshings represent the major solid waste material generated by the tanning industry. Fleshings obtained from vegetable tanning have long been used as a raw material for glue manufacturing. A survey by the investigators determined that the current market price received by selling these fleshings to the glue industry is about Rs 400-500/tonne. Fleshings generated from the chrome tanning stream, on the other hand, command only Rs 25/tonne. The main reason for the low price of chrome fleshings is their contamination by sulphide, which results in a poor recovery of a low grade glue with many impurities. The presence of sulphides also affects the neutralisation process of glue making as hydrogen sulphide gas is evolved (Dvakaran, 1984). In spite of serious efforts by the CLRI, Uttar Pradesh, Jal Nigam and other pollution control agencies, the utilisation of chrome fleshings remains a problem. Solving this problem would involve removal of the sulphides introduced during the liming process.

Super Tannery currently generates six tonnes of chrome fleshings each day. This substantial quantity justifies the selection of this waste for further investigation. Most of the solid wastes and by-products from the firm are currently being sold for further use to small cottage industries in the nearby area. The technical and economic viability of removing sulfide from fleshings was studied to improve the firm's profitability and enhance pollution control efforts.

VI. EXPERIMENTAL INVESTIGATIONS

Materials
Samples of fleshings were collected from Super Tannery. The samples were sun-dried before treatment. Laboratory reagent grade arsenous oxide, sublimed iodine, sodium bicarbonate, potassium iodide, starch, Na(OH)₂, sodium hydroxide pellets, hydrochloric acid, phenolphthalein, phenol, copper sulphate, ammonium sulphate, sulphuric acid, boric acid, potassium sulphate, bromocresol green, methyl red and hexane were used for this study.
Description of Approach
A set of experiments was conducted to characterise the fleshings. Ash, moisture, protein and fat contents were determined (Sarkar, 1981). The sulphide content in the chrome fleshings was also evaluated for further study (Sarkar, 1992). Experiments conducted to remove sulphide from the chrome fleshings included investigating the effects of varying reaction conditions (strength of hydrochloric acid, length of reaction time and the volume of acid used). Preparation of glue from treated and untreated chrome fleshings (Divakaran, 1984) permitted a comparison of the glue yields. A visit to a local glue manufacturing unit was also undertaken by the investigators to observe the glue making process being applied at full scale.

The moisture and sulphide contents of the samples were determined using standard methods (Sarkar, 1992). Sulphide removal was achieved using the principle of alkaline absorption of sulphides (as H$_2$S) by acid treatment. By treating them with hydrochloric acid, sulphides are converted into hydrogen sulphide which can be absorbed into alkaline solution.

Apparatus Used for Sulphide Removal from Chrome Fleshings
A diagram of the apparatus used for the sulphide removal experiments is shown in Figure 5.7. The apparatus included a vacuum flask for holding the fleshings during treatment. The flask had a rubber cork with one hole to accommodate a funnel used to feed HCl to the flask. The flask was connected to a second flask by 1/4” rubber tubing. The tubing conveyed the H$_2$S gas generated in the first flask to the second flask. Flask no. 2 was fitted with a rubber cork with two holes to accommodate the rubber tubing and a 1/4” glass tubing leading to a stoppered funnel used for the introduction of NaOH.

Apparatus Used for Glue Preparation
For preparing glue on a laboratory scale, a two-mouth flask was used to digest the fleshings with water. This flask was placed on a heating element and one mouth was used for the insertion of a thermometer. The other mouth of the flask was fitted with a stuffing box (B24) for a Teflon stirrer. Stirring was accomplished using a Remi stirrer motor equipped with a regulator.
Figure 5.7: Alkaline Absorption of Sulphides as Hydrogen Sulphide from Fleshings by Acid Treatment.
The assembly is depicted in Figure 5.8. A flow diagram describing the complete glue recovery process (starting with the chrome fleshings), is presented in Figure 5.9.

Procedure for Sulfide Removal from Chrome Fleshings
Chrome fleshings were sun dried. The ambient temperature was from 35-45°C. A 10 g sample of sun dried chrome fleshings was obtained and treated with dilute HCl solution. The flask was then left for a suitable time to remove sulphide. Next, the flask was heated gently so that sulfides were evolved in the form of H$_2$S gas. The gas was absorbed by 25 mL of NaOH solution in flask 2.

Procedure for Glue Preparation
The fleshing sample was limed for fat extraction and then neutralised by adding dilute HCl until the pH reached 7.5. After a thorough washing with water, this sample was placed in the two-mouth flask. The sample was stirred constantly for four hours while maintaining a temperature between 60-80°C (accomplished by a heating element). The sample was then mixed with 4 mL of CuSO$_4$ and 2 mL of phenol (for preservation). The prepared glue was transferred to a beaker and left for two days in order to settle out the fats and heavy particles. The glue was then filtered into a tared beaker and dried in a drying oven. Finally, the prepared glue was weighed to calculate the glue yield from the process.

VII. RESULTS

The results of the characterisation of chrome and vegetable fleshings are presented in Table 5.5. It is clear from Table 5.5 that chrome fleshings contain higher moisture and ash contents and reduced quantities of protein when compared to the vegetable fleshings. Residual sulphide from the liming process are also present in the chrome fleshings. The possible reason for the higher moisture content in chrome fleshings is that the proteins have been attacked by sulphide, releasing water (Sarkar, 1981). The effects of changing reaction conditions such as acid quantity, acid concentration and treatment time are presented in Table 5.6.
Figure 5.8: Experimental Setup for Glue Preparation.
Figure 5.9: The Process of Glue Preparation.

1. Add water 25 mL
2. Digestion 70-75°C 1 hr
3. Sulphide removal
4. Neutralisation pH=7.5 60-70°C 2 hrs.
5. Washing
6. Fat extraction
7. Sodium Carbonate
8. Fleshing
9. Washing
10. Water
11. Fat extraction
12. Settling
13. Oven drying
14. 80°C 1 hr
15. 60-70°C 2 hrs.
Table 5.5: Characteristics Of Sundried Fleshings.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Vegetable Fleshings</th>
<th>Chrome Fleshings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Content</td>
<td>9.1%</td>
<td>11.2%</td>
</tr>
<tr>
<td>Sulphide Content</td>
<td>----</td>
<td>1.2%</td>
</tr>
<tr>
<td>Fat Content</td>
<td>4.9%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Protein Content</td>
<td>29.4%</td>
<td>25.7%</td>
</tr>
<tr>
<td>Ash Content</td>
<td>56.6%</td>
<td>57.7%</td>
</tr>
</tbody>
</table>

Glue Recovery

1. Glue recovery from vegetable fleshings: 23.5 percent.
2. Glue recovery from untreated chrome fleshings: 15.16 percent.

Glue recovery from treated fleshings during the bench tests was approximately 21 percent. To see the effectiveness of the procedure adopted for sulphide removal, glue yields from treated and untreated chrome fleshing samples were compared. The recovery of glue from untreated fleshings was 15 percent. The results obtained are encouraging to the extent that the percentage of recovery increased to 21 percent from 15 percent. The process needs more investigation to optimise the conditions so that 23.5 percent recovery percentage available from vegetable fleshings is approached. Improved recovery rates may increase the price obtainable for chrome fleshings, which would have positive implications for tannery economics.
Table 5.6: Sulphide Content of Chrome Fleshings after Acid Treatment

<table>
<thead>
<tr>
<th>Acid Quantity</th>
<th>175 mL</th>
<th>150 mL</th>
<th>100 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Time</td>
<td>24 hours</td>
<td>12 hours</td>
<td>6 hours</td>
</tr>
<tr>
<td>Acid Strength</td>
<td>0.1 N</td>
<td>0.2 N</td>
<td>0.3 N</td>
</tr>
<tr>
<td>Sulphide Content&lt;sup&gt;1&lt;/sup&gt;[g]</td>
<td>0.0806</td>
<td>0.0045</td>
<td>Nil</td>
</tr>
</tbody>
</table>

<sup>1</sup>Sulphide content remaining in the fleshings. The initial sulphide content was 0.12 g in a 10 g sample.
CONCLUSIONS
This study profiles the wastes generated from the case study. A process analysis, material balance and waste quantification provided information to assist in the identification of potential LWT options. The investigation has been greatly assisted by the firm’s awareness and activities by agencies such as the CLRI.

The current study examined the technical feasibility of using sulphide contaminated fleshings for glue production. The process developed for sulphide removal allowed for an experimental glue yield comparable to that of non-contaminated (‘vegetable’) fleshings. In the event that findings can be replicated and applied at full scale, they will provide an example of how environmental and economic concerns may be integrated and addressed in this industry.

ACKNOWLEDGEMENTS
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REFERENCES

INTRODUCTION

Urban environmental problems are quite evident in the municipality of Kanpur. Pollution of air, surface and ground waters, inadequate sanitation, congestion, unsafe and erratic supply of drinking water and improper and inadequate solid waste management are common and are seen in their worst forms.

Jajmau is a suburban area of Kanpur with an area of about 960 hectares, located at an average altitude of 122.5 metres above mean sea level. In 1981 the population was 79,700. A 1987 survey estimated the population to be 105,000.

The Indo-Dutch Environmental and Sanitary Engineering Project (IDP) executed in the Jajmau area was a bilateral cooperation project of the Indian and Dutch governments (UCD Project, 1994). The IDP project was part of the Ganga Action Plan, and its principal goal was to clean-up the river Ganga. The other important goal was to improve urban living conditions in the Jajmau area. The project was initiated in 1987 and was nearing completion at the end of 1994. There were several reasons for the selection of Jajmau as the project area for the IDP. Prominent among them was that Jajmau represented the most neglected and environmentally damaged zones of Kanpur. Jajmau is home to about 150 tanneries, one of the biggest tannery clusters in the world. The geography of the area is also peculiar. Jajmau is sandwiched between military cantonments and an air force base on the north and south, and the river Ganga and the Grand Trunk Road on the east and west.
The pre-project situation of the Jajmau area was so bad that isolated approaches for environmental improvement would have made an insignificant impact on the overall environment. It was also clear from the outset that the success of the project would depend largely on the attitude of the community. If there was adequate community participation in the execution of these schemes, then the success and sustainability of the projects would be better assured. It was also important that, where available, low-cost options would be used. Therefore, it was decided early on to implement an integrated approach for environmental improvement in the area.

Under the integrated approach the following schemes were undertaken:

1. improvement of sanitation
   - rehabilitation of existing sewers
   - expansion of the domestic sewerage system
2. improvements of the water supply system
   - boring of hand pumps under the ‘crash programme’
   - rehabilitation of existing water supply
   - laying of new lines, water generation and storage facilities
3. improvement of the storm water drainage system
4. treatment of domestic and industrial wastewater
5. treatment and disposal of solid wastes, and
6. community participation and public health.

It is worth pointing out that the idea of an integrated approach in 1987 is consistent with the approach taken up in Agenda 21 of the Rio Conference in 1992.
I. PRE-PROJECT SITUATION

Historically, Jajmau is divided into two zones. The northern industrial zone, bordering the river Ganga, is the oldest inhabited part and is where about 200 industries are located. The southern part, which consisted originally of isolated rural villages is now a residential zone.

The Jajmau area is now officially classified into five distinct categories:

- Industrial slums,
- Qualified slums,
- Urban villages,
- Residential areas with commercial activity, and
- Developed residential areas.

**Industrial slums:** Industrial slums are located in the northern part of Jajmau. The northern part is the site of about 200 tanneries, glue, rubber, leather board and chemical factories. The slums are located between the industrial sites, with the residents working primarily in the tanneries. In general, the environmental and sanitary status of these areas was extremely bad. Most of these slums did not even have a minimum level of public services.

In the absence of any proper system for water supply, sanitation, and solid waste management, the discharge from the tanneries created water logging problems in the industrial slums, polluting the ground water and water supplies and gave rise to epidemics like cholera and diarrhoea. The solid waste from tanneries was also a potential source of groundwater as well as particulate pollution. In some slums there were few existing roads, and in the absence of a drainage system, most of these roads remained waterlogged throughout the year. Water was generally obtained from a nearby tannery, or from distantly located wells or public stand posts. The practice of open-field defecation was common, while some people had dry latrines in their houses.

**Qualified slums:** In the south of Jajmau, *Ganga Ganj, Kali Bari and Shiv Katra* are classified as legalised slums or “qualified slums”. This gives residents the right to access urban environmental services. The residents for the most part work in low income jobs such as sweepers, construction labourers, and rickshaw pullers. Sanitation and water supply facilities existed in these areas but were inadequate for the needs of the population.
Urban villages: Jajmau has several partly-developed urban villages which still retain some rural characteristics. In fact, Jajmau’s growth evolved from these historically isolated villages. Villages such as Ompurwa, Pokharpurwa, Gaushala, Chabila Purwa, Wajidpur, Charari and Pardwan Purwa have maintained some of their cultural identity and traditional skills. These villages had some infrastructure in place such as roads, lighting and sanitation facilities.

Residential areas with commercial activity: Residential areas, because of their central location and advantageous proximity to the main road, have developed into prosperous commercial areas. Houses facing the roads have become locations for commercial activities while others were still used for residential purposes. The infrastructure facilities were better and these areas were predominantly occupied by people of middle income class.

Developed residential areas: These are the planned residential areas developed by the Kanpur Development Authority. They were designed for people of mixed income levels, i.e., economically weaker section (EWS), low income group (LIG), and medium income group (MIG). At the beginning of the project, the J.K. Colony was fully occupied, while the K.D.A. Colony was only partially occupied. The occupied houses belonged mainly to the LIG. Those designated for EWS remained vacant as the infrastructure provided for them was rarely functional. According to the baseline survey done in 1987-88 (IDP, 1988), the status of housing was as follows: Pucca houses, 68%, Kuttcha houses, 24% and Semi Pucca houses 8%
Sanitary Status:
A baseline survey carried out in April 1988 to ascertain the sanitary status of the community gave the following picture of the respondents:

- Households with their own latrines: 59%
- Households using public latrines: 9%
- Households practicing open-field defecation: 31%
- No information: 1%

Since there was no proper system for solid waste management, garbage was simply thrown out onto the roads. The sweepers collected the garbage and brought it to intermediary dumping points on the roadsides. From there it was collected by trucks to be ultimately dumped at sanitary landfill sites.

Water Supply Status
The same baseline survey (IDP, 1988) revealed the following data:

- Households dependent on public water source: 56%
- Households with their own water source: 44%

Breakdown of household water sources:
- Private tap connection: 50%
- Hand pump: 10%
- Well: 5%
- Other (pond, river, nearby industry): 35%

A leak detection survey carried out in the Gaushala village pilot area indicated that 43 percent of water was being wasted through leakage. About 90 percent of household water connections were illegal.

Economic Status
The 1988 baseline survey also gathered information on the financial situation of the target population. It gave an idea of the community’s income and an insight into the scope for involving the community in the operation and maintenance of new facilities.
The distribution of the monthly earnings pattern for Jajmau is shown in Table 6.1. The poverty line in terms of annual income was 6,400 rupees (533 rupees or $18 U.S. per month). For the poorest of the poor the annual income was 3,500 rupees (291 rupees or $10 U.S. per month).

<table>
<thead>
<tr>
<th>Area Category</th>
<th>0 – 300 Rs (%)</th>
<th>300 – 600 Rs (%)</th>
<th>600 – 1000 Rs (%)</th>
<th>1000 – 1500 Rs (%)</th>
<th>1500 – 2000 Rs (%)</th>
<th>&gt;2000 Rs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Slums</td>
<td>6.1</td>
<td>51.6</td>
<td>26.7</td>
<td>11.4</td>
<td>2.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Qualified Slums</td>
<td>0.0</td>
<td>36.6</td>
<td>26.6</td>
<td>33.3</td>
<td>0.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Urban Village</td>
<td>1.4</td>
<td>20.8</td>
<td>33.3</td>
<td>20.8</td>
<td>11.1</td>
<td>12.5</td>
</tr>
<tr>
<td>Residential Area</td>
<td>3.5</td>
<td>15.6</td>
<td>26.6</td>
<td>22.6</td>
<td>20.4</td>
<td>11.3</td>
</tr>
<tr>
<td>Developed Residential Area</td>
<td>1.1</td>
<td>10.5</td>
<td>28.0</td>
<td>24.3</td>
<td>20.1</td>
<td>16.0</td>
</tr>
<tr>
<td>% of Total Population (Jajmau)</td>
<td>3.7</td>
<td>27</td>
<td>27.1</td>
<td>19.3</td>
<td>13.6</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Health Status
The area had a very poor health-care infrastructure. The majority of the population relied on unqualified private medical practitioners. Health services for mothers and children were especially lacking. There was only one Mother and Child Health (MCH) centre for the whole area. The majority of deliveries were assisted by untrained traditional birth attendants.

Tannery workers, as a group, are exposed to various occupational health risks. However, before the project, only regular workers were covered by Employee’s State Insurance (ESI).
**Social Status**

In the industrial slums, most of the workforce are engaged in some way by local industry. Many of these workers, originally from eastern Uttar Pradesh and the adjoining state of Bihar, migrated to Kanpur in search of employment.

The population in general was not socially organised for two reasons. The diversity of social backgrounds and the socio-political forces at play inhibited any type of community organisation. Most of the slums are located either on government or privately-held land. The population was generally sceptical about the security of their occupancy, fearing eviction by local strong men. These local men are usually people involved in politics or their henchmen. Votes for the slums are vital for any political party. Thus, on the eve of elections, it is normal for illegal slums to get recognised as qualified slums. Without such recognition, slum residents are not in a position to ask agencies for any urban environmental improvement services.

In the qualified slums, urban villages and residential areas with commercial activity, people are usually related to each other because of their long history of association and of living in the same area together. In none of the qualified slums, however, were the communities formally organised. In general, there was little communication among the agencies involved in the development and maintenance of urban infrastructure. Aside from incidents of stoning of the local water supply office by the community during the summer peak season, there was no evidence to indicate the organisation of the local community. The communities in these areas were demanding change, but their energy was not effectively channelled, due to their lack of organisation.

In the developed residential areas there was also not much social interaction within the community. In general, people were not satisfied with the existing situation but were not sure whether their efforts to get improvements would be of any use. The condition of women was pathetic as they were the worst victims of poor urban facilities.
Water collection was from distantly located water sources, and because of a shortage of private and community latrines open-field defecation was common. Most working women were either employed as household aids or as construction labourers. Some women worked as leather hunters and in the production of other leather goods, under very exploitive conditions.

II. INDO-DUTCH PROJECT

Objectives and Methodology
The main objectives of having a socio-economic unit (SEU) established under the IDP for mobilising the community in Jajmau area were:

- to ensure that priority for implementation of any scheme is given to the most environmentally backward areas.
- to ensure the participation of the local community in the planning, implementation, operation and maintenance of the infrastructure being provided under the scheme,
- to implement the schemes in terms of the identified needs, perceptions and attitudes of different categories of the population with respect to their income levels, social status and gender, and
- to ensure the health of the community in general and the health of industrial workers in particular through the identification of occupational health hazards in industry and the implementation of curative and preventative interventions.

To implement the environmental and sanitary engineering projects with active community participation, direct and indirect approaches were followed (see Figures 6.1 and 6.2).

For the involvement of the community in the execution of schemes directly related to their day-to-day life, direct communication channels were established with the community.
Figure 6.1: Direct Approach.
Figure 6.2: Indirect Approach.
Where the communities played a very active and decisive role, implementation of schemes to improve water supply, sanitation and solid waste management was successful. From within the community, a few relatively more active people were trained as change agents or intermediaries.

For the specialised field of health, an indirect approach was followed. The existing trained personnel were involved and networking was done in order to have maximum health improvement in the available time frame. The trained personnel used as intermediaries by the project were traditional birth attendants (TBAs), primary school teachers (PSTs), private medical practitioners (PMPs), *anganwadi* workers\(^1\) (AWWs) and adult education teachers (AETs), among others.

**Institutional Set-Up**

Due to the uniqueness of its multi-disciplinary and integrated approach, the project institutional set-up was rather complex.

The consultancy team comprising Indian and Dutch firms had three distinct units: the technical unit, the socio-economic unit and the training unit. The technical unit and the socio-economic unit worked in tandem for the implementation of schemes which were of direct interest to the community, and which required active community participation for their optimal diffusion.

From the consultant’s side, one coordinator of the SEU and one expert on women’s affairs were made available and worked with the existing Urban Community Development (UCDO cell of the Kanpur municipality. The UCD cell was represented by its Project Manager while five social workers worked with the consultants. These social workers received a small honorarium and worked out the consultants’ office. The institutional setup was set up this way for the following reasons:

- to ensure the sustainability of the project after its completion
- to use the existing experienced staff of the bureaucracy in order to upgrade their skills and enhance institutional strength, and to have the minimum investments for the staff input in project implementation.

\(^1\) *Anganwadi workers provide healthcare for mother and child.*
Community Organisation
For the successful planning, implementation and long term sustainability of the project, active community participation was deemed to be a pre-requisite. However, the community first had to be organised in order to achieve this participation. Development was made the rallying point for achieving social integration with the community. Poverty was the one unifying factor, cutting across reasons for social friction such as religion and caste.

At the project’s inception, it was found that the community was in general insensitive or rather pessimistic towards the issue of community organisation for the improvement and development of the area. The reasons for this pessimism included:

- poor existing infrastructure facilities
- community ignorance of their roles, rights and duties
- a total lack of dialogue between the community and implementing agencies, and
- the insensitive attitude of maintenance agencies operating out of far-off, centralised offices.

The time needed to win the community’s confidence depended on the target population, the size of the geographical area to be covered, the existing status of the area and the nature of the interaction and communication with the public. In the case of Jajmau it took about six months to win community confidence.

Direct Approach
Under the direct approach, it was resolved to initiate steps involving change agents from within the community and using them as an interface with the government departments in order to resolve existing problems. The consultants acted as a bridge between the community and the government. The community mobilisation around water was particularly interesting. Leaflets were prepared by
the project and were distributed with the help of community volunteers and local mandals. Audio cassettes were recorded and played on rickshaw around the project area. Decentralised camps were organised, and orientation programmes and follow-up meetings were held with the community volunteers. Area meetings were also organised and the people were informed as to how the illegal water connections and on-line leakages can harm the community. All these efforts were made simultaneously with the increased water pressure so that the improvements in water supply were felt by the community (UCD Project, 1994).

From the outset, the community was involved in the following technical activities:

**Water Supply:**
- identification of the location of hand pumps
- identification of community-based handpump caretakers
- identification of community-based handpump mechanics
- identification of sites for public standposts
- identification of community-based standpost caretakers
- identification of community-based standpost mechanics.

**Sanitation:**
- identification of the beneficiaries for the construction of latrines
- identification of the sites for community latrines
- identification of community-based masons

**Solid Waste Management:**
- Identification of locations for roadside bins for the primary collection of solid waste, and
- Identification of community-based volunteers to monitor solid waste management schemes.

The representation of women was more than 50 percent in all activities.
In the initial stages of the project, the participation of the community was in general not very encouraging, due to the reasons mentioned earlier. The participation of females was abysmal. Most of the population in the industrial slum are either Muslim or of backward castes. Until the introduction of IDP, women had never been encouraged to participate in anything beyond their household duties, let alone to take part in a development process.

With the involvement of the community in the site selection for hand pumps, community latrines and the location of roadside bins, links were established between the consultant team and the community. This bond was further strengthened after the selection of community-based caretakers for hand pumps and standposts. These community-based caretakers were trained by the Project and provided with the necessary tools and kits for the regular maintenance of the system.

This process systematically developed self-confidence in the community, especially the women. It is important here to mention that in the areas representing the poorest of the poor, men hardly had any time to contribute to the development process while women contributed significantly, especially with regard to operation and maintenance of the infrastructure. Women who were initially reluctant to come out of their houses contributed to the Project with an intensity not paralleled in any other development project to our knowledge. Some of their achievement have been very innovative, especially in three areas: masonry, plumbing and plastic fabrication.

**Women masons:** In the implementation of the low cost sanitation programme, the services of a large, well-known contractor were engaged. However, the work delivered was considered of very poor standards. The work of low cost sanitation has low profit margins and thus is not a very attractive proposition for large contractors. Instead of trying other construction firms, it was decided to train local women in masonry.

During the community organisation and mobilisation phases, women from the community had requested some form of income-generated activity.

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2 Backward castes cover certain castes of Hindus, Muslims, Sikhs and other religions while the scheduled caste has castes belonging to Hindu and Sikh communities only.
Despite much initial scepticism, a group of fifteen women received training. The production quality was so high that it was decided to train two more groups to complete the huge amount of construction work. All three groups are now registered as independent organisations.

**Women plumbers:** During the surveys, it was found that about 90 percent of the total household water connections were illegal. It was an uphill task to disconnect these connections, since housewives normally do not permit male plumbers to enter the house, on the pretext that they are alone at home. With the successful experience of the women masons, it was decided to train women plumbers as well. Women plumbers were trained and successfully completed almost all of the disconnection work, as well as leak detection and repairs.

**Women FRP (Fibre Reinforced Plastics) fabricators:** The supply of FRP sanitary pans was a constant problem that was delaying the completion of the low-cost sanitation works. To overcome this problem five women were trained in the manufacture of FRP items. These women later supplied FRP pans not only to the Project but also to other government departments. These women also formed a registered society and now operate independently. In addition to sanitary pans, they now produce other FRP items such as roofing sheets, chairs, stools, foot rests and show pieces.

**Main Problems Faced in Community Organisation**
As mentioned earlier, when the project began in 1987, there were no grass-roots organisations in existence in the Jajmau area. The project team was also new to the area but was supported by experienced community organisers from the Kanpur Municipal Corporation (KNM). Problems faced by the team in the initial periods are described below:

Initially, when we tried to get in touch with the local community through community meetings, we found a few people who were more active and vocal. Some of these people acted as self-proclaimed leaders of the community. Gradually, we came to understand that these people were more influential in the area and that sometimes the local community was afraid to speak up in front of them. Nevertheless, some of the active and vocal people did have the community’s respect.
Care has to be taken so that these influential people were not supported through project activities. The participation of the local elite was marginalised for the following reasons. Firstly, the poorest of the poor were the target population for the project. Secondly, rich people living in good houses were not directly affected by the prevailing poor environmental conditions, while slum residents were directly affected.

Through a long period of continuous interaction, these self-described leaders were sidelined while the community in general was trained and guided to become active partners in the development process. The most difficult issue was getting women involved in the project activities. The problem was that most of the people living in the slums were either backward Hindus or Muslims. Most of the women in these slums were too shy to come out and discuss their local problems, which could have been the first imitative undertaken. The Purdah (veil) system was also a problem among Muslim women.

The female community organisers started informal meetings with the slum women to discuss issues which directly affected them. These issues included:

- drinking water supply
- mother and child health
- sanitation
- hygiene
- solid waste, and
- economic problems.

These issues were pertinent to the women’s daily lives, and the Project had some concrete solutions for these problems. With continued interaction, women started participating in the Project activities. There were some incidents initially when husbands stopped their wives from attending Project meetings but once the Project interventions such as hand pumps, water-sealed latrines and sewers had begun, this resistance transformed quickly into enthusiasm. We received such overwhelming support that it can be said that the main contribution to the project’s successful implementation came from the local women.
Only because of the extraordinarily active role played by the women did the project take up income-generation programs for women such as masonry, plumbing, FRP manufacturing, ORS (oral rehydration solution) packet production, and safety kits for TBAs.

**Indirect Approach**

For some activities like public health, mother and child health care, and occupational health programmes, the community was approached through trained intermediaries. The various health intermediaries are defined below.

**Private medical practitioners (PMPs):** In most of the slums, health care was provided mostly by “quack” doctors. Although most of them were not qualified to practise medicine, in the absence of any proper health care system they were the only source of health care for people in the slums and generally commanded good respect. One hundred and twenty PMPs were trained by the project in diarrhoea management, prevention and promotion of water usage, sanitation and solid waste management. In addition, PMPs were also trained to identify serious diseases like tuberculosis (TB) and other high risk cases and were instructed to refer these cases to the medical college for treatment.

**Traditional birth attendants (TBAs):** Most of the deliveries in the slums are assisted by TBAs. These TBAs were trained by the project in safe delivery practices. The training also improved their skills as mother and child health providers and promoted the project objective of improving environmental sanitation through community participation. Safe deliver kits were also developed by the project for the TBAs at the very lost cost of 2.50 rupees each ($0.80 U.S.).

**Primary school teachers (PSTs):** PSTs from the project area were trained with the intention of achieving family education by educating the school children. School sanitation programmes were also undertaken in some of the main schools in order to acquaint the teachers and children with proper sanitary practises.

**Adult education teachers (AETs):** AETs were trained, and adult education centres were established in all of the main slums. The rationale for establishing these centres was to improve literacy as well as to generate awareness about sanitation, health and hygiene.
Anganwadi workers (AWWs): There were trained AWWs available in some of the main slums. Orientation programmes and follow up programmes were organised for them, so that they could play roles as catalysts in project activities in addition to their existing roles as mother and child health care providers.

Community volunteers (CVs) and Community health volunteers (CHVs): More than two hundred CVs and CHVs were selected and trained by the project to teach the community about improved environmental sanitation, better water use, diarrhoea management practices and the use of ORS.

Formation of Mandals (Area Level Group)
Through the direct and indirect approaches, significant numbers of change agents, intermediaries and community volunteers from the various slums were trained. It was thought that if this trained workforce was organised it would provide synergy to the development process of this project, as well as in the future. With this perspective, the project pursued a policy of helping the community to form their own mandals, or grass-roots organisations, consisting of people who were trained as well as other representatives from the community.

Before the implementation of the project, no such organisations existed in the area. Initially, the involvement of non-government organisations (NGOs) was also tried but it failed for several reasons. First, most of money intended for community development went into meeting the expenses of the NGO. Second, NGO involvement was generally found not sustainable as NGOs leave the area upon completion of their projects. Finally and most importantly, there were concerns that the actual community would remain in its role as a beneficiary rather than becoming an active participant in its own development process.

It was for all these reasons that mandals were created. The mandals provide an interface between the community and the agencies involved in the development process. Mandal representatives were trained to consolidate the mandals and make them effective, dynamic organisations at the grass-root level. Specific training to ensure the proper running of the mandals included financial management skills such as record keeping.
Overall, fourteen *mandals* were created in the Jajmau project area. They represented the various target areas identified in the socio-economic survey at the initial stages of the project. The *mandals* and their respective urban categories are listed below.

1. *Makku Shabid Ka Bhatta*  Industrial Slum
2. *Ram Raj Sarai*  Industrial Slum
3. *Raidas Vihar*  Industrial Slum
4. *Ambedkar Nagar*  Industrial Slum
5. *Sanjay Nagar*  Qualified Slum
6. *Shiv Katra*  Qualified Slum
7. *Kali Bari*  Qualified Slum
8. *Ompurwa*  Qualified Slum
9. *Chabila Purwa*  Urban Village
10. *Gajju Purwa*  Urban Village
11. *Pokharpur*  Urban Village
12. *Ganga Ganj*  Urban Village
13. *Durga Vihar*  Urban Village
14. *Tiwaripur*  Urban Village

These mandals represent the poorest of the poor in the project area, who actively participated through mandals in the execution of the project. Out of these fourteen *mandals*, two are all-women *mandals* (i.e., Ganga Ganj and Pokharpur Mandals). These women were convinced that involving men was of no use in the day-to-day operation of their *mandals*. Women also played very active roles in the other *mandals*.

**Finance**

The financial requirements for activities which were undertaken during the entire project are presented in Table 5.2. The project period started in 1987 and continued until the end of 1993.
**Table 6.2: Financial Requirements During IDP Project.**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Amount in Rs lakhs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Training and follow up programmes for CVs, community-based caretakers</td>
<td>7.12</td>
</tr>
<tr>
<td>and mechanics, AWWs, TBAs, PSTs, PMPs, AETs, etc.</td>
<td></td>
</tr>
<tr>
<td>2. Skills training programmes for women masons, plumbers and FRP</td>
<td>3.33</td>
</tr>
<tr>
<td>fabricators</td>
<td></td>
</tr>
<tr>
<td>3. Skills-upgrading training programmes for women masons and FRP</td>
<td>2.21</td>
</tr>
<tr>
<td>fabricators</td>
<td></td>
</tr>
<tr>
<td>4. Promotional activities and production of promotional material</td>
<td>3.14</td>
</tr>
<tr>
<td>5. Longitudinal diarrhoea study (5 rounds)</td>
<td>1.25</td>
</tr>
<tr>
<td>6. Establishment of community centre</td>
<td>5.75</td>
</tr>
<tr>
<td>7. Establishment of mobile crèche for the children of construction</td>
<td>0.11</td>
</tr>
<tr>
<td>workers (at the site)</td>
<td></td>
</tr>
<tr>
<td>8. Honorarium for community workers taken on deputation from the Urban</td>
<td>1.54</td>
</tr>
<tr>
<td>Community cell of the Kanpur Municipal Government</td>
<td></td>
</tr>
<tr>
<td>9. Transportation (petrol, oil, lubricant and maintenance of the one</td>
<td>2.31</td>
</tr>
<tr>
<td>Jeep purchased by the project)</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>Rs 26.76</td>
</tr>
</tbody>
</table>

*1 lakh = 0.1 million; 1 Rs = 0.03 U.S. Dollars

**III. POST-PROJECT EVALUATION**

The project in itself was unique in the sense that it was the first attempt to link urban environmental problems, in the context of the general natural environment, to the active participation of the community. This approach was taken in light of the realisation that while the community was, in certain ways, the creator of these problems, it also directly suffers from them.
The project therefore, tried to involve the community in the resolution of this urban environmental crisis.

With the active involvement of the community, it was not only possible to successfully implement the project interventions, but it also guaranteed their optimal utilisation and proper upkeep. Through continuous interaction, the community started to look at their problems in the broader context of the overall environment and specifically at the effect of their collective action on public health. One very appropriate example is the reduction in diarrhoeal incidence in the project area. Diarrhoeal incidence is an important parameter in assessing the impact of environmental and sanitary interventions in a given area. During the course of the project, five rounds of diarrhoeal incidence survey were carried out by the Kanpur Medical College. The prevailing rate of diarrhoeal morbidity in children under five years of age was 27 percent in August 1988. This fell to 8.5 percent for the same period in 1993. These results were found to have direct links to the community’s level of knowledge, attitude and practices.

A marked improvement in public services was observed. There are now better facilities for water supply, sanitation and solid waste management. The passive community with which the project started was transformed into an active, demanding and assertive community. They will likely act as a pressure group and will define their priorities in the future. With poverty as the binding force, the heterogeneity of the urban slums has given rise to the common concern for the area’s improvement.

**RECOMMENDATIONS FOR FUTURE DEVELOPMENT PROJECTS**

From the experience of having executed a project with active community participation, the following recommendations are made which may help others in the formulation and implementation of similar projects.
• Before the project’s implementation community mobilisation should begin. An allowance should be made for developing rapport with the community. If community-based organisations exist, they should be taken into confidence and if none exist, the community should be supported to organise for itself and for area level groups. Once this is developed, the task of basic data collection and initial surveys will become easier and more authentic.

• The community should be aware that the planned activities are for their own benefit and that they should come forward to spell out their own priorities.

• In planning the projects, there should be built-in flexibility so as to incorporate changes which may be essential for the successful implementation of the scheme.

• The sensitisation of all the agencies involved is a must as this reduces the chances of a lack of coordination among the executing agencies.

• Keeping in mind the existing poor financial status of government agencies, it is advisable to work towards community-based operation and maintenance of infrastructure. This has already proved successful in the case of hand pumps and standposts where the respective mandals perform maintenance work with the help of community funds.

REFERENCES


INDIA’S MANDAL SYSTEM: ITS POTENTIAL ROLE IN RESPONDING TO ENVIRONMENTAL PROBLEMS IN KANPUR

F.U. Rahman and M. Prasad

INTRODUCTION

A *mandal* is a group of at least seven persons who come together to work for a common social cause or causes. These identified causes become the *mandal’s raison d’être.*

In India, the concept of the *mandal* came into being with the advent of community development projects during the second National Economic Development Five-Year Plan. The aim was to help communities organise and establish healthy relationships to foster a spirit of neighbourliness. These *mandals* were to help the government resolve existing urban and rural problems, especially those of impoverished communities. In the urban context, the need to have *mandals* was more essential because of the heterogeneous character of urban communities. Urban residents have a diversity of backgrounds in terms of religion, caste and customs. This leads to impersonal relations and contribute to the general lack of civic consciousness, communal cohesion and zeal for living in a healthy environment as an active member of a community.

In 1965, it was thought that in the absence of strong *mandals,* the success of urban development activities could not be assured. *Mandals* not only play an active role in the planning and execution of development projects but also manage projects in a sustainable manner. Through *mandals,* a sense of togetherness develops and gives rise to group thinking, group planning and group efforts. With proper training and education, *mandals* can play an active role in urban development activities.
Mandals function as a group. Although there are seven office bearers and as many members as required, the functioning is such that each member of the mandal has a sense of involvement and responsibility. This is essential for the proper functioning of the mandal, otherwise in the long term, some of the members feel that their participation in the mandal is of no consequence or use. Generally, this perception will lead to the disintegration of the mandal.

The mandals raise and maintain their own funds. These funds come from the following sources: membership fees from the members, contributions from members for carrying out specific activities, and donations from the better-off community members.

I. HOW MANDALS FUNCTION

The mandals are registered with the Registrar of Societies within the Uttar Pradesh State Government. According to the Societies Registration Act of 1869, a mandal is a group of at least seven persons. There can be as many members as required. The mandal has two bodies, namely the General Body and the Executive Committee.

General Body
The General Body organises the meeting for the election and selects the members for the Executive Committee. The General Body also organises a yearly meeting of all the members of the mandal. It can also organise a special meeting on short notice at the request of mandal members to discuss any special or extraordinary issues. The General Body also makes decisions about the roles of the various Executive members. It approves the annual budget for the coming year and the annual reports of the previous year, including the audited accounts. The General Body is empowered to make any constitutional amendment if it has the support of a two-thirds majority of its members.
Executive Committee
The elected Executive members select the Managing Committee which consists of at least seven
office bearers:
1. President
2. Vice President
3. Secretary
4. Joint Secretary
5. Treasurer
6. Organisational Secretary, and
7. Information Secretary

This committee is selected for a fixed duration of time, the length according to the
constitution of the mandal. The routine meetings of the Managing Committee are fixed on a
monthly, bi-monthly or quarterly basis. Emergency meetings of the mandal Executive Committee
can be called with at least 24 hours’ notice. A decision on any issue can be made by a two-thirds
majority of the members of the Executive Committee.

The Executive Committee is responsible for the day-to-day work of the mandal. The office
bearers contact the government and non-government organisations (NGOs) which may be
executing projects in their area. Once a project is in place, mandals help ensure the project conforms
with local needs. The mandal, through the Executive Committee, takes up the execution of these
projects, with the option of employing staff, should they choose to do so. The Executive
Committee is empowered to undertake action using paid staff on behalf of the mandal. The powers
of the Executive office bearers are outlined below.

President: The President is responsible for the proper working of the mandal. He (or she) conducts
evaluations and monitors the performance of other executive members. He chairs all meetings and
approves the dates of future meetings. Under his guidance, other executive members take an oath
to work for the mandal. The President is empowered to use his vote for critical issues on which the
executive is equally divided.
If the president is not satisfied with the performance of any executive member, then with a two-thirds majority of executive members, he can remove or penalise the executive member in question. The President himself can be penalised by a two-thirds majority, but may be re-installed after paying some monetary penalty if the issue is considered minor.

Vice President: The Vice-President assists the President in carrying out his work and in the absence of the President, the Vice-President has all the powers of the President.

Secretary: The Secretary is the administrative officer of the *mandal*. For the smooth and effective functioning of the *mandal*, she (or he) performs the administrative, disciplinary and organisational duties. She is also responsible for the books, record-keeping and yearly auditing of the *mandal* as well as the organisation of sub-committees for the execution of *mandal* projects. In the General Body meeting she must make available all *mandal* records for the information of the members. The Secretary is supposed to prepare the agenda for the General Body meeting and have it approved by the President before the meeting takes place. She keeps the minutes of the General Body meetings and begins actions based on the decisions made. She is also responsible for the *mandal*’s legal matters.

Joint Secretary: The Joint Secretary assists the secretary in carrying out her work and in her absence has all the powers of the secretary.

Treasurer: The Treasurer is responsible for managing the funds and expenditures of the *mandal*. He (or she) maintains a joint bank account in consultation with the Executive Committee. The official signatories for the account are the President, Secretary and Treasurer. The Treasurer prepares the budget for various *mandal* activities and reports it to the Executive Committee for approval. He is also responsible for the yearly audit of the balance sheet of the *mandal*.

Organisational Secretary: The Organisational Secretary is responsible for internal organisational matters. She (or he) ensure coordination among the executive members for the smooth running of the *mandal*. In case of any lack of unity, the Organisational Secretary brings it to the knowledge of the Executive Committee.
Information Secretary: The Information Secretary is responsible for the publicity of the aims and activities of the mandal.

II. MANDAL ACTIVITIES

The concept of mandals started with the Central Government-sponsored Urban Community Development (UCD) Programme 1966. The programme had the following objectives:

- to create a sense of social coherence on a neighbourhood basis through corporate civil action and promote a sense of national integration
- to develop a sense of belonging in the urban community through increased participation of people in community affairs
- to bring about a change in attitude by creating civic consciousness and by motivating people to improve living conditions (particularly those affecting the social and physical environment)
- to develop local initiative, and identify and train local leaders, and
- to ensure the full utilisation of technical and welfare services by helping the community.

This programme also included physical improvements to amenities, health, sanitation, education, social, recreational, cultural, civil defence and so forth. Economic programmes specifically for women were also organised by the UCD programme. These include income generation through skills training for women masons, women plumbers and women FRP (fibre reinforced plastics) fabricators, as well as women dress designer programmes.

The formation of mandals was to be used as a tool for effective social action where people:

- Organise among themselves for planning action
- Define their common needs and problems
• Believe in self-help, self-reliance and community resources potential
• Guide the community in locating and getting help from various government departments, and
• Coordinate with the government and non-governmental organisations and voluntary agencies for solutions to their problems.

In the Initial years, the mandals engaged in the following activities:

**Education:**
• *bahradi* and child welfare
• school enrolment campaign
• coaching classes and social education class
• adult education
• libraries and reading rooms
• community programmes
• training programmes in various skills
• sightseeing and study tours

**Health, Hygiene and Sanitation:**
• pre-natal and post natal care
• family welfare
• healthy baby competitions
• food nutrition training demonstrations
• medical check-ups especially for children and women
• environmental sanitation programmes which include habits of personal and environmental cleanliness
• preventative care programme
• construction of flush latrines
• health surveys
• family life education, maternal and child welfare
• house up keeping competitions
• play centres for children
• programmes for handicapped and mentally retarded children
• baby *creches*
• education for the mother
Cultural, Recreational and Social Programme:
- sports and cultural programmes
- seminars and camps to motivate youths for community programmes
- national festivals
- dramas, films shows, *bal melas, vikas melas, fates* and other leisure time activities
- other programmes

Civic Development And Amenities:
- programmes for civic and national pride
- training in civil defence, first aid and fire fighting
- national integration camps
- agency visits
- proper utilisation of civic amenities

Economic Programme:
- sewing, tailoring and allied crafts
- income-generating schemes
- training in handicrafts and cottage industries
- recommendations to banks for loan services
- training in cooperation, and cooperative societies
- vocational guidance
- exhibitions and seminars on career development

Housing:
- housing information
- organising and guiding in regards to new schemes
• convincing people to follow planned development
• organising savings groups
• education and awareness in environmental hygiene and safety
• working as a reliable link between the urban poor and authorities
• identifying neighbourhood and community needs and bringing them to the attention of the authorities
• consultancy and voluntary services i.e., legal social surveys, research and publications
• organising youths for disciplined and clean living

Other services:
• blood donation camps
• training in first-aid
• consultancy in urban community development
• training programme feedback, research evaluation and publication, and
• traffic-sense safety training.

The strength of the mandal lies in its fundamental orientation as a community-based neighbourhood organisation. Mandals relate directly to the community, which is not usually true for governmental or non-governmental agencies. These agencies, with few exceptions, are still considered to be outside agencies.

Mandals which are more independent and rely more on local resources and less on governmental support, are more active and effective. Mandals which depend completely on governmental schemes and government aid are less effective since in the absence of any government scheme they are less active. The community’s regard for such mandals is not very high. The strengths and weaknesses of the mandal lie in the functioning of its Executive Body and General Body. Mandals which meet on a regular basis, discuss local problems and try to resolve these problems (with or without government support) are strongest.
Government support to mandals for carrying out designated activities has decreased over time because of currency devaluation, population growth and increasing and diverse demands on government resources.

At the time of the introduction of UCD schemes, the understanding was that expenses for designated activities would be shared equally by the mandal and the UCD department. However, over time, the share of the mandal’s contribution to carrying out its activities has increased relative to that of the UCD. This has created extra financial burdens for the mandals, making it increasingly difficult for them to carry out their activities.

The implementation of physical development is now being done more on a contractual basis. At the inception of the UCD programme in 1966, physical developments like paving roads, boring wells for hand pumps, or the construction of drains were done through mandals, but gradually these activities have come to be carried out by the technical (engineering) departments of municipalities through contractors.

Consequently, the role of mandals in community-related activities has been drastically reduced. The mandals have either not been included at all in the planning and execution of community related activities, or if included are kept on the periphery.

Strong and active mandals act as pressure groups and play very active roles, even if they are not included in the primary or initial planning of activities in their area. They spell out the priorities and requirements for their area, and frequently when planned schemes are not in harmony with local needs, the mandal will manage to have these schemes modified and/or amended. Such mandals are ideal as they command a good level of respect in the community for acting as its vocal representative on various issues of public interest.

III. KANPUR/JAJMUAU EXPERIENCES WITH MANDALS

The Kanpur/Jajmua area has gained experience with mandals in the planning and execution of activities in both the on-going UCD project (started in 1966), and the Indo-Dutch Project, Phase I (started in 1987 and completed in 1993), (see Rahman and Prasad in this volume).
UCD Experience
UCD has had a long association with Kanpur/Jajmau’s mandals. Since 1965, the UCD has worked with the mandals on the activities listed in the previous section. Initially eight mandals from the Kanpur/Jajmau area were included in the UCD programme. Later more mandals and qualified slums were included. The number increased to 27 (excluding the 14 mandals from the Indo-Dutch Project area) functioning with the UCD cell. A list of these 27 mandals is given in Appendix 1. The stepwise inclusion of more mandals in the UCD programme followed the pattern shown below (Table 7.1).

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Mandals Included</th>
<th>Number of Slums Included</th>
<th>Total Population Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>8</td>
<td>-</td>
<td>36,000</td>
</tr>
<tr>
<td>1970</td>
<td>16</td>
<td>-</td>
<td>76,000</td>
</tr>
<tr>
<td>1975</td>
<td>21</td>
<td>-</td>
<td>134,000</td>
</tr>
<tr>
<td>1980</td>
<td>21</td>
<td>15</td>
<td>159,000</td>
</tr>
<tr>
<td>1985</td>
<td>21</td>
<td>35</td>
<td>197,500</td>
</tr>
<tr>
<td>1990</td>
<td>27</td>
<td>89</td>
<td>251,500</td>
</tr>
<tr>
<td>1995</td>
<td>41</td>
<td>89</td>
<td>321,000</td>
</tr>
</tbody>
</table>

While these mandals are involved in all of the listed activities, special mention should be made for the following activities which the mandals have performed very successfully in the respective slums, with the active support of the local community:
**Education:**
- *balwadi*
- *crèche* for the children of working women
- adult education
- provision of newspapers and periodicals at the community centres and library

**Health Hygiene and Sanitation:**
- immunisation of mothers and children
- nutrition programme (i.e., midday meals)
- family welfare camps
- eye relief camps
- proper primary disposal of domestic solid waste and solid waste management in the area
- diarrhoea management
- training of the community with a special emphasis on the improvement of knowledge, aptitude and practices (KAP)

**Cultural and Social Programme:**
- organisation of National festivals
- cultural programmes, film shows and site seeing visits
- annual function of the *mandal*

**Civic Development and Amenities:**
- national integration camps
- first aid training
- civil defence training

**Economic Programmes:**
- crafts training for women
- dress design training for women
- new model *charkha* (spinning) training for women
- other income-generating activities such as radio and television repair, scooter mechanics training, blacksmith training, carpentry.
Housing:
• community motivation to make savings deposits for the purchase of their own houses in registered slums
• promotion of the construction of water-seal latrines and proper water connections, and

Service Orientation:
• organisation of blood donor camps.

Indo-Dutch Experience
Under the Indo-Dutch Project all the slums were represented by 14 mandals (see Appendix 2). Under the Indo-Dutch Environment and Sanitary Engineering Project, more emphasis was placed on environmental and sanitation issues. However, because it was a community-based project, a wide range of activities listed below were interwoven into the overall programme.

Education:
• mobile creches for women labourers at the construction site
• balwadi at the community centre
• adult education centres in slums
• painting, slogan-writing, essay and quiz competitions for primary school teachers and students

Health, Hygiene and Sanitation:
• health check-up camps
• first-aid training camps
• production of safe delivery kits for traditional birth attendants
• production of Oral Rehydration Solution (ORS) packets
• diarrhoea management study
• site selection for roadside bins for the primary collection of domestic solid waste
• joint training programmes of mandal representatives and area sweepers for the effective implementation of the solid waste management programme

Cultural and Social Programme:
• cultural stage programmes, puppet shows and video films promoting environmental awareness, adult literacy, family welfare and health/hygiene issues
• organisation of a ‘Race for Environment’ for children, and
• organisation of a Social Forestry Programme.

Economic Programme:  The mandals played a very active role in the selection of women for the various path-breaking, income-generating activities such as women plumbers, women masons and women FRP fabricators.

Physical Development:  The mandals carried out the physical development of two slums, namely Ambedkar Nagar and Ganga Ganj. The respective mandals constructed the bricks-on-edge roads and drains in these two slums, using materials provided by the municipality and labour by the mandals.

IV. THE ROLE OF MANDALS IN IMPROVING SOLID WASTE MANAGEMENT

The problem of solid waste management is one of the foremost urban civic problems. To date, most of the interventions designed have been more hard-technology oriented, where more mechanisation is proposed for the improvement of solid waste management. These interventions have not been found to be successful since they increase the operational and maintenance costs of the solid waste management system. In the long-term, this became more of a burden for the municipality.
Due to the reasons cited above it was imperative to involve the community in a solid waste management system which was more cost-effective and efficient. A few experiments have been made which demand special reference in the context of involving the community, (through mandals), for improvements in solid waste management. Four of these experiments will now be described.

**Experiment One**

It was found that domestic solid waste management was not effective in most of the areas. In the Indo-Dutch Project area, community intervention was initiated in the monitoring of solid waste management. Joint training programmes were organised for the local sweepers and representatives of the local mandal.

During the joint training programmes, the problems of solid waste management were discussed between the mandal representatives and the local sweepers. The general complaint of the sweepers was that the community was not properly dumping its solid waste in the roadside bins meant for primary collection. The general complaint of the mandal representatives concerned the irregular working hours of the sweepers. The format made for community based monitoring was very simple. The list of sweepers’ jobs were posted, along with an assessment of the quality of service being rendered by the sweepers. The format followed is shown in Table 7.2.

From the assessment of the results of these monitoring sheets, a system was made to honour the best working sweeper of the area with a reward coming from community contributions twice a year. There was already a governmental system for monitoring the work of sweepers, so it was thought that this new system would be considered by the sweepers to be a policing kin of monitoring, rather than one which would give rise to healthy competition in order to improve the work performance of the sweepers. The result of this monitoring was found to be very positive. One sweeper each from the areas was honoured as the best sweeper of the area. It gave rise to coordinated effort of the community and the sweepers for the solution of the solid waste management problem.
### Table 7.2: Sweepers’ Assessment Form.

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>Job</th>
<th>Quality of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very Good</td>
</tr>
<tr>
<td>1.</td>
<td>Sweeping road</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Cleaning roadside bins</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Emptying gully pit</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Emptying roadside bins</td>
<td></td>
</tr>
</tbody>
</table>

**Experiment Two**

With the growing size of cities, municipalities are not able to clean the whole city. In spite of a search for various alternatives, there are several slums which are not being maintained by the municipality. In Jajmau (the Indo-Dutch Project area), there were several slums which did not have any solid waste management system; these slums were not even provided with the services of sweepers to clean the streets.

In one such slum, *Ambedkar Nagar*, there were no infrastructure facilities at all. The Indo-Dutch project provided the slum with hand pumps and private pour-flush latrines. At the end of project, some savings had accumulated, so it was decided to do some development work through the *mandals*. The *mandals* were informed in advance that because of the area’s poor financial status it might not be possible to get the services of sweepers for the area. Instead, the local *mandal* chose to maintain the area. The *mandal* was provided with the money to purchase materials to make roads and drains, and the Indo-Dutch project provided roadside bins in and around the area for the primary collection of domestic solid waste.
Once these interventions were made, the whole scene changed in Ambedkar Nagar. The community now maintains the whole area, including the hand pumps, the roadside drains and the roads. Each family is responsible for the portion of drain and road in front of its house. They clean it on a regular basis and have also hired the services of a private sweeper to cart solid waste to the nearby roadside bin or solid waste container on a weekly basis. The cost of such a system is almost negligible but it can only be successful if the community remains strongly committed. Thanks to the community’s efforts, Ambedkar Nagar is now one of the best maintained slums in Kanpur.

**Experiment Three**
Some of the unattended portions of the city are being cleaned on contractual basis. The municipalities have tendered the work and award the contracts to the lowest bidders. However, the quality of work is abysmal. No proper cleaning is being done by these contractors because they employ very few sweepers who are paid very low wages.

Local mandals have shown their willingness to take up the responsibility of cleaning the area, but as it is impossible to complete with the contractor’s low bids. They have failed to get any work from the municipality to date. *Mandals are currently trying to get these contracts on a non-profit basis from the municipality.*

**Experiment Four**
The Indian Institute of Technology’s (IIT) huge solid waste management system was being managed by a private contractor. The quality of work was not very satisfactory. An in-depth study was conducted informally by a group of persons who (on a voluntary basis) guided the sweeper’s society from outside. The group was headed by Dr. Abhay Shukla and included one of the authors (Rahman). This study found that the sweepers were very poorly paid and thus had a great lack of enthusiasm in doing their job. After several meetings with the sweepers, they were convinced to organise among themselves. The sweepers, with a minimum of outside support, formed a workers’ cooperative.
Initially, administration was reluctant to allow the cooperative to bid on the contract. However, because of support from the campus community, the administration later provided not only the tender documents, but awarded the contract to the workers’ cooperative because it submitted the lowest bid. One of the authors (Rahman) is the technical advisor to the society of sweeper who are now managing the IIT Campus Solid Waste Management.

The quality of work improved and it was noticed by the community, that with the enhancement of the sweeper’s income (more than double than what they used to get from the contractor), the sweepers were motivated to perform well. The sweepers now maintain a library, and have formed their own code of conduct to keep sweepers from indulging in alcoholism, gambling and other social ills. Almost all the sweepers who were alcoholics have stopped drinking because of the strict code of conduct. They are taking care of the education of their children and are leading better lives.

**CONCLUSIONS**

In general, the involvement of *mandals* in urban problems is very important. This involvement can bring down not only the costs of the operation and maintenance of the solid waste management systems, but can also make such systems more effective. There is, in general, a lack of trust between the community and the government agencies involved in the development, operation and maintenance of the solid waste management systems. However, proper coordination with *mandals* can bridge this gap.

The financial position of most municipalities is so poor that it is not possible for them to even pay the salaries of their staff. The government departments attribute the prevailing poor conditions of urban living to a poor recovery of revenues from the community, while the community blames the government agencies for poor service levels.
To cut this vicious circle of poor revenue leading to poor services and poor services leading to poor revenue, the government should make an honest attempt to tackle urban problems by involving communities through mandals, and to coordinate with agencies that can help, by way of financial support, to improve urban waste management systems.

Mandals have experience in many social projects. The challenge for them now is to become involved in the planning and design of programmes from the outset. For ongoing projects, mandals can also play a positive role in the implementation, operation and maintenance of the schemes. Since schemes such as waste management, water supply or sewage are meant to improve urban living conditions, there is no point in ignoring the community which is ultimately affected by the conditions and benefitted by improvements. The mandal, with proper training and support, can play a very useful role in the sustainable development of cities.
APPENDIX 1: LIST OF MANDALS (Other than Jajmau)

1. Janta Vikash Mandal (Sujjat Ganji)
2. Sarab Janik Vikash Mandal (Chaudari)
3. Sanjai Jyoti Vikash Mandal (Hari Colony Juhi)
4. Sarvodaya Vikash Mandal (Ajit-guy Harijan Basti)
5. Dayanand Vikash Mandal (Nayapurwa)
6. Adarash Vikash Mandal (Ajitganj)
7. Azad Nagrik Vikash Mandal (Babapurwa)
8. Subhash Chaudra Bose Vikash Mandal (Bakargani)
9. Indira Vikash Mandal (Dhaknapurwa)
10. Nehru Vikash Mandal (Nayapurwa Harijan Basti)
11. Jivan Jyoti Vikash Mandal (Bagahi Bhatra)
12. Shastri Vikash Mandal (Bagahi)
13. Patel Vikash Mandal (Naubarta)
14. Pragatisheel Vikash Mandal (Garerianpurwa)
15. Sharawisheel Vikash Mandal (Fazalganj)
16. Karkarta Vikash Mandal (Rawalpur)
17. Lok Vikash Mandal (Vijur Nagar)
18. Mahila Vikash Mandal (Nehru Nagar)
19. A.N.D. Vikash Mandal (Munshipurwa)
20. Navneet Vikash Mandal (Munshipurwa)
21. Shri Krishnan Shiksha Samite (Juhi Pili Colony)
22. Jau Kalyan Samite (Barra)
23. Sewa Vikash Mandal (Manupurwa)
24. Lohia Vikash Mandal (Manupurwa)
25. Mahila Vikash Mandal (Ratlipurwa)
26. Adarash Vikash Parishad (Darshanpurwa)
27. Kanpur Urban and Rural Development Society (Sarvodaya Nagar)
APPENDIX 2: LIST OF MANDALS (Jajmau)

1. Kalibadi Basti Vikash Mandal
2. Chhabilapurwa Basti Vikash Mandal
3. Chhetriya Nagar Vikash and Garam Udyog Jankalyan Samite Sanjai Nagar
4. Pokharpur Basti Vikash Mandal
5. Bhallaslati Basti Vikash Mandal
6. Mahila Milau Samite Gangaganj
7. Ravi Rai Basti Vikash Mandal
8. Raidash Vihar Basti Vikash Mandal
9. Gajjupurwa Basti Vikash Mandal
10. Ambedkarnagar Basti Vikash Mandal
11. Jamiya Saidiya Mohalasudhar Committee Makusahidka Bhatts
12. Ompurwa Basti Vikash Mandal
13. Tewaripur Basti Vikash Mandal
14. Sheokatra Harijan Basti Vikash Mandal
PART THREE:

THE POLICY AND ADMINISTRATIVE CONTEXT
INTRODUCTION

The end of the Cold War has given humanity an opportunity for a fundamental rethinking about the nature of relations among nations; that rethinking ought to be directed to make our planet safer because we are still facing a planetary-proportion threat of ecological disaster and poverty. But we live in a world where poverty prevents at least one-fourth of humanity from receiving even the basic human needs (adequate food, safe and sufficient water, primary health, education, and shelter). As long as the economic disparity remains, stress on the environment continues because for the poor their struggle for survival overrides any concern for environmental preservation. This conflict is not only world-wide, but we see it within nation states. The situation in India reflects this conflict. That is why the struggle for sustainable development in India is a daunting one.

I. SUSTAINABLE DEVELOPMENT: BACKGROUND, CONCEPT AND ISSUES IN GENERAL

Since the release of the Brundtland Commission report, “Our Common Future”, the concept of ‘sustainable development’ has captured the world’s attention and has emerged as the new ecumenical political ideology. The term was defined by the Brundtland Commission as “…development that meets the needs of the present without compromising the ability of future generations to meet their
own needs”. The definition contains two key concepts: (1) the concept of needs, in particular the essential needs of the worlds’ poor, to which overriding priority should be given; and (2) limitations imposed by the state of technology and social organisation on the environment’s ability to meet present and future needs. But it is not clear who, among North and South, is going to determine the “needs” of the present generations; and how we are going to ascertain the “ability” of future generations? The answer to these questions from the North will be different from that of the South.

**Sustainable Development**

Development or economic progress has always produced, as a side effect, the degradation of the environment. The more the material progress in general, the more deterioration. The concept of sustainable development has fundamentally changed the nature and scope of debate about the environment and its relationship to development. As the Brundtland Commission stated: “We have in the past been concerned about the impacts of economic growth upon the environment. We are now forced to concern ourselves with the impacts of ecological stress…upon our economic prospects”.

For the first time, those in the field of economic development and environmental management appear to agree over the need to save our planet and to create environmental stewardship. The World Bank in its 1992 World Development Report, Development and the Environment writes: “Sustainable development is development that lasts. A specific concern is that those who enjoy the fruits of economic development today may be making future generations worse off by excessively degrading the earth’s resources and polluting the earth’s environment.” Although this definition is not comprehensive, nevertheless, for the first time the World Bank has acknowledged that “meeting the needs of the poor in this generation is an essential aspect of sustainably meeting the needs of subsequent generations”.

The concept of development which hitherto used to be exclusively associated with economic growth has thus been expanded to include specifically the environmental perspective. The integration however is better captured in the concept of environmentally sound and sustainable development (ESSD). The concept requires that a country must believe in maintaining a balance
between its human resources and its natural heritage, so that its people may live in ecological harmony. Such an explicit policy may engender the necessary interconnection and coordination between various sectors in that government.

**Cultural Context of Sustainable Development in India**

In India, ever since the program of industrial development was ushered by Pandit Jawaharlal Nehru, there has been a question of viability and sustainability of the process of industrialisation with the attendant materialism/consumerism. The Gandhian view of human progress de-emphasises materialism-without-limit. Rather it banks on moral progress and spiritual attainment of each and every human-being. This he called *Sarvodaya*. His view drew from India’s rich cultural and spiritual legacy which emphasises the concept of *Vashudhaiv Kutumbakam* (all the people and creatures living on earth are members of the extended family of humans).

Sustainable development from Gandhian perspective, ought to include the upliftment (both spiritual and material) of all, without exploitation and destruction of others. Indeed, the philosophy of *sarvodaya* is intimately linked with the concept of *Loka Sangrahamevapi* (to secure welfare of all by ones’ deeds). How to achieve a development which brings welfare to all without harming others and destroying the environment is a challenge before India. Can a socially just and culturally acceptable sustainable development be achieved when the nation is confronting two major crises: population growth and continuation of poverty?

**II. POPULATION GROWTH AND ENVIRONMENTAL DEGRADATION**

In the case of India, two issues are always mentioned with respect to their impact on the environment: (a) population pressures and (b) continuing poverty. Demography, when taken as the size of the population and its rate of growth, is considered as a principal factor in environmental degradation. The faster the population increase, the greater the depletion of natural resources and environmental degradation.
But reduction in population increase, if that is the answer, cannot be achieved even by some authoritarian measures. For example, when Mrs. Indira Gandhi ordered vasectomy operations to reduce India’s population during her emergency rule in 1975-1977, her government was repudiated immediately in a General Election of 1977. Later no political party in India would dare to raise this issue again. Even in China, population control methods have worked very slowly. Demographers have estimated that “even in the unlikely event that we managed to immediately reduce world fertility to a level of simple replacement (of the order of two children per couple) and maintain this level in the future, the world population, due to the effects of its present age distribution and to the expected increase in life-expectancy, would continue to grow for approximately a century before levelling off at a level which would almost double the present figure.”

We know, however, from our past experience that a high density of population does not always cause the same proportion of environmental degradation as we have seen in some sparsely populated nations. For example, if one compares the population density of the United States or Australia with India or China during this century, there has been comparatively, more environmental degradation per capita in the U.S. and Australia compared to India and China over the same period. It is not being suggested here that the density of population of a country does not contribute to environmental damage, but instead of over-emphasising population as the key factor in environmental degradation, we should look at other factors. That culprit is poverty. The problem of environmental degradation should be approached not purely from a demographic standpoint.

Poverty and Pollution
In June 1972, when Mrs. Indira Gandhi addressed the UN sponsored Human Environment Conference, she asserted that “it is an over-simplification to blame all of the world’s problems on increasing population. Countries with but a small fraction of the world population consume the bulk of the world’s production of minerals, fossil fuels and so on.” She asked further: “On the one hand the rich look askance at our continuing poverty – on the other, they warn us against their own methods.”
We do not wish to impoverish the environment any further and yet we cannot for a moment forget the grim poverty of large numbers of people. Are not poverty and need the greatest polluters?”

It is obvious that not much has changed during the past twenty years since Mrs. Gandhi made that statement. Developing nations are still struggling to overcome poverty, hunger, and disease. Poverty and the needs of developing nations are yet to be addressed appropriately despite four decade of developmental efforts. When the international aid program started in mid-1950s, it was assumed that in a relatively few years the basic human needs (food, living conditions, health, and education) and social justice would be met. But this did not happen. For hundreds of millions of people life remains a constant struggle for survival. Sustainable environment for them can become a concern only when poverty is eradicated and living conditions become tolerable. As Shridath Ramphal, former Secretary General of the Commonwealth of Nations and a member of the Brundtland Commission noted:

If poverty is not tackled, it will be extremely difficult to achieve agreement on solutions to major environmental problems. Mass poverty, in itself unacceptable and unnecessary, both adds to and is made worse by environmental stress…That is why the global policy dialogue must integrate environment and development.9

Although consumption pressure is dependent on a number of people making demands, it is intensified by the quality of such consumption. It has been estimated that every birth in the North puts as much pressure on resources as tens of births in the South. Just as poverty must be eradicated in the South, the life style in the North will have to be modified.

**Nature of the Problem: Link Between Environment and Development**

During the two environmental decades (1972-1992), the major challenge before the government of India has been how to strike a balance between the urgent need to secure basic needs (food sufficiency, improve health and provide water for drinking, and shelter) and the need for environmental sustainability. Although various institutional and legal mechanisms were initiated, the pressures of a growing population, and generally weak system of environmental law enforcement have added to the seemingly intractability of the problem.
The Government of India was forced to acknowledge through its Policy Statement for Abatement of Pollution (1992) that “the state of the environment continues to deteriorate”.11 India’s response to environmental problems is being watched by nations the world over. If India is able to prevent the deterioration of her environment as well as poverty, it will be an example for others in the Third World to follow. The major environmental concerns of India today are the results of continuing poverty, growing population (including human settlements and movements), and the side-effects of enhanced industrial activities. India’s people are very impatient when it comes to improving their living conditions. They would not hesitate to put more demands on the environment if the short gains could ensure fulfilment of their daily basic needs.

Population in India has become a major source of environmental degradation because it now exceeds the country’s carrying capacity. Its population of 844 million in 1992 is increasing at the rate of 2.11 percent annually, which means about 17 million people are added each year. In addition, India has probably the largest cattle population on earth, about 500 million domesticated animals which have only 13 million hectares for grazing. The increasing population of both human beings and animals is putting tremendous pressure on the environment. In the race for survival, both animals and human-beings suffer. For example, over 250 million children, women and men of India suffer from under nutrition. The prospects for the future are grim indeed.

In addition to the alarming situation arising out of population pressure, India faces immense challenges from the side-effects of industrial development and human settlements.

(1) The forest cover is dwindling due to over-grazing and harvesting of trees for commercial and domestic-fuel purposes, and illegal encroachments. The actual forest cover in the country, according to the State of the Forest Report (1991), was 64.07 million hectares during 1987-88.12 Most of the forest cover loss has occurred since independence. This has resulted not only in the extinction of rare plant and animal species, but has also contributed to soil erosion and floods.

(2) By the end of the 1980s, there were hundreds of large industries with only a few of them having any installed pollution abatement plants, with some of these non-functioning throughout the
In addition, there were many thousands of medium size industrial plants which did not have any pollution abating units. Although the situation improved significantly by 1995, the environmental damage has been done. Rivers and groundwater have become polluted. In the case of the River Ganga, the Government of India had to establish a special authority to monitor the water pollution-causing industries and to require them to install abatement units, as well as to require the local municipal authorities to install sewage treatment plants.

(3) In many cities, industrial activities are located in city cores close to the residential areas. Emissions from these industries are causing many respiratory diseases, aggravated by auto-emissions and population congestion. Unplanned encroaching urbanisation is yet another environmental threat. India is actually facing a classic urban nightmare. In 1981, there were only 12 cities with over one million population, by 1991 this number has increased to 23. In 1951, India’s urban population was 62 million, by 1981 this number had grown to 158 million, and by 1991 it grew to about 227 million. Of these, over 30 percent live in slums. When such a large number of people are concentrated in small unplanned spaces, they suffer not only from shortage of drinking water and sewer facilities but also from a host of other diseases.

(4) There is also the problem of environmental refugees from dam construction, mining and mineral exploration. An estimated 14.5 million people have been displaced, and among these only 3.9 million have been rehabilitated.

(5) India is the largest producer and consumer of pesticides in South Asia. The most productive agricultural regions of the nation show a severe pesticide pollution problem. For example, “more than 665 people died in 1989-1990 because of pesticide poisoning, and thousands of cases of crippling resulting from pesticides have been recorded in the country”.

(6) Another worrisome problem is fertiliser pollution due to the intensive farming methods used in various parts of the country. Synthetic inorganic nutrients used generally escape to river basins, dams, and coasters waters causing algae growth, oxygen depletion, and related problems.

These are only some of the numerous environmental problems. Clearly India is facing double jeopardy with her attempt to industrialise as well as to face the challenge of poverty and growing population.
India’s environmental problems are complex and the choices available are difficult. This requires a vision and an ‘environmentally sound foresight’ which should be reflected by formulating a proper environmental policy and translating it into institutions whose capabilities need to be enhanced so that they can function effectively as an integral part of the ESSD strategy.

We now consider in the next section a policy framework which may assist a nation like India with its objective of putting in place ESSD programs.

III. A FRAMEWORK FOR ENVIRONMENTALLY SOUND AND SUSTAINABLE DEVELOPMENT

Each nation needs to bring the issue of ESSD from the margins to the mainstream of its political thinking and decision-making. A suggested framework (Cf. Figure 8.1) illustrates several interlocking mechanisms which should be considered by a country in its attempt to develop an integrated ESSD policy and pollution control strategy.

Policy Instruments
A country can utilise two types of policy instruments to attain its pollution control objectives: regulatory mechanism, or effluent charge strategy. The regulation-enforcement instrument requires that the authorities take the following four steps: set rules and regulations government the behaviour of industries in each of the sectors (including environmental audits, effluent control devices, maximum allowable limits on discharges, and so forth); establish a set of penalties for non-compliance; continually monitor the actions of targeted industries so that the instances of non-compliance can be detected with spot-checks and regular audits; and finally, make timely use of the judicial process in seeking the imposition of penalties on the defaulting industries.
Figure 8.1: National Framework for Environmental Policy and Management.

The effectiveness of this approach is based on the premise that even minor violations, if detected, would not be ignored by the enforcement authorities, that defaulting industries would first be given an opportunity to mend their ways before forced to pay major fines or injunctions, and that the enforcement authority has sufficient budget and human resources to enforce the law.

The Effluent Charge Strategy uses economic incentives such as effluent or emission charges. In order for this strategy to work, the enforcement authority ought to consider the following three steps: determine a set of charges or prices per unit of discharge of each polluting substance that is predicted to induce the necessary abatement actions on the part of polluters; continually monitor the level of discharges as well as establish a system of self-reporting with spot checks and environmental auditing mechanism; and levy the pollution charge over the reporting period. This approach provides a graduated incentive to industries by making pollution itself a cost of production. It also provides incentives for technological innovations.

Institutional Change
As the Brundtland Report indicated, environmental protection and management can no longer be safely left to weak and underfunded departments or to several departments with overlapping responsibilities. It is not enough to improve the quality and transparency of decision-making. The existing institutions and procedures must also be changed. Environmental considerations must be formally recognised as essential decision-making criteria within government and private sector organisations. To improve decision-making, all these partnerships must be strengthened and expanded.

Legislation Needed
To protect public health and the environment, effective laws should be passed and vigorously enforced. For example, through the Environmental Impact Assessment (EIA) process, governments should ensure that environmental factors are considered in decision-making. This can be done through the use of such regulatory mechanisms as bans, standards, guidelines, and permits.

National Environmental Standards
National standards pertaining to water, air, effluent emission, noise, waste, pesticide residues and odour should be established by all governments. It should be noted though that strengthened standards can only be achieved through increased investments from both public and private sectors as well as by concerted action on the part of the government regulatory agency.
Laboratory Testing and QA/QC Procedures
To monitor industrial emissions, effluents, and other polluting substances, a network of environmental laboratories is needed (both in public as well as in private sectors. To ensure that the procedures used by all the laboratories (especially those in the private sector, or even those operated by other ministries) are appropriate, and that properly calibrated analytical instruments are being used, there should be a proper accreditation programme to maintain the necessary quality assurance (QA) and quality control (QC) procedures. Without such a programme, prosecution of an environmentally-related offence may be difficult if the competency of the laboratory doing testing and analysis is in question.

Environmental Enforcement and Compliance
The success of enforcement and compliance strategy will depend on gathering sufficient evidence and information. The evidence in the form of a sample is generally sent to an accredited laboratory for analysis and testing. Enforcement involves regular inspection and monitoring to verify compliance, investigation of any violations, and applying measures to compel compliance. Prosecution and conviction is the final stage in the compliance strategy.

Environment Audit
Environmental audit is a basic management tool to be used by enterprises and commercial concerns to evaluate how well their management system and equipment are performing with respect to environmental laws and standards. It encourages industries to adopt low waste technologies (LWTs) and helps in minimisation of resource consumption. Environmental audit should be seen by industries as a part of their QA/QC process so that they can establish a “green edge” over their competitors in environmentally sensitive markets, both domestic and foreign. Governmental regulatory agencies should act as advisers to industries rather than enforcers; enforcement and compliance then becomes a joint responsibility.

Need for Public Participation in Decision-making
There is a growing recognition that the public has a right to information and that more direct citizen involvement will reduce conflict, enhance trust in agency decision and improve the quality of decision-making. Public involvement allows for raising of new issues and serves to counterbalance narrow agency biases.
Active participation is necessary to ensure that policies reflect public preferences. Procedural justice is necessary to foster public acceptance of government decisions.

**Economic Instruments**
Economic instruments that reflect environmental costs will encourage industry to take the environmental consequences of their actions into account. Possible measures include effluent taxes, tradable emission rights, deposit/refund systems and user charges. Sustainable development requires appropriate resource pricing and economic instruments to achieve environmental objectives. Used properly, these can ensure that the environment is more fully considered in production and consumption decisions made at all levels of society.

**Strengthening Partnerships with Stakeholders**
Better environmental decision-making requires cooperative efforts at all levels and with all the stakeholders. In addition to government, other stakeholders consist of the following groups: industry owners and operators, environmental non-governmental organisations (NGOs) and various community organisations, tribal and aboriginal communities, labour organisations, and various professional bodies. Each of these groups as an equal stake in the conversation, protection and sustainable use of the environment. The environmental NGOs are playing a crucial role in educating people about environmental issues. Business is an essential partner in the search for, and implementation of, effective solutions to environmental problems. Labour has an important role in changing the way decisions are made and in working with governments and the business community to achieve environmental objectives. Women, individually and through the many organisations of which they are a part, are also a key to changed decision-making. These partnerships will be essential in the long-term pursuit of achieving sustainable development.
IV. ASSESSING THE PERFORMANCE IN INDIA

The framework discussed in the previous section suggested that following mechanisms for an integrated environmental management policy and programs: (a) policy instruments, (b) institutional changes, (c) necessary legislation, (d) setting national environmental standards, (e) laboratory testing and QA/QC procedures, (f) mechanism for enforcement and compliance, (g) environmental audits, (h) need for public participation, (i) economic instruments, and (j) strengthening partnership with stakeholders. Let us see how India’s policies and programs measure up against these factors.

Environmental Policy
Most of India’s environmental policies and programs were introduced before the economic liberalisation policies in the early 1990s. The National Conservation Strategy and Policy Statement says: “The primary purpose of the strategy and the policy statement is to reinforce our traditional ethos and to build up a conservation society living in harmony with Nature and making frugal and efficient use of resources guided by the best available scientific knowledge”. However, the capacity to transform this rhetoric into reality of building a conservation society against the onslaught of rapid economic growth will be difficult. Even when policies are translated into legislation, lack of appropriate research tools, financial resources, human management capabilities, and the time constraints to enforce measures result in administrative deficiency. In such circumstances, judicial remedies remain the only option available.

Institutional Changes
The Government of India established a Department of the Environment in 1980, then expanded its mandate in 1985 to include forests and giving it the status of the Ministry of Environment and Forests. A Central Pollution Control Board and State Pollution Control Boards were created to regulate pollution prevention activities. There are a number of government departments and ministries, including research organisations, which are involved in the environmental protection and conservation programs. The Ministry has initiated various legislative and administrative actions. However, environment is a state matter and the effectiveness of compliance, monitoring, and regulation depends much upon the machinery in the States. It is here where there appears to be a bottleneck, and it is here where the real battle of ESSD is going to be fought.
Environmental Legislation
India’s main environmental law is the *Environmental (Protection) Act* which was passed in 1986 after the Bhopal industrial tragedy. India’s *Environmental (Protection) Act* is supported by two earlier pieces of legislation: the *Water (Prevention and Control of Pollution) Act* 1974 (with its amendment in 1988), and the *Air (Prevention and Control of Pollution) Act* 1981 (with amendment in 1988). There are other supporting laws such as the *Wildlife (Protection) Act* 1972 (amended in 1983, 1986, and 1991), the *Forest (Conservation) Act*, 1980 (amended in 1988), the *Public Liability Insurance Act* 1991, and the *Water (Prevention and Control of Pollution) Cess Act* 1977. These laws provide central and state governments with ample authority to control point source pollution. However, various institutional impediments (such as inadequate institutional capability, policy conflict, bribery, and undue emphasis on command and control in the administration of laws), 20 and the slow movement of cases through courts impede progress in this area.

National Environmental Standards
Under Part II, Section 3 of the *Environment (Protection) Act* of 1986, the central government has the authority to lay down standards “for the quality of the environment in its various aspects” and “for emission or discharge of environmental pollutants from various sources whatsoever”. Further, the government is authorised to develop procedures and safeguards for handling of hazardous wastes. 21 Effluent and emission standards have been specified for a variety of industries.

Laboratory Testing and QA/QC Procedures
The *Environment (Protection) Act* of 1986 empowers the central government to establish or recognise environmental laboratories and institutes. 22 The Act further provides, under Section 23, the authority to the central government to delegate this power to the state government and other authorities. The federal government has designated more than 70 environmental laboratories throughout the country the analysis of water and air samples. However, two things remain to be done: (1) in order to have the same nation-wide QA/QC process, there should be a standard
procedure which must be followed by all such recognised laboratories with respect to testing, release of test-results, and protection of confidentiality; and (2) there should be a national training program in testing procedures for all technical and professional personnel in such environmental laboratories.

**Mechanisms for Enforcement and Compliance**

In India’s case, several areas of environmental protection fall in the category of administrative traps. With the exception of solid and hazardous wastes, nuclear waste, and acid rain which are clearly in need of more regulation, the problem is not of numbers but of design and enforcement. It is not the absence of policy, but the inadequacy of its design as well as its enforcement that are at the core of the problem. In addition, there is a possibility that the compliance system may become excessively bureaucratic and administratively punishment-oriented. Under such circumstances, industries will have to seek court interference or to use other illegal methods to delay the compliance violations.

**Environment Audits**

On March 13, 1992, the Government of India through its gazette notification [No. GSR 329 (E)], modified the Environmental Protection Second Amendment Rules thereby requiring that any person carrying on an industrial activity (including operation and processing) shall submit an environmental audit report for the financial year ending on March 31st in the form prescribed to the State Pollution Control Boards. The form requires information such as quantity of raw material (per unit of product) used in the processing and manufacturing (including water used), quantity of pollutants generated in terms of air and water, the quantity of solid waste generated, and information on recycling and reuse of such waste. The basic thrust of this scheme is to promote environmental accountability at the point source level, adoption of low waste technology, and the minimisation of raw resource consumption. Out of hundreds of thousands of industries in operation in India, only 2995 submitted audit reports by December 1993. As there was a widespread non-compliance, deadlines were extended a number of times.

Industries are against this requirement because they feel that the data may not remain confidential, or the data may be used by other regulatory agencies for prosecution.
The environment regulatory agencies of India have an extremely difficult task of assuring industries that their audit reports will not be used to instigate prosecution or litigation. There is also a lack of trained and qualified professional environmental auditors. Finally, the cost of hiring environmental auditors may be prohibitive to small industries as the fee by be between 75,000 to 200,000 Rupees. And even in those cases where audit reports have been filed, these “are not double-checked to find out whether the forms hold the correct data…the industries do not get any feedback”.

**Economic Instruments**
The thrust of India’s environmental policy is regulation and enforcement. However, various fiscal incentives have been provided to industries so that pollution from point sources can be controlled. According to the 1993-1994 Annual Report of the Ministry of Environment and Forests, industries may seek: (a) 100 percent depreciation allowance for installing pollution control devices; (b) lowering of custom and excise duties for goods and material used for pollution control programs; (c) financial assistance (for small-scale industries) for capital investment in effluent treatment plants; and (d) loans at substantially reduced rates of interest by banks for the instalment of pollution control systems. However, the effect of these incentives has been minimal. Either industries are reluctant to seek loans and financial assistance due to the prevailing corruption-plagued decision-making practices of financial institutions, or they feel that they are better off by handling the situation through extra-legal manners until such time when the system of enforcement and compliance becomes universally tight. In addition to the availability of such incentives, the government is also considering instituting an effluent tax, resources-cess for industry, and implementation of environmental standards based on the production capacity of industries and resources used.

**Strengthening Partnerships with Stakeholders**
There is an erroneous perception in India that there are only two groups, governmental institutions and environmental NGOs who ought to be recognised as the main stakeholders for the environmental protection and conservation. However, owners and operators of various industries are affected by government policies, rules and regulations. Further, India has a significant number of tribal areas. Tribal people who have been victimised by various developmental projects are now resisting changes. Deforestation, mining, and hydro-power projects are affecting their health, indigenous culture and their environment. In addition, one should not exclude cultural and religious organisations.
The federal government policy statement on environment and development has acknowledged that NGOs, citizen groups and village level institution like forest panchayats and Gram Sabha “should be empowered with locus standi and support for mobilisation of public opinion and participation in development activities”. Further, a network among NGOs and interface between them and governments is needed “to work on community involvement, providing information on environmental surveillance and monitoring, transmitting development in science and appropriate technology to the people at large”.26 In addition, the role of women’s organisation related to the environmental protection is being encouraged. One of the most celebrated examples of public participation and NGO activity is the Sardar Sarovar Dam controversy which the Narmada Bachao Andolan (movement to save Narmada River) under the leadership of Ms. Medha Patkar has undertaken. In almost every area of environmental protection, the government’s decision-making process has rarely been participatory. When people face bureaucratic hurdles and insensitivity on the part of governmental machinery, they use the instrument of satyagraha. Local groups (such as Van Samitis – forest committees in Palamau, Van Suraksha Samiti – forest protection committee in Tehri Garhwal, or Kerala Sastra Sahitya Parishad – which took the cause of save Silent Valley) are taking serious interest in the protection and conservation of their surrounding environment.

The role of environmental NGOs in India has been steadily growing and their numbers are increasing. In 1989, according to the World Wildlife Federation (WWF) India, there were 908 NGOs and voluntary organisations registered for work on environmental related causes.27 Notwithstanding a healthy growth of NGOs working in the environmental field, they are yet to be accepted by governmental machinery as equal partners simply because some of them have aligned themselves with the existing adversarial political process. At the same time, environmental NGOs are generally distrustful about actions of environmental ministry/department officials because from their viewpoint, governmental machinery is inflexible and unimaginative and most government officers do not show commitment to the cause of environmental conservation and protection. There is a need for both sides to work closely.
CONCLUSIONS

India has ample legislative and administrative authority to handle various environmental problems. Enforcement and compliance remain the biggest challenge before the federal and state governments. Inter-ministerial jurisdictional conflicts, and the lack of proper coordination and cooperation among the government ministries plague the system.

A framework for sustainable development and environmental management, as discussed in an earlier section of this paper ought to vary from country to country. For example, in the case of countries such as India and China, it has to be charted against the backdrop of tremendous population pressure which in turn has given rise to deforestation, soil erosion, the silting of rivers and streams, and desertification. Development for such nations will have to become synonymous with environmental protection and conservation. Sustainable social and economic development calls for a determined fight against poverty, which is related to population pressure. Thus, at the national level, developing nations should consider establishing a national population policy which recognises the interaction between population and the environment. This framework would call for action on three fronts: evaluating the environmental implications of population growth and its urban/rural mix, assessing the environmental impact of the public’s use of natural resources, and considering human-centred development measures (such as fulfilling basic needs and upgrading the status of women) as an integral part of development policies.

It should be noted that the state of the environment of a nation cannot be isolated from the state of the world environment and economic development. It is a closed circle. Developing nations are acutely aware of the fact that poverty is the greatest threat to the quality of the environment anywhere. The poor not only suffer extensively from the environmental damage caused by their rich cousins, but they themselves are also the cause of environmental decline. Environmental degradation and economic deprivation are interrelated. No country or a group of nations can tackle the world-wide problem of environmental pollution single-handedly. We live in a world of shared and interacting environmental resources. It is imperative for us to believe in the right of all people anywhere on earth to have access to a quality environment.
One thing is clear about the environmental crisis in India; during the past two environmental decades, especially since the 1984 Bhopal disaster, there has been a steady and growing awareness among the elites about the ecological challenges facing the country. This has been followed by an impressive growth of institutions seeking to deal with the problems of pollution and environmental conservation both at the national and provincial levels. At the same time, the mounting pressures of population, expanding urbanisation, and the growing base of poverty have led to the ecologically unsustainable exploitation of natural resources which is threatening the fragile balance between ecology and humanity in India. Although India is not alone in this challenge, nevertheless, its problems will have to be tackled by its own people. The real challenge before India is how to meet the basic needs of its growing population on an overburdened land, and leave a legacy for its future generation so that they may also enjoy the bounty of nature which the present generation is recklessly exploiting. The hitherto unimaginative developmental strategies and largely imported developmental schemes will have to be replaced by environmentally sound and sustainable development. India must search for ways to usher in the Environmental Sarvodaya so that the problem of waste becomes manageable as the nation prepares to enter the Twenty-first Century. For this, the country would do well not only by borrowing from its rich cultural heritage and traditional conservation ethos, but also by learning from the experience of industrialised nations, as well as looking for a way ahead keeping in harmony with environmental imperatives of the land.

ENDNOTES

2. World Commission on Environment and Development, p.5.
5. The source of this term is Gita, verse 20, chapter: Loka-sangrahamevapi sampasyan kartum arhusi. The concept has been explained by Tilak in his commentary on Gita: the word ‘Loka’ has a comprehensive meaning which includes both humanity and the entire cosmos while ‘Sangraha’ means “maintaining, feeding, protecting, and defending it [Loka] in a proper way, without allowing it to be destroyed”. Bal Gangadhar Tilak, Shri Bhagavad-Gita Rahasya (Poona, India: Tilak Brothers, 1902), p.927.
20. See, for further elaboration, E. Achtell, “Institutional Impediments to Sustainable Development: A Case Study of Industrial Waste Management in India,” M.A. Thesis prepared under the supervision of O.P. Dwivedi (Guelph, Canada: University of Guelph, Department of Political Studies, 1995), pp.52-61.
INTRODUCTION

Not long ago, both domestic and industrial wastes were considered as residuals meant to be discarded. However, perceptions have changed during the last few years. One of the major environmental issues facing a developing nation like India is how to manage industrial and commercial wastes. For example, the mega cities of India produce huge quantities of waste some of which may contain toxic and hazardous materials. The incident (November 13, 1994) of poisonous emissions from burning of waste material believed to be cyanide, by a rag picker in East Delhi, which made about 500 people ill and caused four deaths illustrates how lethal material gets into garbage.¹

This paper is an analysis and review of various policies, rules and regulations which govern the process of waste management in India with particular emphasis on industrial wastes. It also examines the area of conflict and cooperation arising among different levels of government. Reviewing the policies of the federal government of India in this respect and the relative role of state governments and local authorities (with a focus on the state of Uttar Pradesh and the industrial city of Kanpur as a case study), the paper makes a strong plea for a more rigorous coordinated effort at various levels including the national government, state government, urban local bodies, international agencies, the community and the private sector in order to tackle the problem of waste management. Intergovernmental cooperation is most essential for achieving the goals of environmental-friendly waste management. [For background to the issue of sustainable development and environmental management in India see papers by Dwivedi, Achtell and Coates in this volume].
I. POLICIES AND LEGISLATIONS ON ENVIRONMENT PROTECTION AND POLLUTION CONTROL IN INDIA

To protect the environment from pollution due to various sources, there is no dearth of laws, regulations, policies and enabling legislation in India. In the Constitution of India, there are some specific provisions on environmental protection. Besides there are acts like the Water (Prevention and Control of Pollution) Act 1974, the Water (Prevention and Control of Pollution) Cess Act 1977, the Air (Prevention and Control of Pollution) Act 1981, the Environmental (Protection) Act 1986, and a series of Rules thereunder including the Manufacture, Storage and Import of Hazardous Chemicals Rules 1989, and the Public Liability Insurance Act 1991. Most of these acts deal with industrial pollution and industrial effluents. In another act, the Factories Amendment Act 1987, there is a provision by which Site Appraisal Committees set up by the state governments scrutinise all applications for new hazardous plants as well as expansion of existing plants, to assess the risks to the surrounding environment. The Environment (Protection) Act 1986 is another enabling legislation with a broad sweep to prevent, control and abate all types of environmental pollution. It defines procedures and safeguards for the manufacture and handling of hazardous substances. The Water (Prevention and Control of Pollution) Act 1979 established the Central Board for the Prevention and Control of Water Pollution as well as similar boards in all twenty-five states. Under the Act, the state boards are empowered to formulate and enforce standards related to industrial effluents. The Central Board performs similar functions in the union territories and coordinates activities among the state boards.

The government of India, while setting lofty objectives for rapid industrial growth and development in its statement on Industrial Policy (1991), has categorically stated that the pursuit of these objectives will be tempered by the need to preserve the environment and ensure the efficient use of available resources. The government of the state of Uttar Pradesh also placed similar emphasis on environmental protection and pollution control in its Industrial Policy of 1994 as:
...considering the importance of environment, special efforts will be made for protecting the ecological balance and environment while promoting industrialisation. Directorate of Environment will also play the role of friend and guide. It is in this context that a Working Group has been constituted under the chairmanship of Director, Environment. This Working Group has representatives from industrial organisations. The Pollution Control Board and the Directorate of Environment shall effectively publicise information pertaining to prevention of pollution. Accreditation shall be given to private institutions so that the objective of keeping the environment clean is fulfilled and industrialists too are not unnecessarily harassed.7

As in many other countries, the problem lies in the implementation of these policies. An official in the Office of the Directorate of Industries, Kanpur, remarked that “no work is done on the implementation level no matter how much policies are made each year”.8 There are many policies which are respected more in violation than in practice by the industries due to governmental apathy. The government of India is conscious about the problem of implementation but the remedial measures taken are simply inadequate.

II. INTERGOVERNMENTAL ASPECTS OF WASTE MANAGEMENT IN INDIA

Crucial to effective implementation is proper coordination among the different government agencies. In this paper the roles of the federal government of India, the state government of Uttar Pradesh and the municipal government of Kanpur in controlling industrial pollution are discussed. Also, comment is made on policies with regards to industrial technology, programs on research and development (R&D), various incentive programs influencing locational decisions and investment priorities with particular emphasis on Uttar Pradesh and the city of Kanpur. These do impact the generation as well as the management of industrial wastes.
Role of the Government of India

The federal structure of India has made the central government more responsible and accountable in environmental protection and pollution control than the states and the union territories. Through the Ministry of Environment and Forests (MEF) and the Central Pollution Control Board (CPCB), the federal government plays a vital role in safeguarding the quality of the environment. The main objectives of the MEF are “conservation and survey of flora, fauna, forests and wildlife; afforestation and regeneration of degraded areas and protection of environment”.9 The MEF manages its function of prevention and control of pollution primarily through the activities of the CPCB. The Ministry, through its Environmental Impact Assessment (EIA) responsibilities, has developed guidelines for the preparation of EIA statements. By this process various projects are either approved or rejected on the basis of some set standards. In the language of the MEF:

While according environmental clearance necessary safeguards for pollution control, energy conservation, wastewater recycling and adoption of clean technology were stipulated for avoiding adverse impact on the environment.10

In the case of industrial pollution, the MEF sets “time bound targets for compliance of pollution control requirements in highly polluting industries”.11 The central government also provides assistance to the State Pollution Control Boards (SPCBs) and state/union territory Departments of Environment for “strengthening their manpower and procurement of scientific equipment”.12

According to an Additional District Magistrate of Kanpur,13 most of Kanpur’s industrial waste is dumped untreated into the Pandu River, which meets the Ganga downstream from Kanpur. Despite the fact that this waste enters the Ganga downstream, it is still recognised as Kanpur’s responsibility. The city, or more specifically, the District Magistrate, is responsible for ensuring that court decisions related to industrial polluters are complied with. The concerned courts, in turn, receive recommendations from the Uttar Pradesh Pollution Control Board (UPPCB) that a particular industry be closed.

Central Pollution Control Board

Being the principal pollution control organ of the MEF, the CPCB is at the apex of the pollution control bureaucracy. The CPCB’s objectives are “to promote cleanliness of wells and streams in different areas of the states by prevention, control and abatement of water” and “to improve the quality of air and to prevent, control or abate air pollution in the country”.14
The activities of the CPCB include”

(i) setting minimum standards for ambient air and water quality
(ii) providing technical advice to SPCBs
(iii) coordinating the activities of the SPCBs
(iv) training SPCB personnel
(v) formulating action programs at the national level for dealing with problem areas and problem industries
(vi) developing methodologies for monitoring
(vii) publishing documents, including comprehensive industry-specific documents which provide information on issues such as available technology, costs and regulations disseminating information to SPCBs for action, and
(viii) providing technical information to initiatives such as the Ganga Action Plan.\textsuperscript{15}

The CPCB carries out these functions as Central Board at the national level and as the state board for the states and union territories.

**National Waste Management Council**

Realising the need to establish a focal organisation to coordinate activities of various sectors of the economy, the government of India constituted the National Waste Management Council (NWMC) in 1990. The objectives of the NWMC are to\textsuperscript{16}:

(i) promote and collect, collate and publish information regarding the availability of wastes, technologies for waste and markets for recoverable materials
(ii) analyse information to overcome constraints to commercialisation of available technologies for both waste utilisation and waste minimisation and identify areas in which new technologies need to be developed
(iii) render advice to the government, industry and such other sectors as may seek their advice on
the aspects of waste management and on incentives/disincentives needed to facilitate waste
utilisation
(iv) recommend R&D schemes for developing new technologies
(v) advise government on fiscal//regulatory measures to promote waste utilisation, and
(vi) promote of measures to create awareness among those concerned.

The setting up of a coordinative body like NWMC by the central government is a constructive
step. Expressing its concern over the hazardous nature of various industrial wastes and lack of
adequate control provisions, a sub-group of NWMC has suggested that “the industries should be
encouraged to utilise wastes for recycling and reuse”. It further recommended the provisions of
“tax incentives for this purpose to encourage investment in this area”.

The Government of Uttar Pradesh and Control of Industrial Pollution
As in many federal countries, the implementation and enforcement of the environmental law and
policy formulated by the central government of India is primarily the responsibility of the state
governments. In this section, the role of the state in the enforcement of industrial pollution control
regulation is examined within the context of the state of Uttar Pradesh.

Uttar Pradesh’s Department of Environment DOE) and the UPPCB are instrumental in
enforcing the pollution control measures as per the directive regulations of the central government.
Their main function is to ensure that industries obey the regulations and use pollution control
mechanisms. The central government assists with the funding of the DOE activities. Through
UPPCB, the DOE issues no objection certificates to industries. The issuance of the certificate
involves checking the plans for industrial units to ensure environmental considerations. The DOE
operates its own research laboratories and provides advice to industry on how to meet
environmental standards. It also organises conferences and seminars. The UPPCB implements
central government regulations at the field level. Among its major functions are:
Enforcement of Pollution Control by the Government of Uttar Pradesh
The monitoring and inspection activities of UPPCB help in identifying industries which violate pollution control standards. A deadline for compliance is then generally set for those industries. In order to assist industries in complying, the UPPCB has technical consultants which will, for a fee, advise on technology change. If, after the deadline for compliance has passed, the defaulter’s emission remain above he described standards, the UPPCB will initiate prosecution on its own behalf. The capital of Uttar Pradesh, Lucknow, has established a special ‘environmental court’ for this purpose.

According to the various acts, penalties upon prosecution can include closures, fines, and/or imprisonment. For example, for decades the holy river Ganga has been receiving millions of untreated domestic sewage from hundreds of towns and cities and toxic industrial effluents from thousands of industries, located along its 2,500 kilometre stretch. This once self-purifying river is slowly being turned into a toxic dump by highly polluting industries, as well as by municipalities along the Ganga Basin. Taking the entire Ganga Basin area of Uttar Pradesh (excluding Kanpur) as an example, between 1987 and 1993, 860 industries were identified as “water polluting”. Out of these, 191 did not respond to notices issued to them by UPPCB in September 1993 for submission of a report on pollution control status. These ‘wilful defaulters’ were subsequently ordered closed by the Supreme Court of India. Another 3 which did not make progress regarding installation of effluent treatment plants (ETPs) were directed to close. Therefore, a total of 234 industries were ordered closed. However, 142 subsequently installed ETPs and were permitted to reopen. Of the remaining 626 “water polluting” industries, 493 installed ETPs, of which 261 were able to meet standards and the remaining 232 being in default. These defaulters are required to meet standards either by technical upgrades or by proper operation and maintenance of ETPs.
Out of the remaining 133 industries, 66 are in the process of installing ETPs and 67 have remained closed.21 The judiciary in India is thus emerging as an important player enforcing compliance with environmental legislation and pollution control standards.

**The City of Kanpur**
Kanpur, the largest city of Uttar Pradesh and the state’s business and industrial capital, is considered one of the highly polluted cities of India. It appears unable to deal with pollution despite the fact that, as one of India’s larger and most industrialised cities, it has an extensive institutional infrastructure for industrial pollution control.

**Central Pollution Control Board, Kanpur Zonal Office**
The CPCB’s Kanpur Zonal Office is the regional office of the CPCB for the states of Uttar Pradesh, Rajasthan and Madhya Pradesh.22 The Zonal Office, with a staff of 20, assists states in the implementation of national policies. It monitors emissions to the Ganga and other rivers, and provides general advice to industries on how to meet prescribed standards. The Kanpur Zonal Office has also been indirectly involved in Ganga Action Plan through the identification of 34 industries which were polluting the river. Twenty-two of these industries were Kanpur-based. Outside of its monitoring activities, the Kanpur Zonal Office does not play a direct role in the enforcement of environmental law, as this is the domain of the SPCBs. Furthermore, due to staffing and financial limitations, what monitoring and investigative activities the Zonal Office does perform are directed at large industries and industrial clusters to the neglect of small-scale industries (SSIs).23

**UPPCB Kanpur Regional Office**
With a staff of 45, the Kanpur Regional Office of the UPPCB is responsible for the implementation of pollution control regulation in the Kanpur region.24 The primary function of the Regional Office, which is one of thirty in Uttar Pradesh, is to carry out monitoring and inspections so as to ensure that ETPs are being properly operated and that effluent standards are met.

The role of the Regional Office includes ordering inspections, carrying out surprise inspections, and giving testimony in court related to allegations of default. When an industry is found to be in violation of pollution control regulation, the five district agencies empowered to implement environmental law are informed.
These are the electricity board, the water board, the superintendent of police, the industrial licensing authority, and the district magistrate. These agencies can effectively close an industry by, for example, disconnecting its power supply.

If the Regional Office is approached by an industry for advice on how to control pollution, advice is given for a nominal fee. The process usually begins with the testing of effluent to determine the level of pollution being generated before specific measures are recommended. The Regional Office also has at its disposal a technical advisory cell consisting of outside consultants. Despite the growing rate of industrialisation in the Kanpur region, the Regional Officer feels that the current system is efficient and effective in controlling pollution.²⁵

III. OTHER RELEVANT GOVERNMENT LEGISLATION

When analysing the role of the various levels of the government in environmental pollution control, one cannot forget the impact of policies. For example, policies potentially influence industrial technology and R&D programs, as well as the type of technologies adopted by industry. The government of India, in its Statement on Industrial Policy (1991), has made it clear that it “will continue to pursue a sound policy framework encompassing encouragement of entrepreneurship, development of indigenous technology through investment in R&D, bringing in new technology, dismantling of the regulatory system, development of the capital markets and increasing competitiveness for the benefit of the common man”.²⁶ Foreign investment and technology collaboration will be welcomed to obtain higher technology, to increase exports and to expand the production base.²⁷ According to the government, “foreign investment would bring attendant advantages of technology transfer, marketing expertise, introduction of modern managerial techniques and new possibilities for promotion of exports”.²⁸ Further, “in order to invite foreign investment in high priority industries requiring large investments and advanced technology, it has been decided to provide approval for direct foreign investment up to 51 percent foreign equity in such industries”.²⁹
“With a view to injecting the desired level of technological dynamism in Indian industry, the government will provide automatic approval for technology agreements related to high-priority industries within specified parameters. Indian companies will be free to negotiate the terms of technology transfer with their foreign counterparts according to their own commercial judgements”.

“Hence, in its industrial policies, the government of India is emphasising foreign investment and technology transfer as well as technology import. This no doubt will be vigorously pursued in the present atmosphere of rapid economic liberalisation. The assumption is that Indian industries, facing the competition and pressure of foreign technology import, will invest much more in R&D to develop indigenous competence”.

The industrial technology policy of the government is bound to influence pollution control in the sense that some of the imported technologies may include those that reduce, recycle or treat wastes generated. The state of Uttar Pradesh has also devised its industrial policy with the aim of “creation of a healthy and progressive industrial environment” for “boosting the pace of industrial development”. Among the strategies are “encouragement to foreign capital investment in partnership with Indian industrialists for setting up of industries and developing infrastructural facilities, easy availability of institutional finance for setting up of an industry and their expansion, identification of priority sectors for industrial development and an incentive policy to promote such industries”.

In order to attract large industrial and commercial undertakings to the state, it has been proposed that special incentive be given to such units. As such, an “empowered committee has been constituted under the chairmanship of the Chief Secretary” of the state “to ensure timely release of sanctions for putting up an industry”. This committee has been authorised to consider special concessions to industrial units which have an investment of more than Rs 50 crore on a case-to-case basis. Decisions shall be taken on the basis of location of the unit, employment potential and the possibilities of downstream projects, apart from the contribution to the general economic development of that area. Regarding foreign investment, the state government is in favour of encouraging foreign capital investment, with special emphasis being laid on attracting investment for developing infrastructural facilities.”
“Optimum utilisation of existing investment by industrial units is the prime concern of the state government”. “A number of facilities/concessions have been provided to the sick units with reference to deferment of Trade tax, electricity dues, excise dues and payment of debt”.36

In the city of Kanpur, R&D activities are being undertaken in some institutions like the Harcourt Butler Technological Institute (HBTI), the Indian Institute of Technology (IIT), the National Sugar Institute, the Central Leather Research Institute (CLRI), and the Government Textile Institute in the field of industrial waste technology.37 Apart from HBTI and IIT, which are doing research for all kinds of industries, the institutions mentioned above are undertaking specialised research seeking cost-effective technological approaches to control pollution, minimise waste and treat the effluents. The Kanpur Branch of the National Environmental Engineering Research Institute (NEERI) is involved in hazardous waste facility siting.38

Interestingly enough, despite the fact that there is no dearth of policies on environmental protection and industrial pollution control, officials concerned with industries are themselves sceptical about the government’s seriousness in translating these policies into action. Higher officials in the District Industrial Centre, Kanpur, and Directorate of Industries, Kanpur, take the general view that there is no visible work and sincere initiatives on the part of the government, either the union or the state. When pondering over these remarks, one is left wondering who is the government these bureaucrats refer to. Are they themselves not part of the government? Should they not feel responsible for the failure of the government in successfully abating pollution?

This scepticism among government officials has also been expressed regarding recent policy pronouncements on clean technologies. The third conference of Chief Ministers of the state governments held on September 17th, 1994 recommended that a national policy on clean technologies for power generation be enunciated. Such a policy could bring about a replacement of coal and other polluting fossil fuel-based technologies by sustainable renewable technologies.39 It was agreed to take up demonstration projects for recovery of energy from urban, municipal, industrial and agricultural wastes and to provide the necessary budgetary allocations in state plan for this purpose.
The ministers also agreed to issue suitable directives to concerned authorities, local bodies and industry associations to include energy recovery as an integral component of the waste disposal schemes and programmes for which the central government would also provide suitable technical and financial support.

With regard to the above recommendations, it was mentioned by yet another official in the Directorate of Industries, Kanpur, that although the policy was very good, the instructions given to the state government by the central government were not feasible. Due to practical problems relating to enforcement as well as the paucity of financial resources, objectives could not be achieved in the near future. Another higher official in the same Department was critical of the judiciary and the CPCB (Zonal Branch) for their orders to close industries without giving them the proper directions as to where to get the effluent control devices and the technical know-how to make them functional. The official was also discouraged about the level of coordination among various departments and government organisations involved in pollution control. It was felt that there was a discernible apathy among them (i.e., to mutually interact and communicate with each other). The same official was of the opinion that inter-departmental relationship was in a state of confusion.

The official was quite critical of the CPCB’s inclusion of even smaller industries in the 17 categories of industries identified as responsible for causing pollution. When accusing the central government of sometimes formulating faulty and impractical policies, the official alleged that the state’s policies were very much generalised without pinpointing priority areas.

There is plenty of evidence that notwithstanding the numerous environmental regulations and policies, the industrial waste pollution problems appear unaltered. There are several explanations. The overlap and duplication of supervisory powers generate confusion and conflicts among various departments and agencies concerned with the problem. In many places the central government has failed to bring coordination and harmonious division of functions among the various organisations responsible for pollution control and environmental protection. Practical advice and guidelines to industries to install required technologies for effluent control have been much less than satisfactory. Little attention has so far been given to the problem of developing suitable waste technologies for the industries. The lack of professional expertise in sector agencies has often resulted in the selection of unsuitable equipment and the application of technologies that not cost-effective.
There is also lack of coordination and direction in R&D efforts and inadequate incentives for technology transfer from the laboratories to industry. No enough funding is provided for pilot-scale demonstration of laboratory results. Low value is placed on technology transfer by scientific and technological personnel engaged in R&D work.42

One of the leading experts in the area has suggested the following priority areas for a suggested plan of action:

(a) a national Master Plan should be prepared to highlight important issues, identifying thrust areas, and develop a work programme along with the framework of technical and financial support needed to achieve it

(b) appropriate technical guidelines for industrial waste management activities should be developed

(c) demonstration of pilot projects at national and state level on proper design and operation of waste management systems should be established

(d) adequate R&D activities to develop appropriate equipment and technology should be carried out vigorously, and

(e) effective sector monitoring and planning at the national level, with continuous and systematic data collection, should be developed.43

There is also a great need to clearly define the boundaries of responsibilities of various organs of the government related to the function of pollution control and industrial waste management so as to avoid the duplication and overlapping of jurisdiction and the resulting conflict and confusion.

CONCLUSION

This complex problem of industrial waste management and industrial pollution control represent a formidable challenge for the government at all levels in India due to technical, institutional, legal and such other constraints. The problem needs to be tackled by coordinated efforts among various levels of government and agencies if cost-effective solutions are to be found.
There should be coordination in technology transfer, information dissemination, financial assistance and monitoring by the central and state governments, and regulation of industries. The state governments should be consulted on a regular basis by the central government in various policy and implementation matters on the management of waste and controlling pollution.

In the field of technology, emphasis should be given to low waste technologies. With its vast technical manpower and scientific skill, India is capable of technological innovations in the area of industrial waste management.44

ENDNOTES

2. Article 48A, which was added to the section on Directive Principles of State Policy under the Constitution (Forty-Second Amendment) Act of 1976 decrees that the “State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country”. Similarly, article 51A(g), which was also added in 1976 under a new chapter of the Constitution entitled “Fundamental Duties”, states that all citizens have a responsibility “to protect and improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures”.
8. Interview by A.K. Biswal with Mr. Trilok Singh, Assistant Director of Industries, Uttar Pradesh, Directorate of Industries, Kanpur on 20 July 1995.
19. Achtell, p.44.
23. Achtell, pp.50-51.
32. Government of Uttar Pradesh, Uttar Pradesh Industrial Policy, p.3.
33. Government of Uttar Pradesh, Uttar Pradesh Industrial Policy, p.3.
34. Government of Uttar Pradesh, Uttar Pradesh Industrial Policy, p.11.
37. Based on information provided to A.K. Biswal by Dr. R.K.Trivedi, Harcourt Butler Technological Institute (HBTI), Kanpur on 20 July 1995.

39. This information was obtained from a booklet shown to A.K. Biswal in the Directorate of Industries, Kanpur, however the document was not made available by the official.

40. In an interview with Mrs. Shashi Singh, Assistant Director of Industries, Uttar Pradesh, Directorate of Industries, Kanpur on 21 July 1995.


42. Shukla, p.135.

43. Shukla, p.136.

INSTITUTIONAL IMPEDIMENTS TO THE USE OF LOW WASTE TECHNOLOGIES: A CASE STUDY OF INDUSTRIAL WASTE MANAGEMENT IN INDIA

E. Achtell

INTRODUCTION

It has been said that India’s environmental problems can be classified into two broad categories. The first refers to problems arising as negative effects of the process of development and the second refers to those arising from conditions of poverty and underdevelopment.1 It has also been argued that in order to overcome these interrelated problems, a concerted effort at integrating environmental considerations into decision making at all levels is essential.2 In other words, it is necessary to “harmonise economic development and environmental imperatives.”3 This is because “environmental conservation is, in fact, the very basis of all development.”4

The purpose of this study is to demonstrate that although the groundwork for a movement towards sustainable development has been laid in India, there is a serious gap in implementation due to various institutional impediments. This paper looks specifically at the non-nuclear industrial waste management component of sustainable development. In this area, despite an ostensibly stringent framework of pollution control regulation as well as a policy agenda stressing the use of low waste technologies (LWTs), the problem of industrial pollution is worsening. This work, which is based on an analysis of primary and secondary documentation, as well as personal interviews and participant observation carried out in India from August to November 1994, will focus specifically on the institutional impediments to the adoption of LWTs.
I. THE PROBLEM OF INDUSTRIAL WASTE IN INDIA

While India faces a myriad of pressing environmental problems, this work focuses on the problem of industrial waste management. Under the current program of economic liberalisation, intended partially to overcome the problem of international debt and encourage foreign investment, India’s significant industrial sector is likely to grow at a faster rate. These “strides in industrialisation” have brought “unwanted and unanticipated consequences.” Migrants leave environmentally bankrupt rural areas and seek work in poorly regulated, polluting, and accident-prone industries. These industries not only contribute to the devastation in the countryside, through effluent and the demand for natural resources, but also to the problem of “unplanned and encroaching urbanisation.” India is “facing a classic urban nightmare,” with all that this entails, including conflict over limited services and employment opportunities.

In 1990, India’s National Waste Management Council (NWMC) reported that due to “outdated technology” and “an unsystematic and hazardous way of (industrial waste) management” India has been experiencing “serious environmental degradation.” In 1993, the Government of India’s Environment Action Programme gave an indication as to the environmental impacts of the country’s high levels of industrial waste generation. High values of carbon monoxide, sulphur dioxide, and suspended particulate matter in cities and towns are indications of industrial pollution. Besides the obvious health and environmental impacts, the almost intolerable levels of air pollution in India’s cities are wreaking havoc on the country’s renowned architectural heritage. Low dissolved oxygen, high biochemical oxygen demand, ammonia, and heavy metals have been recorded along India’s principal river stretches. In 1994, the Government of India was compelled to identify nineteen river stretches as “grossly polluted” under the National River Action Plan. A survey undertaken by the Central Pollution Control Board (CPCB) of 241 Class II cities (population under 100,000) in 17 states “indicates that on an average, 90 percent of the water supply is polluted. Only 1.6 percent of the polluted wastewater gets treated.” In 1991 the World Bank reported that:
industrial sources, although comparatively smaller in volume, compared to municipal discharges, continue to contribute over one third of the total load of pollutants into rivers and other water bodies. About half of this load originates from large and medium scale industries, especially those in the chemical and related sectors. Sources of water pollution are particularly worrisome given the periodic water shortages in the country and already large impact of industrial sources of pollution on the quality of surface waters and groundwater reservoirs.13

The scarcity of safe drinking water has resulted in “water riots” in several cities14 and could contribute to the problem of environmental refugees. An analysis of the causes of these high levels of air and water pollution concluded that “the conventional end-of-pipe control technologies have not been able to curb pollution to the desired effect, nor able to achieve reduction in energy utilisation per unit of output.”15 Therefore, a policy shift towards the promotion of LWTs, which is consistent with the goals of sustainable development, was deemed necessary.

Although the barriers to sustainable development in both developed and developing countries are many, the problems in developing areas are of a primarily “institutional” type. Atkinson defines institutions as:

- configurations or networks of organisational capabilities (assemblies of personal, material, symbolic, and informational resources available for collective action) that are deployed according to rules and norms that structure individual participation, govern appropriate behaviour, and limit the range of acceptable outcomes.16

In essence, an institution is a conglomeration of people, rules, and organisation.17 An institutional impediment, then, refers to an inadequacy on the part of one or more of these constituents parts which renders an institution incapable of fulfilling its assigned mandate. In India there are numerous problems related to the realisation of sustainable development which fall into the category of “institutional impediments”. Before identifying the institutional impediments to the use of LWTs, an overview of environmental policy for LWT is presented.
The problem of industrial pollution in India is in part the result of unplanned and overly rapid industrialisation, as well as too great an emphasis on pollution control rather than prevention through waste minimisation. In response to this problem recognition, there exists in India a broad policy agenda for LWTs. As such, the LWT approach to industrial waste management is promoted by different environmental actors, including government agencies, international lenders, research institutes, non-governmental organisations (NGOs), and industrial organisations.

Given its position at the top of the environmental policy hierarchy, the Central Government plays a pivotal role in the promotion of LWTs in industrial development. The low waste approach is indicated in various policies and programs for environmental protection. For example, the Ganga Action Plan (GAP), launched in 1986 in response to findings that this important national river was being irreparably damaged by municipal and industrial waste, has seen the construction of 28 electric crematoria and the release of 36,000 turtles into the river near Varanasi which, “besides maintaining the river ecology also aids in pollution abatement by feeding on dead decaying detritus and other organic material.” However, the emphasis of the GAP is clearly on treatment rather than reduction of waste. The overall objective is to arrest the degradation of the Ganga through interception, diversion, and treatment of domestic sewage and “prevention of toxic and industrial chemical wastes from identified grossly polluting industrial units entering into the river”. The GAP has emphasised development of infrastructure for effluent treatment as well as monitoring of “grossly polluting industries” discharging effluents into the Ganga and its tributaries. An effort at public awareness and education has also been undertaken.

Published one and a half years after the United Nation’s Conference on Environment and Development (UNCED), and expanding upon ideas initially framed in the Policy Statement on Abatement of Pollution 1992 and the National Conservation Strategy and Policy Statement on Environment and Development 1992, India’s Environment Action Programme (EAP) “attempts to integrate concerns for conservation, sustainable development and human welfare with (India’s) quest for a dynamic economy exemplified in the ongoing process of economic reforms.”
This objective is particularly crucial as the country “moves into a trajectory of high economic growth.” Some important “priority” areas focused upon by the EAP are “control of industrial and related pollution with an accent on the reduction and/or management of wastes, particularly hazardous wastes” and “improving access to clean technologies.” Despite addressing the issue of LWTs for effective industrial waste management, the EAP provides no indication as to how actual implementation will occur, how the initiatives will be financed, or when tangible results might be expected.

Like the Government of India (GOI), international lenders, including the World Bank (WB), the United Nations, and the Asian Development Bank, profess a strong commitment to the promotion of LWTs in industrial development. An industrial waste management initiative sponsored by the WB, the Industrial Pollution Prevention Project (1994), serves as an excellent example. The overall objective and specific goals of the project are essentially the same as an earlier ostensibly successful initiative, the Industrial Pollution Control Project (1991). The Industrial Pollution Prevention Project’s emphasis on a preventative approach encompassing clean technologies and waste minimisation, as opposed to curative measures, entails the establishment of a Central Clearing House for Clean Technologies to be located at the headquarters of the National Environmental Engineering Research Institute (NEERI), Nagpur, “outreach” to minimisation circles. However, despite the sheer volume of capital being made available and the potentially positive environmental impact, none of the industries visited by the author in Kanpur had ever heard of the WB’s Industrial Pollution Control Project or Industrial Pollution Prevention Project, or any other forms of assistance for waste management initiatives. According to the Secretary, Industrial Pollution Control and Rehabilitation of Sick Units, making greater use of the funding made available through these projects is that they have more professional, active, and sophisticated chambers of commerce than Uttar Pradesh.

Research institutes and NGOs also play an important role in the development and promotion of LWTs in India. For example the NEERI makes a considerable contribution to environmental research and development (R&D) in India.
On the request of the CPCB, NEERI has started developing an information package on cleaner technologies. This is in recognition of the fact that “adooption and promotion of cleaner technologies in India is considerably impeded by lack of exchange of information between various interest groups on opportunities for pollution reduction.”

Also, in 1992, under the WB Industrial Pollution Control Project, NEERI held a workshop on LWTs which helped influence the Ministry of Environment and Forest’s (MEF) policy emphasis on pollution prevention.

In terms of NGO involvement in LWT promotion, Delhi-based Development Alternatives (DA) is active primarily in the area of appropriate rural technology. DA has also done work with small-scale textile dying and electroplating units in the Delhi area in the interest of reducing water consumption and has its own plant which produces hand-made paper from scrap paper and cloth.

Located in Delhi, the Indian Environmental Society (IES) emphasises environmental awareness-raising, education, and training, as well as the promotion of low waste technologies. The group has established recycling centres which produce construction bricks from industrial marble slurry, as well as greeting cards made from waste paper. These products are sold to provide income for rag-pickers as well as to sustain IES activities.

Efforts are also being made by industrial organisations in terms of promotion of LWTs. The Confederation of Indian Industry (CII), with 3,000 member companies, has as its principal objective the provision of consulting services to industry on a number of issues, including customs and excise, environment, quality, technology, and so forth. The overriding objective of the CII’s Environment Management Division is the promotion of cleaner production and responsible entrepreneurship among industries in India. These objectives have been pursued through a number of activities, including: publication of case studies from Indian enterprises that demonstrate that “environment protection makes sound business sense”;

“enterprise level training programmes” to motivate workers and management to strive towards waste minimisation; and the organisation in 1993 of a training program on “Environmental Audit and Waste Minimisation” for Central and State Pollution Control Board personnel. The CII has also identified a number of barriers to the achievement of these objectives.
From this overview it seems apparent that the waste minimisation approach to industrial production is clearly recognised in India as advantageous in the interests of environmentally sound industrial development. However, as will be shown in the next section, despite this broad policy agenda, barriers exist to the effective implementation of the waste minimisation approach.

III. INSTITUTIONAL IMPEDIMENTS TO THE ADOPTION OF LOW WASTE TECHNOLOGIES

India’s environmental problems, including the industrial waste crisis, have grown despite what appears to be a sophisticated environmental policy agenda and numerous environmental regulations. In fact, over the years “more than two dozen laws have been enacted to protect India’s environment.” These laws “cover all aspects of the environment – from pollution to conservation, from deforestation to nuclear waste.”38 A common observation, however, relates to the ineffectiveness of the regulatory regime in controlling, let alone arresting environmental degradation. For example, regarding the fight to control vehicular air pollution in Delhi, it has been remarked that “despite a plethora of laws, and organisations empowered to implement them, the situation has continued to worsen.”39 This leads one to conclude that there are problems with the effectiveness of the mechanisms of enforcement and compliance. In response to the analysis of the causes of air and water pollution quoted above, the promotion of waste minimisation through improved access to LWTs has been identified as a “priority area” by the GOI. However, in practice the focus remains decidedly end-of-pipe (EOP). This gap between regulation and enforcement, between policy and reality, is the result of various institutional impediments.

In India the waste minimisation approach has thus far been limited primarily to liquid waste management.40 Examples of waste reduction, reuse, recycling, and by-product recovery in the textile, tannery, metal finishing, beverage, pulp and paper, and distillery industries have been documented.
As a result of studies conducted by the NEERI, the NWMC, as well as other organisations, “the elements of cleaner technology are now being integrated by (the) MEF with the bilateral funding agency programmes.” However, the approach of government remains predominantly “reactive, repair oriented and media specific”, with emphasis placed primarily on “EOP treatment.” Furthermore, industry remains unaware or unconvinced of the advantages of the low waste approach.

The potential for waste minimisation and of inducing a “cleaner industrial culture” in developing countries like India is “both enormous and desireable.” In fact, studies have shown that in India, a “20 percent reduction in waste generation is possible through simple house-keeping measures requiring no or marginal investments.” However, despite the fact that cleaner industrial production provides opportunities for increased profitability and greater environmental soundness, and that there are supporting policies and programmes for its promotion, the waste minimisation approach and use of LWTs has not effectively taken off in India. This is due to various institutional impediments to sustainable development, including ineffective information dissemination; managerial turnover and other bureaucratic dysfunctions; intellectual property rights; emphasis on command and control; and absent or misdirected incentives.

**Ineffective Information Dissemination**

Earlier it was shown that there exists in India extensive knowledge about LWTs and the waste minimisation approach to industrial production. However, knowledge does not automatically translate into awareness or utilisation. A proactive stance both on the part of those possessing information and those requiring it is essential if policy implementation is to occur. One of the principal barriers to the adoption of the waste minimisation approach and LWTs in India is the ineffective dissemination of relevant information. The point was reiterated by several respondents that the institutional structure in place for information diffusion is not effective.

For the Head of the CII's Environment Management Division, the Environmental Information System (ENVIS) provides a great deal of information related to cleaner industrial production but is ineffective in informing industry because no one knows that the service exists. This point was confirmed by a Joint Secretary with the MEF in New Delhi who noted that the ENVIS system has no connection with industry or industrial organisations.
Also, despite best efforts, acting as the waste-minimisation mentors for industry in India is beyond the mandate and capacity of industry-related organisations like the CII. Furthermore, NEERI has extensive waste-minimisation information “on-line”, including 510 case studies from fourteen industrial sectors. However, it is unclear how this information might be accessed by or of use to small-scale industries (SSIs). One of the most substantial barriers to the adoption of LWTs in India is related to attitude and perception on the part of industry. Financial constraints are often presented as the primary reason for continued reliance on EOP pollution control. It is automatically assumed that the costs of switching to a low waste approach outweigh any possible benefits. Therefore, there is resistance to considering alternate approaches to production. This misperception regarding costs and the consequent attitudinal barrier is one of the many results of inadequate information dissemination. In fact, a lack of information can go so far as to result in confusion in understanding the difference between cleaner production techniques and technologies. This can generate further myths regarding the costs of the low waste approach. For example, housekeeping, one of the most effective waste minimisation “techniques”, requires almost no financial investment or dependence on alternate technology.

For many, this attitudinal barrier could be mitigated if information was more effectively disseminated. One means cited for this is greater use of demonstration projects. However, it is also important to note what is often at the root of ineffective information dissemination. Bureaucratic malaise can be a barrier. For example, while in Kanpur it was suggested by the Head of NEERI’s Kanpur Zonal Laboratory that the author travel to Nagpur, a distance of 1,000 kilometres, to obtain two clean technology documents from NEERI’s head office. A similar response to an interested industry would most likely end that industry’s search efforts. This attitude of indifference on the part of such a senior bureaucrat is consistent with Jain’s observation that in many cases “public administration in India has lost any conception of the value of time.” The attitudes and behaviour of civil servants, then, may act as institutional impediments to sustainable development.
Managerial Turnover and Other Bureaucratic Dysfunctions
Besides bureaucratic corruption, which has implications for the enforcement of pollution control regulation, the bureaucracy in India suffers from other dysfunctions which often render it ineffective in the implementation of public policy. For example, a short time after the commencement of field research in India, this author observed that in many cases, top civil servants were newcomers to their influential posts.\textsuperscript{54} This phenomenon of rapid managerial turnover is a characteristic of public administration in India that has implications for effective implementation of policy, such as that related to LWTs.

In theory, managerial turnover is a product of one of India’s important administrative principles. That is:

the policy-making organ of the government must have no permanent cadre of officers but must instead be manned by personnel who are taken on fixed-term deputation from implementation levels so as to project field realities fully into the process of policy making.\textsuperscript{55}

However, it is also important to note that in practice “the civil service of the country has become politicized over time.”\textsuperscript{56} Therefore, as Maheshwari observes:

matters like postings, transfers, and promotions are decided by the executive, and as such, the politically appointed ministers increasingly look to these as handy devices of reward and punishment. Careerism in the civil service makes its members receptive to the signals of ministers. As a result, there is a growing political interference in administration and, as often as not, both the civil servant and the politician have learned to accommodate each other in a wide variety of matters. Consequently, civil service ethics in India is under heavy stress.\textsuperscript{57}

It would appear as well that under these conditions policy implementation takes a back seat to political manoeuvring. Shifting political alliances and resulting transfers mean that top officials, called “birds of passage” by Mahashwari,\textsuperscript{58} are often unaware of the reasoning behind or implementation plan for particular policies. This was evidenced several times in India when senior bureaucrats were compelled to call in subordinates to explain not only the intricacies but the broad goals of certain initiatives.

Referring to the problem of policy implantation in India, Jain observes that “non-performance has never been ground for disciplinary action. The result is a psychology of evasion wherever possible, even years-long delays in implementation of major decisions.”\textsuperscript{59}
Therefore, “despite the existence of a huge administrative machine” in India, “nothing seems to get done.”

Inaction on the part of bureaucracy has serious implications. As noted by Maheshwari, “public administration is the acknowledged instrument of development in India which imparts special significance to it in the society.” Therefore, one might assume that given the vital role of the government, if meaningful steps are not taken towards policy implementation then reorientation towards the use of LWTs in industrial production will not occur.

**Intellectual Property Rights**

Besides ineffective dissemination of information, caused in part by a somewhat unmotivated bureaucracy, an impediment to the adoption of LWTs in India is intellectual property rights (IPRs). In 1992 the GOI stated that:

> with new and additional funding support and transfer of environmentally sound technologies from the developed countries, we will be in a position to augment our capacity to deal with environmental problems.

However, as a result of the completion of the Uruguay Road of the General Agreement on Tariffs and Trade (GATT), and associated emphasis on the protection of IPRs, the transfer of LWTs may be hindered.

The term “intellectual property rights” refers to the “legal expression of privileges granted by the State for the use, frequently exclusive”, of the creations of the human intellect. A patent is the “exclusive right to make, use or sell a particular application of a new idea.” Patents, which are “both reward for, and public recognition of a significant intellectual achievement,” are the legal form of IPRs. The basic rationale behind the pressure for IPR protection is the fear on the part of technology producers of piracy, which lessens the return on their initial R&D investment. With increased international trade and a concomitant increase in the cross-border flow of goods and services, concern over IPR protection has also increased. Therefore:

> in the post-Uruguay Round period, Intellectual Property Right protection is deemed to constitute an important component of an environment conducive to international transfer of technology, including foreign direct investment.

As such, IPR protection has become an enshrined component of the world trading system.
That IPRs can act as a potential barrier to the transfer of environmentally sound technologies was originally pointed out to the author by the Secretary of the DOE, Uttar Pradesh. According to the Secretary, although the process of economic liberalisation, beginning in earnest in 1991, has allowed foreign interest to invest more freely in India, for various reasons the advanced countries are not yet totally satisfied with the program. One important reason is that India is perceived as not yet having developed an institutional framework adequate enough to ensure the protection of IPRs.\textsuperscript{67}

In order to allay the fears of transnational corporations, which are a major source of technology supply under India’s liberalised economy, as well as other foreign technology exporters, India is reported to be taking steps in strengthening its IPR regime.\textsuperscript{68} This is particularly important with regards to the United States, which has shown interest in the area of environmental technology transfer to India, but which is also one of the most cautious with regard to IPR protection.\textsuperscript{69} However, the U.S. remains unconvinced that India is cognizant of the need to protect IPRs.\textsuperscript{70}

It should be noted that IPRs, in a climate of global competition, may have the potential to bolster indigenous technological innovation. As argued by Dwivedi, Nef, and Vanderkop: the politico-administrative systems “in the periphery” tend to exhibit a series of systematic characteristics which inhibit technological development and development in general. Among these, the imitative, ritualistic, formalistic, corruption-plagued, uncoordinated and generally deficient nature of the Third World state constitute the fundamental barrier to technological development.\textsuperscript{71}

Thus Gadgil laments India’s “continual borrowing of technology, without investing in innovation.”\textsuperscript{72} In fact, only 10 percent of the world’s R&D expenditures are incurred by developing countries like India.\textsuperscript{73} Perhaps a greater focus on expenditures in this area, over expensive imported technology or curative environmental measures, would help augment India’s self-reliance.\textsuperscript{74}

**Emphasis on Command and Control**

The tendency in India to “legislate away” problems, in particular those related to environmental protection,\textsuperscript{75} has the effect of pushing the costs of enforcement beyond the ability of enforcing agencies to fulfill their responsibilities. This curative approach also avoids tackling the root causes of problems.
Several times in India respondents used the example of child labour laws, which effectively outlaw the means of subsistence for a large portion of India’s children without providing alternatives or addressing the causes of child labour and poverty. In the realm of industrial pollution control, however, there exist barriers to the movement away from the curative, “command and control” approach to environmental regulation towards the implementation of a more preventative, “polluter pays” alternative.

First, the regulatory approach is seen as easier than a “polluter pays” or “economic instruments” approach. As pointed out by a senior bureaucrat in the Uttar Pradesh DOE, a “polluter pays” system requires the formulating of a gradation to determine the rates that polluters will pay in accordance with the toxicity of their waste, type of industrial activity, and so forth. This process is considered too cumbersome and complex by authorities who would rather deal with the issue through the formulation of new laws. The problem, of course, is that with increased regulation there is also an increased regulatory burden and enforcement challenge.

Another barrier is that there exists no coherent strategy regarding the use of economic instruments for environmental protection. This is because officially it is not yet known whether economic instruments are more effective than a regulatory approach. The economic instruments approach is new everywhere and no one has enough experience to provide definitive answers. More studies are therefore being recommended.

However, the reliance on command and control often works to the advantage of polluting industries. For example, often when an industry is ordered to close it can, by virtue of its access to sophisticated legal assistance, obtain a stay and thereby continue operating. In this sense, polluting industries are seen to “take shelter” under the very courts charged with closing them. Eventually, the case against a known polluter maybe dismissed due to the lengthy legal process involved and the “intense backlog of cases”. As pointed out somewhat hopelessly by an Additional District Magistrate of Kanpur, “no amount of law is going to help people when the chief motive is profiteering and, due to a lack of awareness, there is no civic sense.”
Absent or Misdirected Incentives

Although it has been argued that a common misperception related to LWTs is its ostensibly high cost, it should be noted that financial constraints do play a role in impeding their adoption. These financial constraints are often the result of absent or misdirected incentives.

According to the Head of the CII’s Environment Management Division, the MEF’s various policy pronouncements on LWTs are merely statements of intent. Despite these policy prescriptions, there exists no incentives, subsidies, soft loans, or action plan for the movement towards cleaner production.\(^8\)\(^1\) What incentives do exist for industry are often misdirected, running counter to the interests of waste minimisation. The Incentives made available by the GOI (Table 9.1) are primarily for curative, pollution control measures.\(^8\)\(^2\) Thus, in India the orientation of government subsidies is toward EOP. This orientation no doubt helps determine the technology choice of industry. Due to a lack of incentives, industries are not compelled to ascertain where clean technologies are available.\(^8\)\(^3\) Furthermore, with regards to EOP-oriented incentives, the MEF gives no indication as to how industries are made aware of them or to what extent they are utilised. Indeed, industries in Kanpur claimed no knowledge of government subsidies for pollution control or prevention measures. The WB concluded in 1991 that “the effect of these (EOP) incentives has been marginal so far.”\(^8\)\(^4\)

Another disincentive identified is the failure to implement legal measures for pollution control. This aggravates the cost difference between traditional or EOP technologies and cleaner technologies.\(^8\)\(^5\) Also, the use of LWTs by industry is not mandatory in regulatory terms.\(^8\)\(^6\) As pointed out by a Senior Environmental Chemist with DA, regulations should be in place to prescribe the use of appropriate technologies so as to avoid expensive retrofitting.\(^8\)\(^7\) In relation to this issue, the Head of the CII’s Environment Management Division pointed to a policy conflict arising out of misdirected incentives. It was noted that the GOI provides subsidies for the establishment of small-scale industries.\(^8\)\(^8\) This is part of the government’s strategy to promote industrial growth. As stated by the GOI:

> appropriate incentives and the design of investments in infrastructure development will be used to promote the dispersal of industry particularly to rural and backward areas.\(^8\)\(^9\)
Table 9.1 Fiscal Incentives for Industrial Pollution Control in India.

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<th>Fiscal Incentives For Industrial Pollution Control In India&lt;sup&gt;90&lt;/sup&gt;</th>
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<tr>
<td>o 100 percent depreciation allowance for installation of pollution control devices</td>
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<tr>
<td>o Custom duty at reduced rates of 35 percent plus 5 percent auxiliary charges levied on equipment and spares for pollution control</td>
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<tr>
<td>o Custom duty at the reduced rate of 25 percent and full exemption from additional duty for kits required for conversion of petrol driven vehicles to compressed natural gas driven vehicles</td>
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<tr>
<td>o Excise duty at a reduced rate of 5 percent on manufactured goods that are used for pollution control</td>
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<tr>
<td>o Excise duty exemption for bricks and blocks manufactured of fly-ash and phosphogypsum</td>
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<tr>
<td>o Exemption under section 35 CCB of the Income Tax Act to assesses who make contributions to organisations which carry out natural resource conservation programs</td>
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<tr>
<td>o Financial assistance towards capital investment up to 25 percent or Rs 50 lakhs (whichever is less) to small scale industries for establishment of common effluent treatment plants</td>
</tr>
<tr>
<td>o Provision of loans at reduced rates of interest by financial institutions for installation of pollution control equipment</td>
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Although subsidies may be available for common effluent treatment plants under such schemes, use of LWTs is not required. In its program to encourage industrialisation through subsidisation, then, we see a conflict with environmental protection. In Gujarat, then, we see a conflict with environmental protection. In Gujarat, for example, the state government has moved to denotify a wildlife sanctuary to make room for industry. As noted by one observer, “ironically enough, industrialists will find themselves eligible for special incentives should they choose to locate in the (sanctuary) area” as it is classified as an especially “backward area considered in greatest need of industrial attention.”<sup>91</sup> As stated by the WB:
the pricing, trade, fiscal (taxes and subsidies), and monetary (interest/exchange rate) policies adopted to promote industrialisation have an impact on the nature and volumes of industrial pollution. While promoting industrial transformation, these policies have unintended effects on the environment that need to be understood and addressed.92

At the heart of this subsidy-driven policy conflict is the environment versus development debate. As argued by the Director of the National Institute of Public Finance and Policy, it is necessary to balance the costs and benefits of industrial development in “backward” areas. Some environmental and social costs are necessary for the sake of growth.93 Citing the example of the recent “development” of a poor hill area of Himachal Pradesh which now possesses both previously non-existent basic facilities and industrial pollution, the Director opined that romantic ideas about preserving certain areas intact are unfair to the poor. There is a need for a certain level of tolerance for pollution and the local people, rather than urban-based environmentalists, should be allowed to decide what is most in their interests. It is interesting how this attitude of the necessity to do battle against poverty at almost any cost has undermined environmental policy in India since the time of Indira Gandhi’s historic pronouncement in Stockholm in 1972.94 What is also clear is that development initiatives and incentives which conflict with environmental protection have not overcome mass poverty and are foreclosing India’s future.

TOWARDS MORE EFFECTIVE INDUSTRIAL WASTE MANAGEMENT IN INDIA

“Cleaner industrial production is critical to sustainable development”95 and as such it is accorded special emphasis in India’s environmental policy. The main argument of this study has been that India possesses a comprehensive policy agenda favouring the use of LWTs, but because of inadequacies or dysfunctions in terms of human resources, rules, or organisation (institutional impediments), effective industrial waste management is not being achieved.
The gap between sustainable development policy and reality is clearly illustrated when the extent of apparent organisational involvement in waste minimisation is juxtaposed with the state of India's environment in general and use of LWTs in particular. The institutional impediments at the root of the reality gap include: the ineffective dissemination and utilisation of gathered information; managerial turnover and other bureaucratic dysfunctions; intellectual property rights and the associated perception on the part of the global community that India institutions are too weak to adequately protect them; an over-emphasis on the command and control approach to environmental protection; and the realisation of perceived financial constraints due to incentives which are either absent or in conflict with the promotion of LWTs or general environmental protection. Clearly, mitigation of these barriers is necessary before the adoption of LWTs and the waste minimisation approach can truly take off in India.

A current debate in India is related to whether the country’s recent reorientation towards a more market-centred approach to industrial development will, in the long term, mitigate the institutional impediments to sustainable development or sound the death knell of the country’s already ravaged environment. In 1994 the WB noted that:

*as the economy liberalises and industrial growth accelerates, the potential impact of industrial activity on the environment may further stress the natural resource base of the country and impact the welfare of the population.*

Many respondents interviewed in India reiterated this sentiment regarding the potentially detrimental environmental and social impacts of liberalisation. However, many also support the policy, arguing that it will actually benefit the environment and the interests of industrial waste management. For example, it is argued by the proponents of liberalisation that through the freeing of regulations it will be easier to access clean technologies. As stated by the GOI, by eliminating “cobwebs of unnecessary bureaucratic control” in areas such as foreign technology transfer, it is acknowledging that “the Indian entrepreneur has now come of age” and is thus in a position to enter freely into “commercial technology relationships with foreign technology suppliers.” However, it is important to recall that the issue of IPRs discussed earlier may hamper some of the progress made in improving access to LWTs. At any rate, it is clear that the liberalisation of the India economy is a foregone conclusion. Therefore, it is necessary that optimum use be made of the opportunities that this new reality affords.
This paper has focused primarily on the inadequacies and dysfunctions of government and its institutions in achieving effective industrial waste management in India. Frequently, government leaders in India show an extreme lack of political will, invoking newspaper headlines, denouncing it as “Leaderless, Rudderless”. The government is also accurately described as recalcitrant or even corrupt. However, these descriptions are necessarily qualified by the recognition that government cannot be held entirely accountable for environmental decline. Responsibility also rests with industry and citizenry.

As noted by one respondent, no country in the world provides an ideal model for a policy regime or institutional framework that is totally conducive to the employment of clean technologies in industry. Therefore, besides rectification of the institutional impediments outlined in this study, the achievement of effective industrial waste management in India necessitates the fostering of a cleaner industrial culture. Even more fundamentally, however, is the need to develop a greater “civic sense” among the general populace in tandem with more responsible entrepreneurship.

In terms of industry, “a new corporate etiquette” would entail the recognition of environmental responsibility as a process whereby industry is continuously seeking to improve its environmental performance. This would challenge the standard practice of simply trying to achieve a benchmark or opting for a best available technology by actually going beyond what is required. However, essential in conjunction with this is a reconsideration among the populace regarding “the customary shunting of all civic responsibility onto the Government.” To quote the Commissioner (Land and Projects) of the Delhi Development Authority, “You can’t expect the government to clean up your backyard…We have to change. We have to do it ourselves.”

A first step towards greater social responsibility and a cleaner industrial culture would be to address the “traditional Indian custom” of littering and place emphasis on the “now endangered tendency” of recycling. The achievement of sustainable development and the minimisation of industrial waste in India requires emphasis not only on institutional strengthening and technology improvement, but also on changing public behaviour.
ENDNOTES


9. International concern has been generated in light of the noticeable deterioration of the Taj Mahal in Agra, Uttar Pradesh, over the past years. Legal history was made in 1993 when the Supreme Court of India ordered the closure of 212 industrial units in and around Agra which were found to be wilful defaulters of air emission standards and thus assumed to be direct contributors to the deterioration of this historic monument. See M.C. Mehta, “Taj Trapezium: A Wonder Under Smog,” *The Hindu Survey of the Environment, 1994* (Madras: The Hindu, 1994), pp.59-63.
23. In the opinion of a Programme Officer with UNIDO in New Delhi, interviewed 11 Oct. 1994, the GOI is adept at writing current and sophisticated policy statements, employing all the latest buzzwords (i.e., “clean technologies”), however, implementation is a farce.
24. The goals and objectives of the project are to be achieved through institutional, investment, and technical assistance components. The institutional component (US $25.5 million) seeks to overcome the weaknesses of the Central and specified SPCBs through efforts to strengthen their monitoring and enforcement capabilities. The investment component (US $300 million) is meant to finance individual waste minimisation projects undertaken by enterprises, the construction of common effluent treatment plants at industrial clusters, and demonstration projects. Finally, the technical assistance component (US $4.5 million) is intended to assist the MEF in evaluating problems, including an organisational assessment of the SPCBs, and developing solutions to these problems; and to assist industries in undertaking feasibility studies for pollution control investments. At a total project cost of US $330 million, the implementation period is 1994 to 2001.

25. World Bank, p.93. Waste minimisation circles are analogous to “quality circles”. Industrial managers and workers participate in brainstorming sessions to formulate means to reduce waste and improve efficiency. Through its emphasis on available skills and in-house knowledge, the idea has great merit. As pointed out in an interview with the Deputy Director, Pollution Control, National Productivity Council, some of the most relevant suggestions for waste minimisation come from the shop floor, as workers know the plant and the process inside out and are thus in an ideal position to identify areas where housekeeping can be improved or waste reduced. Furthermore, a scientist with the Toxic Waste Management Division, NEERI, remarked that this type of bottom-up innovation is often more successful and more readily accepted by workers than change imposed from the top. What these comments, as well as the “brainstorming” approach fail to address, however, is worker reluctance to identify areas for waste minimisation and efficiency improvement due to concerns regarding job security.

26. From an interview conducted at the office of the Secretary, DOE, Lucknow, 28 Oct., 1994.

27. Headquartered in Nagpur, NEERI has zonal laboratories located in Ahmedabad, Bombay, Calcutta, Delhi, Hyderabad, Jaipur, Kanpur, Kochi, and Madras; an overall staff of 735; and budget for 1992-93 of over Rs 10 crores. National Environmental Engineering Research Institute, NEERI 93 (Nagpur: National Environmental Engineering Research Institute, 1993), passim.

28. NEERI, p.117.
29. NEERI, p.118.
30. From an interview with a Senior Environmental Chemist, Development Alternatives, 1
32. Confederation of Indian Industry, “CII: India’s Industrial Reference,” (New Delhi:
Confederation of Indian Industry, n.d.).
33. Confederation of Indian Industry, “CII Initiatives on Implementation of Agenda 21 Items,”
(New Delhi: Confederation of Indian Industry, 1993), passim.
34. Confederation of Indian Industry, “CII Initiatives”, p.3.
35. Confederation of Indian Industry, “CII Initiatives”, p.5. According to CII, since its
inception in 1992 the Environment Management Division has organised over 100 training
programmes workshops, clinics, seminars, etc., both to create awareness and to train
industry personnel in specific areas of environment management. Of these nearly 75 were
devoted to “environment Audit” as a management tool for minimising wastes and
conserving resources. The focus was on reducing consumption of input resources per unit
of product output.
37. K. P. Nyati, “Cleaner Industrial Production in Developing Countries: Prospects, Barriers,
and Strategies,” Presented to the Organisation of Economic Cooperation and
Development’s Workshop on Development Assistance and Technical Cooperation for
Cleaner Industrial Production in Developing Countries, Hannover, 28-30 Sept. 1994.
Assistant Resident Representative with the United Nations Development Program
commented that India had no shortage of environmental laws given the country’s tendency
to legislate away problems. In an interview held 26 Oct. 1994, in Kanpur, an Additional
District Magistrate of Kanpur remarked that pollution continues despite the fact that India is
full of laws.
43. Nyati, p.6.
44. Nyati, p.6.
45. For example, in an interview held in New Delhi, 4 Oct. 1994, the Head of the CII’s Environment Management Division cited the absence of a proactive information dissemination mechanism as comprising a major barrier to cleaner industrial production in India. For the Secretary of the DOE, interviewed in Lucknow, Oct. 28, 1994, a lack of information results in a lack of awareness on the part of industry regarding LWTs. In other words, as appeared to be the case in Kanpur, industry is not even aware that there is a problem, let alone a solution. This is particularly true of SSIs.
46. From an interview held in New Delhi, 4 Oct., 1994. The Environmental Information System (ENVIS) is an India-wide network of centres which provide information on a broad range of environmental issues to any interested party. Besides the focal point located in the MEF, there are 17 subject specific centres located in different areas of the country (including Environmentally Sound and Appropriate Technology) which carry out activities in information collection, storage, retrieval, and dissemination. Government of India, *Annual Report 1993-94*, p.94.
47. From an interview conducted in New Delhi 12 Oct. 1994.
49. From an interview with the Senior Deputy Director (Pollution Control), National Productivity Council, New Delhi, 18 Oct. 1994.
50. As noted by NEERI: “There is a certain perceived risk that discourages entrepreneurs from adoption (of) the relatively new concept of cleaner technologies… The major problem in promotion of cleaner technologies in India relates to lack of appropriate information and resulting misconceptions.” Government of India, *Environment Action Programme*, pp.188-189.
52. See for example, Asian and Pacific Centre for Transfer of Technology, (March-April), p.18.
   Also, in an interview in New Delhi, 4 Oct. 1994, the Head of the CII’s Environment
   Management Division spoke of the lack of demonstration projects as an important barrier to
   the adoption of LWTs in India. As noted by a Senior Environmental Chemist with
   Development Alternatives, industries will not act simply for the betterment of the
   environment. Thus it is necessary to clearly demonstrate and make obvious the financial
   benefits of adopting LWTs.
53. R.B. Jain, “Public Service Accountability in India,” Public Service Accountability: A
   Comparative Perspective, eds. J. Jabbra and O.P. Dwivedi (West Hartford, CT: Kumarian
54. For example, the Chief Administrator of Kanpur, interviewed 26 Aug. 1994, was at his post
   for four months before being ousted; the Secretary of the Ministry of Regional
   Development, UP, interviewed 1 Sept. 1994 in Lucknow, had held several top positions,
   including Secretary of Industry, in the past two years; the Secretary, DOE, who is also the
   Chairman, UPPCB, interviewed in Lucknow 28 Oct. 1994, had only come into these
   portfolios in the past months; and both the Director and Deputy Director of the DOE’s
   Environment Directorate, interviewed in Lucknow 28 Oct. 1994, acknowledged being new
   to their positions.
56. Maheswari, p.56.
57. Maheswari, p.56.
58. Maheswari, p.57.
60. Jain, p.134.
68. Asian and Pacific Centre for Transfer of Technology, (May-June), p.45. Steps include a proposed amendment to the Patent Act, which would increase the period of patent protection from seven years to 14 years in the case of pharmaceuticals and processed foods and 20 years in other cases. The APCTT states that the reason IPRs operate well in developed countries is that there “the rationale for patent protection is clear.” Asian and Pacific Centre for Transfer of Technology, (May-June), p.5.
74. It is recognised that in a country like India where simple survival is a very real concern for millions of people, industrial R&D, like environmental initiatives, may be seen as a luxury. As noted by one author, the technological dependency of poorer countries on the developed countries arises out of the fact that the former “do not have the resources to embark on a technology development programme.” Asian and Pacific Centre for Transfer of Technology, May-June 1994), p.8. However, it is important to note that India already possesses a sophisticated scientific and R&D infrastructure. A prime example is the Ministry of Non-Conventional Energy Sources, with extensive activities in the areas of solar and wind power. Government of India, Annual Report, passim. Waste minimisation is not a uniquely Western concept to which “advanced” interests can claim ownership. Therefore, greater advantage, for the sake of pollution prevention and economic advancement, should be made of India’s indigenous capabilities in this area.
76. From a meeting at the DOE, Lucknow, 28 Oct. 1994.
77. From an interview with the Director, National Institute of Public Finance and Policy, New Delhi, 20 Oct. 1994.
81. From an interview held in New Delhi, 4 Oct. 1994.
82. As noted by the APCTT, “The approach of Government (in India to industrial waste management) has been reactive, repair oriented and media specific… Financial incentives are available mainly for an EOP treatment. No financial incentives are yet available for use of cleaner technologies.” Asian and Pacific Centre for Transfer of Technology, May-June 1994), p.17. The CII reports lobbying efforts on its part to have waste recovery and waste utilisation technologies, i.e., LWTs, subject to 100 percent depreciation, as is currently the case with EOP technologies. Confederation of India Industries, “CII Initiatives”, p.8. Also, in 1991 the MEF began the annual presentation of National Awards for the Prevention and Control of Pollution to encourage industries to take steps in these areas. Government of India, Annual Report, p.93.
83. From an interview with the Head, Environmental Management Division, CII, in New Delhi, 4 Oct. 1994.

84. World Bank, p.10. As part of its Industrial Pollution Prevention Project, the WB emphasises the necessity of shifting from concentration-based to load-based effluent standards. This would strengthen incentives for the adoption of cleaner technologies and “remove the incentive for polluters to dilute effluents by adding water”, a practice witnessed in Kanpur. World Bank, p.4.


86. From an interview with the Senior Deputy Director, (Pollution Control), National Productivity Council, New Delhi, 18 Oct. 1994.

87. From an interview in New Delhi, 1 Nov. 1994.

88. From an interview in New Delhi, 4 Oct. 1994.


90. Adapted from Government of India, Annual Report, p.53.


92. World Bank, p.3.

93. From an interview held in New Delhi, 20 Oct. 1994.

94. At the 1972 United Nation’s Conference on the Human Environment, then Prime Minister Indira Gandhi asked “are not poverty and need the greeters polluters?” Dwivedi and Khator, p.22.


97. Social impacts of liberalisation are important to note. Wolpert, for example, observes that one of the immediate impacts of India's structural adjustment was “rampant inflation”, which saw the price of “many vital necessities” rise by fifteen percent. Furthermore, “more educated Indians found themselves unemployed, as a capitalist free-enterprise economy replaced Socialism” and “Washington nodded warm approval of Manmohan Singh’s budget.” Wolpert, *A New History of India*, p.443. Other consequences have included mass unemployment and the termination of indigenous industries. Also, some authors have attributed the resurgence of virulent Hindu nationalism to the social upheaval caused by liberalisation. See for example, James Chiriyankandath, “India: The Crisis of Secularism,” *Annual Editions: Third World 94/95*, ed. Robert J. Griffiths, (Guilford, CT: The Dushkin Publishing Group Inc., 1994).


100. From an interview with the Head, Environment Management Division, CII, New Delhi, 4 Oct. 1994.


102. From an interview with the Head, Environment Management Division, CII, New Delhi, 4 Oct. 1994.


INTRODUCTION

Over the past twenty years, the administration of environmental planning and management has become an important area of concern in India. Growing preoccupation with the environment stems from the realisation that industrial development and the drive towards modernisation have resulted in the depletion of the natural resource base on which humanity’s present and future development depends. In India, the threefold pressures of poverty, enhanced industrial activity and burgeoning population render the task a formidable one. In India, people can no longer lay waste to an area and more on. There is nowhere to “move on” to.

This paper considers the management of environmental waste in India within the context of Sustainable Development (SD). India’s success in pursuing SD is dependent on how skilfully and optimally its natural resources are conserved and utilised. The organisation of government administration and management plays a crucial role. The incisive distribution of government finances, the creation and enforcement of guidelines and the ability to influence the impact of citizens on the environment, are among the more important tasks that depend on effective administration.
I. INDIA’S CHALLENGE FOR SUSTAINABLE DEVELOPMENT

In India, environmental problems are perceived as rooted in the lack of development, or the struggle to overcome conditions of poverty. India has adopted rapid industrialisation as the quickest route to the economic well-being of its people. The objectives of industrial policy as stated in India’s Environment Action Programme include expansion of opportunities for gainful employment, reduction of social and economic disparities and removal of poverty. ¹ The expansion in the industrial sector has been towards capital and energy intensive sectors, which are also the most polluting. Enormous increases in population have only compounded pressures on the environment. As of the March 1991 census, the population of India was 844 million. This figure is increasing by 2.1 percent, or 17 million people each year.² In the absence of environmental stewardship, sustainable methods of resource exploitation, clean technologies and proper waste management, industrial development reinforces underdevelopment and compromises the long-term ability of the natural environment to provide goods and services.

II. THE ADMINISTRATION OF SOLID WASTE IN INDIA

In India there has been too little regard accorded to the costs of waste generation and waste disposal. If industrial development is to be sustainable, it is essential that the process of converting natural resources into productive goods be made efficient, both in terms of garnering a higher output from the same material inputs and minimising waste.

Cleaner production in industry has been defined by the United Nations Environment Programme (UNEP) as the conceptual and procedural approach that must be taken to ensure that all phases of the life cycle of a product are addressed with the objective of prevention or minimisation of short and long term risks to humans and to the environment.
A report from the Indian Institute of Public Administration, Centre for Urban Studies states: “the major sources of pollution in most of [India’s] small and medium cities continue to be largely domestic and non-commercial”. A more immediate challenge is the development of skilled and informed management systems to deal with present waste output. This paper will concentrate on the efforts by the Indian administration to forge new means to address the problems around the management of Indian municipal solid waste.

A review of policy, legislative and planning initiatives by the Indian government in the field of waste management will indicate the presence of institutional, legislative, socio-economic and technical constraints to the management of urban solid waste. It will be shown that policies for waste management programmes must give equal importance to both socio-economic and technical hardware aspects if planning, implementation and monitoring of solid waste are to be successful. The paper will include recommendations to increase effective and efficient procedures for solid waste management (SWM).

The Nature of the Problem
India generates around 25 million tonnes of municipal solid waste a year, the impact of which is described as literally burying urban areas in garbage. The urban waste problem in India is an outcome of rapid and massive increase in urban population that has taken place over the last 20 years, the change in quantities and nature of consumptive goods, and lack of policy, planning and management capabilities to adequately address the problem.

India is gradually changing from a predominantly rural society to one with a substantial urban population. India’s urban population according to the 1991 Census was 217 million and is predicted to increase to 340 million by 2000 A.D. This latest increase in urban population would amount to almost 50 percent over nine year, accounting for 1/4 of India’s predicted total population. Demographic changes in India are occurring largely due to the structural transformation of the Indian economy and shifts of labour and capital from rural to urban activities. Agriculture which accounted for roughly 55 percent of the Gross Domestic Product (GDP) in 1950-51 has declined to 32 percent in 1990-91. Thus, urbanisation is not a transitory phenomenon, but is seen to reflect permanent structural changes that have occurred since independence.
There are 23 cities in India with a population of greater than one million, four of which have a population exceeding five million. Together the cities with population of more than a million account for half of India’s urban population. On the basis of size alone, the challenge to municipal administration in providing adequate services and infrastructure for urban solid waste is immense. Three factors exacerbate the problem.

(a) The accumulated backlog in urban housing along with a rapidly increasing population of urban poor have resulted in the proliferation of slums and squatter settlements. A high incidence of marginal employment and urban poverty implies that the poor cannot afford to pay for housing and urban services with the result that these services have deteriorated further.

(b) The weak financial and organisational base of urban local bodies has led to subsidised and inequitable supply of urban services and land, and to haphazard growth. Lack of effective control over changes in land-use has encouraged unplanned and often illegal urban sprawl.

(c) The gap between demand and supply of infrastructural services has been continuously widening. Increasing pressures of population, particularly the skewed distribution of urban population in mega-cities, and the escalating per capita cost of providing urban services, account for the deterioration of infrastructure services and amenities. Approximately 33 percent of the total urban population have no access to sanitary facilities. They use open drains, roadside berms and vacant spaces for defecation and disposal of solid wastes. Those areas not served are largely unincorporated settlements or unplanned slum communities inaccessible to formal collection and disposal techniques, and all without political influence to demand services, due to their constituency as new rural migrants and poor people in general. With slum populations estimated at 49 million in 1990, increased occupation of urban land with ever growing numbers of people living in extreme poverty further aggravates congestion, over-crowding and high levels of pollution. Lack of infrastructure for water, sewerage, drainage and general environmental sanitation services add to the spread of infectious diseases and epidemics.

Project planners are now seeking approaches to objectively assess overall system efficiency in the delivery of services. The urgency of the task is obvious. One must remember however, “it is not even enough to plan for coverage’ of the population with facilities, there has to be a plan for sustainable functioning of the facilities.”
Institutional Framework for SWM

According to the Indian Constitution, care for public health and sanitation is to be dispensed by the state. The management (i.e., the collection and disposal) of solid waste, however, is generally under the direction of municipal corporations empowered by the state. Yet the role of municipal governments accorded the responsibility of providing water supply, wastewater disposal, refuse pickup, public health, and shelter for the poor is ignored in national and state strategies for sustainable development.

Strategies for sustainable development at national and state levels have focused on the application of both mandatory and coercive means for cleaning up existing pollution and preventing the occurrence of new pollution. The treatment, transportation and disposal of wastes, and any steps taken to reduce, re-use, or recycle wastes fall on the municipalities.

Institutionally, in most municipalities, SWM is entrusted to a multipurpose inspectorate in either the Health or Revenue Department. Powers to issue notices and to undertake legal proceedings are delegated by the Municipal Health Commissioner, usually a medical doctor. Since environmental problems have grown more complex and proper management necessitates specialisation and expert input from diverse areas, concern has developed over the control of SWM by the Health Officer/Division alone. Vesting the authority in this sector ensures that municipal managers are aware of the severe health problems that may result from inaction, but there is concern that the means for efficient collection and safe disposal of waste may not be given the same weight. In other countries, responsibility for refuse operations lies with the public works unit of municipal government, and is managed by engineers. Awareness of the health issues related to the presence of solid waste is important but relegating waste to the Health Department may be providing insufficient impetus for other departments to work with them. The administration of SWM may benefit from intersectoral and interdepartmental collaboration in waste-related issues and the creation of a local department responsible solely for the mixed yet related aspects of municipal solid waste.
Although the municipal government is responsible for laying down laws, acts and lists of obligatory and discretionary duties with regard to solid waste management, many of these regulations are currently outdated in India. For example, the city of Kanpur is governed by an Act from 1932. By-laws on matters such as drainage, disposal of noxious soil and waste (hazardous and non-hazardous) have fallen into disuse, and legislation for reducing, recycling and recovering wastes, integral to meeting objectives for sustainable development, is virtually non-existent. Legislation at the municipal level, by way of Acts and provision, are regarded as scattered ad hoc routine provisions without the necessary focus on the overall view of human environment and the need of mitigating the dangers to which the citizens are exposed.\(^\text{13}\)

The presence of outdated institutional structures and obsolete and disjointed legislation for administering SWM is reflected in waste collection and disposal practices.

### III. OPERATIONAL IMPEDIMENTS TO SOUND SOLID WASTE MANAGEMENT PRACTICES

**Financial Uncertainty**

Municipalities perceive themselves to be without the financial support to access human and technical resources for collection and disposal of wastes. In Bangalore, India’s fifth largest city, five million people dispose about 2,000 tonnes of solid waste per day. The Bangalore city corporation, Entrusted with the responsibility of waste disposal is so short of manpower, machines and vehicles that it is equipped to handle and recycle only one fourth of what is generated. The rest is dumped indiscriminately around the city spreading disease and pollution.\(^\text{14}\)

Prohibitive costs associated with acquiring new landfills and lack of space for disposing of current wastes is at the root of dumping municipal solid waste in and around Indian cities.
Officially, landfill is specified for dealing with 90 percent of solid waste. Forces of modernisation and intensive land use for development have precipitated concomitant rises in land values. The result is that municipalities suffer from an inability to secure (low-cost) landfill sites for waste disposal. Research on volume reduction of solid waste for alleviating disposal problems in India has concentrated on various types of incineration. Yet Dr. B. Sundraresan, former Director of the National Environmental Engineering Research Institute (NEERI) in Madras asserts:

Incineration is not a solution as far as garbage disposal in Madras is concerned. Over 50 percent of the garbage is organic and hence it cannot be used for energy generation. Incineration is rejected as an overall solution to the storage and treatment of waste on the grounds that calorific value from vegetable/putrescible matter in most Indian urban solid waste is sufficiently low. Instead of enabling energy or cost recovery by burning wastes, “supplementary fuel may be necessary for at least part of the incineration process.” Though incineration displaces costs incurred by land space requirements for landfill, the density of wastes in Indian urban refuse results in negligible economic gains from incineration.

Financing for solid waste operations comes from general revenues or taxes collected as general property taxes, sewer and water taxes and a variety of municipal fees. It is estimated that between 40 to 60 percent of the municipal budgets are used to provide the SWM service. However, the real cost of municipal SWM is not well understood because of lack of proper cost accounting. Municipal cost items having to do with water and sanitation are generally aggregated to the extent that labour and equipment used to provide solid waste services are not distinguished. The same municipal workers perform other functions such as drain cleaning and street sweeping.

Cost reduction in the delivery of SWM has not been given serious attention since budget shortfalls are usually made up through a reduction in service or subsidies from state government. Small and medium-sized cities depend on provincial or state governments for financing solid waste operations and infrastructure. Traditionally the approach to financing has been that state governments provide capital funding for new equipment, and the municipality finances the operations from its traditional revenue base. Municipal governments have neither the capability nor the time to deal with questions surrounding efficient allocation of resources.
The Indian Institute of Public Administration observes:

An understanding of the trade-offs between labour and capital and economies of scale elude municipal management in favour of having to deal with daily crises and operational difficulties.¹⁹

Inefficiency of Service
In India, the service that exists for SWM is generally inefficient with much of the refuse left uncollected. The reasons include inadequate or inappropriate equipment, lack of labour motivation and cultural issues. The result is often sewers clogged by uncollected waste, health problems because of disease vectors around dump sites and general dissatisfaction with municipal operations.

Work Practices and Worker Management
Methods for handling waste have not been adjusted to adequately address the current socio-economic realities of waste output in contemporary cities. Solid waste operations tend to be inefficient, employing a large number of workers protected by unions and provided with complete benefits.²⁰ Generally one to three people per 1,000 of the general population are involved in sanitation work. Public disinterest in sanitation and insufficient financial support by state governments contribute to worker management problems. From a technical standpoint, municipal departments responsible for addressing issues of solid waste are ill-equipped and they do not usually have any means of keeping themselves abreast of modern developments in this field. There are no arrangements for orientation and training of the existing staff to undertake conscious pollution control measures.²¹

Municipal workers often must clean up the refuse by hand, using baskets which are passed up to collection trucks for loading. Various categories of solid domestic and commercial waste are mixed together at dump sites, posing a hazard to conservancy workers. In some cities truck crews do not have shovels necessary for cleaning the area around communal bins. In others, workers are not supplied with protective clothing or if they are, it is often sold for its cash value. Half-hearted attempts on the part of municipal crews and truck staff to load waste around communal bins have been documented. Lack of appropriate equipment, lack of will on the part of workers, and lack of enforcement by the city all contribute to ineffective SWM.
Municipal house collection by waste conservancy staff is rare in urban centres and is unlikely to become widespread given the chronic shortage of funds and trained personnel. Thus, the process of municipal collection begins at ‘primary dumps’ or concrete bins and containers to which households and commercial enterprises bring their waste daily. In cities with a population greater than one million, often more than 10,000 primary disposal units are known to exist, many of which are unofficial.

The phenomenon of large scale dumping of collected wastes is a further consequence of ineffective SWM practices. Disposal of collected wastes is generally at dump sites located in vacant land near the city. These sites are merely dumps not controlled landfills. At these dumps, no daily cover is applied and little equipment is available to work and compact the waste. In some cases the dumping is done illegally. Although in most urban areas there are municipal codes prohibiting indiscriminate dumping of refuse, little is done to enforce them. Municipal employees and the authorities have other priorities, especially in poor and peri-urban communities where most of these problems occur.

**Cultural Issues**
Status associated with working in SWM is low in India. Municipal workers come from the ‘untouchable’ class. Other castes disdain this type of work. Clear norms exist as to what social classes are to work in various jobs such as sweeper, truck loader, driver, supervisor and management. Because of these norms, there is limited flexibility in carrying out a wider range of duties. This clearly restricts the options that municipal management has for human resource allocation.

There is little public concern for the care of public areas such as streets, sidewalks and public toilets. Most urban residents feel that the maintenance of these common areas is the responsibility of the municipality alone. Indiscriminate dumping or neglect when placing refuse around collection points outside the home makes residents loathe walking directly to the bin and over old waste to place their refuse. Residents are described as merely ‘approaching the dump’ to dispose of waste, with the result that there is often as much refuse dropped outside the communal bins as inside. This has been said to discourage workers from cleaning up since it demonstrates a lack of pride on the community’s part (for contrast, see Rahman and Prasad in this volume).
Low Waste Options
There is a growing recognition that neighbourhood level garbage collection, managed in collaboration with the residents, is often the cheapest and most effective solution to SWM. This is particularly true if there is reclamation of the wastes through composting or other means at the neighbourhood level. The constituents of domestic wastes that are often recycled include paper, textiles, metals, glass, rubber and plastics. An active secondary market exists for recycling these scrap materials.

In 30 percent of cities without formal municipal waste management, for reasons such as inaccessibility of streets to municipal collection equipment and limited equipment and staff, a large and competitive informal market has developed for reuse and recycling of wastes. The unskilled and uneducated generate income through waste picking. The recovery of wastes such as paper, plastics and metals by waste pickers who sell these to dealers, wholesalers or directly in the open market accounts for roughly one to two percent of the workforce in urban centres. The recycling effort at present, is often organised to the disadvantage of the waste pickers and to the benefit of the municipality and middlemen. The pickers, mostly women and children, are paid little but toil at informal urban dumps and landfills over long hours with few rights and no benefits.

In most Indian cities, the impact of this type of recycling is not well understood by municipal officials, nor is it well documented. However there is some estimation that voluntary reclamation accounts for 20 to 25 percent of all solid wastes. When considering the degree to which municipal authorities are unable to keep pace with urban waste collection and disposal needs, recycling of waste through picking alleviates some stress on an already overburdened system.

Local levels of government have been accused of maintaining a bias in favour of expensive projects for the procurement and maintenance of equipment, institutional strengthening and reform of management system operations to the neglect of cheaper, culturally specific alternatives that could entail formalising parts of the informal waste economy and attempting improved conditions for itinerant workers. The task of SWM as described by the Chief Finance Officer of the Calcutta Municipal Corporation (CMC) is one of “planning and administration with a bit of economics and engineering”.

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In cities where waste pickers recover roughly 15 percent of waste from primary dumps, and in the case of Bangalore City where they number 25,000 with an added 4,000 wholesalers and dealers, the municipality relies heavily on these informal activities to ease the burden of SWM practices.

Where synthetic wastes could be reduced by 20-40 percent through source separation, the remaining organic and inert wastes provide the means to effect low-cost, low-technology, and high resource recovery systems of SWM through the adoption of composting or vermiculture production. Organic wastes and coal fly ash constitute 80 percent of landfill in India, and if composted, can both reduce the pressure on the current need for locating and maintaining landfill sites while forming the basis for horticultural industries, through use as fertilizers in agricultural production. Biomass can be converted into methane and burned for heat and power if separated from other rubbish through composting. Research in the area of composting indicates that where initiatives are kept small and decentralised, wastes are more readily decomposed. Flintoff claims that:

in present Indian conditions diseconomy of scale applies to composting and that unit costs of compost production increase as plant capacity rises and mechanisation is increased. Thus to achieve the lowest production cost, a policy of encouraging multiple small manually operated plants should be followed.

Municipal policy measures for actualising decentralised composting are of recent origin. Suggested locations for compost sites at city parks, community gardens and golf courses, indicate an effort to search for local sites that could decrease the costs incurred from hauling wastes long distances, setting up new landfills in costly areas, and supplying conservancy staff to manage landfills. Solutions for decentralised composting in open city spaces usually reserved for leisure or recreation may seem politically naïve. However, this is probably a recognition of the magnitude of the SWM solutions, such as incineration or centralised composting mechanisms, hitherto inefficient and troublesome for municipal authorities to operate and maintain.
Inappropriate Technology

“By and large, the fact that capital is more limited in India than in most industrialised countries actually demands a more profound knowledge of the nature of environmental problems and their cause, to allow limited resources to be used to best effect; only with large capital resources can conventional solutions be implemented which apply uniform standards”.

In the past, benefits to developing countries such as India, from transfers of ‘expertise’ from industrialised countries were thought to emanate from technological or ‘ready-made’ schemes modelled on western innovations and thinking. In the field of SWM, the wide use of modern collection equipment, such as mechanised, self-emptying trailers, compactor trucks, and disposal methods such as incineration have been tempting to Indian municipal waste managers, as a means for abating waste problems.

Technologies carry with them built-in decisions that reflect markets, level of economic development, attitudes, and technical cultures of their place of origin. Efficiency of the transfer process is dependent on the skills and knowledge in the receiving country. India has attempted experiments with new as well as old waste handling and disposal technologies, successful elsewhere, only to find that they are not viable for institutional, social, financial and technical reasons. In some municipal garages solid waste handling equipment can be found either under repair or permanently disabled. This is the result of lack of expertise for maintenance and repairs, or lack of resources.

India installed a dozen composting plants during the late 1970s and 1980s. Only two or four are still in operation. The reasons for this include inattention to daily operational details, as well as lack of funding provided for equipment and maintenance by the municipalities and states. The notion that composting does not require much attention, that it is a ‘natural’ process, is common among municipal administrators. However, changes in refuse composition over the years, frequent breakdown of trucks and mechanical separation of equipment have all contributed to the failure of these plants.

Lessons from failures of SWM technology such as incineration, composting plants, and anaerobic digestion systems need to be documented as a lesson for future planners. Ultimately, all technology must fit the socio-economic conditions of the receiving country if it is to be effectively utilised.
IV. ADMINISTRATIVE REFORMS FOR SOLID WASTE MANAGEMENT IN INDIA

“If the root of such difference between the West and the South is culture, then should not ‘culture’ be the foundation upon which one should build alternate models of development?... What is being suggested is that the ‘power to shape ideas and events’ which has so far lain with the West, needs to be shared now. This is nowhere more evident than in the field of environmental management”.

The introduction of new capital equipment, no matter how efficient, will not substantially alter the current climate for SWM in India. Rather than focusing on a single problem, interdisciplinary approaches to the cooperation and organisation of institutional, cultural, economic and technical aspects of solid waste issues must be addressed. Research and experimentation are necessary.

**Research and Development**

Little research and Development of SWM equipment suitable to various local conditions appears to have been done by either national or international companies that make collection equipment. Unquestionably, changes in design could improve the efficiency of much equipment being operated in Indian municipalities. Links between private manufacturing companies and municipalities could be developed in order to create a line of collection vehicle, refuse bins and other associated equipment suited to local conditions, and designed to work in conjunction with each other. Since the development of better technology depends on many factors such as overall technological development in India and investment capability of city municipalities, system improvements immediately possible are those that can be obtained by utilising existing resources to the best effect.

**Improved Planning and Organisation**

The adoption of appropriate collection and disposal methods for urban solid waste is, in part, dependent on the creation of local, regional and national physical development plans and surveys for monitoring the location, kind and quantities of waste being produced from various activities. Without this baseline information, it is impossible to adequately treat and dispose of the waste produced daily in urban centres.
In the city of Kanpur, a physical and chemical plan was drawn up in 1972 by the India Institute of Technology. The authors analysed waste samples both in terms of content and quantity from each ward or zone in the city. Wastes were analysed in terms of compostable matter. The city of Kanpur updated the study in 1990. The update outlined plans for treatment of the waste. Most Indian cities have yet to publish initial, much less updated blueprints of the nature and source of urban solid waste.  

Unplanned collection depots, routing systems and ad hoc planning of landfill sites results in chronic lack of vehicles for collection and transportation of waste to landfills, long distances over which garbage is hauled for dumping, improper treatment of disposed waste and reduction in overall efficiency of the system. Clearly planning procedures need to be developed for optimal utilisation of resources, creation of a long-term planning horizon, ability to analyze the system as a whole, and rational selection of alternate disposal sites.

Improved SWM Accounting Systems
SWM cost accounting systems need to be improved. Where based on micro-computers and software, more accurate financial forecasting and efficient deployment of financial as well as labour and material resources could be monitored. Current approaches to financing SWM have not been developed since taxes augmented with state and federal funds have been relied on for this purpose. Independent, locally operated accounting systems are imperative if accountability and efficiency of service are to become a part of municipal SWM.

Federal and State Level Assistance
Assistance to cities from the state and centre governments for improved systems of SWM should come in the form of enhanced institutional and infrastructural support. These higher levels of government should take on a role of providing guidance, software and training to municipal officials, as opposed to simply allotting finances to be used for ‘best effect’. Thus far only limited financial assistance has been provided and institutional development has been left to the municipalities themselves.

Municipal Level Training
The provision of training to municipal sanitation workers, managers, engineers and health officials on sound approaches to waste management is as important as any financial or technical support in the field of SWM.
The capacity to manage urban growth and to implement technological and programme changes is dependent on the capacity to make autonomous and sensible decisions. Building this capacity will take time and requires specialised and interdisciplinary training in the areas of science and social science. Training programmes for management level workers would enhance knowledge and skills in developing SWM strategies for optimal planning and operation in micro-level implementation. Training programmes that emphasise operations monitoring, such as accounting systems and modern computer based planning techniques, might assist municipal managers not only with SWM, but also in delivering other essential services such as sewers and water management as well.

Integration of Non-conventional Approaches to SWM

(1) Despite changes in financing, training, planning and legislation for SWM, the chronic lack of space for the dumping of solid wastes, increased costs associated with acquiring new landfill as well as obscure and distant locations for secondary sites, may force municipalities to consider more sustainable alternatives to traditional methods of SWM. The integration of non-conventional goals in SWM would entail:

(2) Support for informal activities of waste recovery and recycling
(3) Promoting and exploring means to increase separation of wastes at the source to reduce hand picking and increase efficiency of recycling
(4) Developing community/private sector/municipal partnerships for waste recycling, and
(5) Increasing public awareness of the need to reduce and recycle waste and of the benefits of separation.33

What is first required is an economic evaluation of recycling and reclamation. The impact of reclamation and recycling of waste, with specific regard to pickers, on the waste stream, and the potential for organising, improving and expanding these activities to meet a broader set of urban objectives needs to be more fully addressed. Such an evaluation could aid in determining the true economic potential of recycling while incorporating social and ecological goals into the SWM process. The total turnover of the recycling operation has been estimated by Bose and Blore at well over Rs 60 million a year.34 Others estimate the size to be over Rs 200 million (or $7 million U.S.).
The privatisation of SWM services deserves exploration. The participation by the private sector in the delivery of SWM services is an approach recently gaining ground in industrialised countries. There is evidence to suggest that it might be a more efficient means of collection than current municipally controlled operations. Both institutional resistance and public suspicion exists in relation to privatisation of SWM. Where the public feels that refuse collection is a municipal service and should be provided at little or no cost, municipal officials fear the wrath of municipal waste unions that oppose the use of private contractors. Moreover, there is a lack of established firms in India capable of providing this service. A pilot project followed by an in-depth evaluation would be useful.

There is also a need to experiment with different composting systems. There is growing recognition that neighbourhood level garbage collection (whether private, public or mixed), managed in collaboration with the residents, is often the cheapest and most effective solution to SWM. This is particularly true if there is reclamation of the wastes through composting of organic wastes in specific, and on a representative scale, would require an integrated approach to SWM and the involvement of a broad range of social actors. Cities would need the cooperation of municipal departments and private corporations to devote required land for such operations. Cooperation on the part of planning departments is critical to locating and managing of composting sites. Separation of wet and dry wastes by domestic and commercial actors would aid in reducing sorting time, as well as reduce health hazards for sanitation worker or waste pickers that may be recruited to collect and sort wastes. The successful implementation of this form of SWM demands an active role from municipal managers an genuine interest on behalf of the public.

Community Involvement and Public Education
Public participation is necessary in dealing with solid waste problems. Participation in decision-making at the local level is more often rhetoric than reality. Ensuring community participation in SWM issues depends on building awareness and a sense of community ownership through involvement and mobilisation around such issues as the building and placement of commercial waste bins. More than simply telling people about the importance of hygiene and sanitation, individuals from the locality should be trained for the implementation of awareness and education programmes (Cf. Rahman and Prasad in this volume.)
CONCLUSION

In order for economic activity to be environmentally sustainable, certain conditions need to be adhered to concerning the use of renewable and non-renewable resources, the emission of wastes and associated environmental impacts. The first principle of sustainable development is that these conditions have absolute priority over Gross National Product (GNP) growth. Underdevelopment is often touted as the main cause for inefficiency in India's systems for solid waste management. As improvement in the overall economy occurs, other incremental improvements should follow. Lack of attention to these issues will result in an increase in the dramatic difference between service to prosperous neighbourhoods and that available to the poor, and levels of morbidity and mortality. It is vital that long-term strategies be developed and that investments be made so that municipal officials are not overcome by the crisis-like nature of current SWM problems. In order to close the gap between precept and practice of SWM, greater coherence and enforcement of policy, management training, decentralised decision making and public involvement must be sought. The solutions can only come from an understanding of the technical, socio-cultural, political and economic context surrounding these concerns, and the limitations these conditions place on available options.

ENDNOTES

2. K.S. Bhatt, “Present Status of Solid Waste Management Under Indian Conditions,” Civic Affairs 40, No.12 (July, 1993): p.9. For perspective, it takes an average 18 months for the population of India to increase by more than the total population of Canada (26 million).
3. India Institute of Public Administration, Environmental Pollution and Urban Administration (New Delhi: Centre for Urban Studies, 1977), p.4.
13. India Institute of Public Administration, p.2.
14. N. Basu, “Too rapid a growth” The Hindu Survey of the Environment (Madras: The Hindu, 1992), p.89. In major cities of Ahmedabad, Bangalore and Hyderabad, only 25 to 70 percent of daily wastes are collected from primary inner city dumps by the municipality.


17. Ramakrishna, p.100.


19. Fritz and Misra, p.10

20. Fritz and Misra, p.3

21. Fritz and Misra, p.3


23. Bose and Blore, p.3.


32. Shekdar, p.513.
PART FOUR

LESSONS LEARNED
THE ECONOMIC ARGUMENT FOR LOW WASTE TECHNOLOGIES:
LESSONS FROM KANPUR

A. El-Tayeb, H. Cummings and I. Siddiqui

INTRODUCTION

Objective of the Paper
This paper has been prepared primarily to support the argument that Low Waste Technologies (LWTs) are financially viable and can create revenue for the firm. The paper also suggests a general framework to be used in evaluating the financial costs and benefits of LWT.

Organisation of the Paper
This introductory section gives an overview of the waste problem and firm responses to such problem. The potential benefits associated with implementation of the LWT strategy are highlighted to indicate the advantage of the LWT option over end-of-pipe (EOP).

In section one, differences between financial (firm level) and economic (community level) analysis in project evaluation are discussed. Section II is a discussion of different theoretical approaches used in project analysis. A general framework which will be used as a basis for the selection of the evaluation methods relevant to the type of LWT employed is also developed in this section. In Sections III and IV, two case studies of Kanpur firms that are currently employing LWT (a tannery and a dairy) provide support for the theoretical presuppositions regarding the profitability of LWT. It is mainly derived from the authors’ experience and review of current literature on LWT.
The Waste Problem and Firm Responses

Most production processes create waste-by-products which are disposed of in some way. Some wastes command a positive market price and are recycled or used in some form and others constitute an economically or technically unusable wastes which command no market price and have to be dumped or discharged into the environment. A firm confronted with a waste problem as such has the choice to decide among three possible alternatives:

(A) Direct disposal of wastes without treatment by dumping them in a nearby river or “shovelling” them into the backyard of the facility. This option is referred to as the “do nothing” situation and usually involves no cost to the firm. This practice can be brought to a halt by increasing the fine on pollution discharge or introducing and enforcing more stringent standards. Community awareness resulting in public pressure may also push the firm to consider other options.

(B) Treatment of wastes at the end of the manufacturing process (commonly referred to as “end-of-pipe treatment”). This option includes *inter alia* treatment plants for water purification, dusting systems, incinerators, and removal of waste products to a community plant approved for such treatment. This approach usually involves the cost of purchasing and installing new equipment in addition to the cost of operating and maintaining the system itself.

(C) Waste reduction at source by calling into question the process and systems themselves. This could be done by either making changes to the operations which generate the waste or re-integrating the waste into the production cycle (e.g. recycling, recovery, upgrading to profitable uses) (for details see Table 1.1 in the Introduction of this book).

The Advantage of LWT Strategies

Any practice that prevents material from becoming waste will reduce the amount (and dollar value) of raw materials required and will also reduce the overall quantity (and potential cost) of waste requiring management. If the reduced costs outweigh the cost of implementing and maintaining a waste reduction strategy, then the plant comes out ahead from a strictly financial point of view.
The following benefits have been realised by industries that have adopted LWT (Yap and Heathcote in this volume and references therein):

(a) savings on raw materials
(b) conservation of valuable resources
(c) complete or partial autonomy related to water resources through water recycling
(d) reduced generation of wastes
(e) savings in waste disposal and handling costs
(f) complete or partial discontinuance of existing waste treatment facilities (and hence significant reduction in pollution control costs),
(g) improved quality of treated wastewater
(h) increased efficiency of the production process
(i) improved labour productivity
(j) increase property value, and
(k) good public image and publicity.

I. FINANCIAL VERSUS ECONOMICAL ANALYSIS

The primary objective of this paper as stated earlier is to determine the narrow “private” profitability of LWT to the firm as opposed to the wider “social” profitability to the community as a whole. But before going into the analysis, it is worth distinguishing between financial analysis and economic analysis. Financial analysis takes into consideration only those costs and benefits that are incurred directly by the project. It is carried out from an individual or corporate/private perspective and is more concerned with narrowly defined profit or loss. It incorporates various distortions in the overall economy, such as overvalued foreign exchange rates, subsidies and taxes.
As a tool for evaluation, it provides a clear indication of incentive to adopt or implement a project from a private sector perspective.

Economic analysis on the other hand, is conducted from the standpoint of the community’s welfare and reflects the social opportunity costs and benefits of various actions. It recognises factors which are of interest to the national economy, but which may not be reflected in the financial cost. These factors include a premium on imported goods (as they cost the economy in terms of foreign currency) and unskilled labour (often under-utilised and priced in accord with the economic cost to society). Taxes, duties and other internal transfers included in the financial analysis are excluded from the economic analysis. They are appropriate to include in a financial analysis since they are paid by system purchasers but inappropriate to include in an economic analysis since they are not a cost to the country’s economy. The purpose of the economic analysis is to determine if the investment is justified from the society’s viewpoint. The main differences between financial and economic analyses are summarised in Table 10.1. Both approaches are valid given the different perspectives involved. A project can be evaluated using both financial and economic analyses to determine both the narrow “private” costs and benefits as well as the wider “social” costs and benefits.

II. METHODS FOR EVALUATION OF COSTS AND BENEFITS

One of the most confusing aspects of incorporating cost analysis into evaluation and decision making is that a number of different, but related concepts and terms are often used interchangeably. Among these are cost-benefit, cost-effectiveness, cost utility, and cost feasibility. The purpose of this section is to provide a brief discussion of the most common methods used in evaluating projects: cost-benefit and cost-effectiveness analyses.
<table>
<thead>
<tr>
<th></th>
<th>Financial</th>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focus</strong></td>
<td>net return to equity capital or to private group or individual</td>
<td>net returns to society</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>indication of incentive to adopt or implement</td>
<td>determine if the investment is justified from the society viewpoint</td>
</tr>
<tr>
<td><strong>Prices</strong></td>
<td>market prices</td>
<td>efficiency prices (shadow prices)</td>
</tr>
<tr>
<td><strong>Taxes</strong></td>
<td>part of cost of production</td>
<td>part of total societal benefits</td>
</tr>
<tr>
<td><strong>Subsidies</strong></td>
<td>source of revenue</td>
<td>part of societal cost</td>
</tr>
<tr>
<td><strong>Loan</strong></td>
<td>increases capital resource available</td>
<td>a transfer payment</td>
</tr>
<tr>
<td><strong>Interest</strong></td>
<td>a financial cost; decreases capital resource available</td>
<td>a transfer payment</td>
</tr>
<tr>
<td><strong>Discount rate</strong></td>
<td>market borrowing rate</td>
<td>opportunity cost of capital</td>
</tr>
</tbody>
</table>
Cost-Benefit Analysis

Cost-benefit analysis (CBA) refers to the evaluation of projects according to both their costs and benefits. CBA attempts to measure the value of both the costs and benefits of each alternative in terms of their monetary units. Since each alternative is assessed in terms of its monetary costs and the monetary values of its benefits, each alternative can be examined on its own merits to see if it is worthwhile adapting. In order to be considered for selection, generally any alternative must show benefits in excess of costs (Richard, 1994). However, it can be argued that although a socially desirable outcome may not yield an excess of benefits, it may on the other hand, warrant implementation and require subsidy from an area where excess benefits have been accrued. Generally, CBA converts costs and benefits to today’s values using discounting procedures for future values. The stream of benefits and costs can be compared, discounted back to the present and a net present value calculated. The best choice among the different alternatives is then the one that has the highest net present value (NPC), the highest rate of return on investment (ROI), lowest cost-benefit ratio or the highest ratio of benefits to costs (Richard, 1994).

Cost-benefit analysis can be carried out in different ways. It can be done by comparing costs and benefits that will arise “with the project” and compare them to the situation as it would be “without the project” (Gittinger, 1982). The difference is the incremental net benefit arising from the project investment. This is usually referred to as the “with-without” approach. Alternatively, the analysis can be carried out by comparing costs and benefits of the project as separate investments and the difference is the net benefit arising from the project. One advantage of CBA is that it provides a precise monetary comparison of benefits to costs, enabling people to use this as a widely understood selection criterion (Bussey, 1978). The disadvantage of the approach is that benefits cannot always be quantified nor monetised, and it can invite simplistic decision-making based on one factor alone. For example, how does one assess the benefits associated with an improvement in air quality or community appreciation of new cleaner technology?
Cost-Effectiveness Analysis

Cost-effectiveness analysis (CEA) refers to the evaluation of alternatives according to both their costs and their effectiveness (Levin, 1983). When the identified costs are combined with measures or indicators of each alternative’s success at meeting a stated effectiveness criterion, the alternatives can be evaluated on the basis of these indicators. These are the elements for a CEA. It is carried out mainly in cases where quantifying benefits in monetary terms proves difficult.

The CEA method is based on the assumptions that: (a) only projects with similar or identical goals can be compared, and (b) a common measure of effectiveness can be used to assess them. These effectiveness data can be combined with costs in order to provide a cost-effectiveness evaluation that will enable the selection of an approach which provides the maximum effectiveness per unit of cost, or which requires the least cost per unit of effectiveness. The method is applicable in such circumstances as: devising the most efficient (least cost) method of meeting a given environmental objective (e.g. achieving a certain level of air and water quality).

The cost-effectiveness approach has a number of advantages. The most important one is that CEA merely requires combining cost data with effectiveness data. Furthermore, it lends itself well to an evaluation that is intended to accomplish a particular goal. Its major disadvantage is that one cannot compare the C/E ratios among alternatives with different goals, nor can one make a determination of whether a project is worthwhile in terms of its benefits exceeding its costs. The preferred alternative according to the cost-effectiveness criteria might actually be a poor investment if one is to ask the question of whether the project is worthwhile. The cost effectiveness approach is often used for social sector activities where obtaining a desired outcome (reduced mortality for example) is a widely accepted societal goal and the object is to achieve it at the least cost.

Selection of the Evaluation Approach

Before beginning the evaluation of LWT, it is important from the outset to establish a general framework that can be used as a guideline in the selection of an evaluation approach.
The outline of this framework is presented in Table 10.2 and discussed in more detail in the section below. The evaluation approach can be selected according to the following criteria:

(a) access to and availability of baseline data
(b) type of LWT employed
(c) scale of the operation under investigation
(d) characteristic of the waste stream
(e) nature of costs and benefits.

**Access to and availability of baseline data:** The level of detail available and ease of access to information within the firm will determine the possible extent and end results of an evaluation of a LWT. When there is a lack of or inadequate relevant baseline information, a comparison based on the situation in the past, i.e., without LWT, and the situation after the change, i.e., with LWT, is either impossible to undertake or will produce misleading results (see discussion CBA). For example, when data contrasting production levels with the quantities of waste a plant produces is insufficient or cannot be determined, casual inference is difficult. It will be impossible to know, for example, whether any observed changes in the quantities of waste generated over a period of time are a result of changes in waste management practices, or are due to the effects of production increases or decreases.

**Type of LWT employed:** The level of technology application and its sophistication are major factors in the selection of the evaluation technique. In cases which involve a major modification in the manufacturing process, the estimation of LWT costs and benefits in isolation of other processes will become a difficult task. This is partly due to the fact that the effects of such modifications will be scattered throughout the manufacturing process, and cannot be traced directly to the technology modified. Resource recovery is usually the case where the technology can easily be separated from other manufacturing processes (see Table 1.1 in the Introduction of this volume).
Table 10.2: Criteria for Selection of Evaluation Approach.

<table>
<thead>
<tr>
<th>Evaluation Method</th>
<th>Cost-Benefit Analysis</th>
<th>Cost-Effectiveness Analysis</th>
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<tbody>
<tr>
<td></td>
<td>“With-without” Approach</td>
<td>Limited Cost-Benefit Analysis (technology in isolation)</td>
</tr>
</tbody>
</table>
| Information Demands       | • information complete  
                            | • easy access               | • incomplete            |
|                           | • easy to access       | • incomplete               | • easy to access but difficult to quantify in monetary terms |
| Scale of Manufacturing Operation | applicable to        | • large relative to: LWT employed | applicable to          |
|                           | • large               | • resource recovery         | • large                |
|                           | • medium              | • recycling                | • medium               |
|                           | • small               | • may require investment in capital | • small               |
| Type of LWT Employed      | • process change      
                            | • resource recovery        | • recycling            |
|                           | • process modification| • recycling                | • process change       |
|                           | • may require major R&D| • may require investment in capital | • resource recovery    |
| Waste Stream              | • may target more than one waste stream | • LWT targeted specific waste stream but cannot be separated from other waste stream | • Waste stream can easily be separated & evaluated |
|                           | • quantifiable/or unquantifiable |                                 |                        |
| Nature of Costs & Benefits| • indirect costs & benefits are significant & difficult to isolate | • directly related to LWT  | • benefits cannot be directly quantified in monetary terms nor related LWT |
|                           | • easy to isolate     | • easy to isolate          |                        |
Scale of the operation: Conversely, the scale of operation (i.e., the whole manufacturing process) will also influence the selection of a method and evaluation technique. For example, the “with-without” approach may show that a saving of a hundred thousand rupees a year for a plant making an annual profit of billions of rupees from product sales would be too insignificant to notice if the technology is evaluated only in terms of its effects on final product prices (either increase or decrease). In such cases, isolation of the technology from the rest of the process will be the best way to do the evaluation.

Characteristic of the waste stream: The effects of installed LWT on waste generation is difficult to quantify accurately in cases where an End-Of-Pipe (EOP) treatment is carried out concurrently. To carry out research on the technology’s effectiveness in term of reducing waste, there should be a common criterion (i.e., a specific waste stream targeted by both the end-of-pipe technology and LWT for effectiveness). For example, the effectiveness of a low waste technology employed to reduce the level of sulphide in wastewater should be compared with the effectiveness of an EOP treatment used to treat the sulphide in wastewater after it is generated (see discussion on CEA). However, in the real world of applied research, we rarely find this situation.

Costs and benefits: Each evaluation method requires a certain level of detailed information about costs and benefits. A comprehensive cost-benefit analysis requires a complete knowledge of costs and benefits including both economic and financial variables. A cost-effectiveness analysis is designed primarily to overcome the problem of quantifying benefits in monetary terms. In a situation where benefits are difficult to quantify, evaluating the technology according to its costs and effects in reducing waste will be the best approach (cost-effectiveness analysis). Another point is that the costs and benefits do not always directly relate to the technology employed.
III. RESOURCE RECOVERY: THE CASE OF THE CHROMIUM RECOVERY PLANT

Background
The Indian leather industry is one of the oldest and fastest growing industries. According to an estimate made by the Central Leather Research Institute (CLRI), there are about 2,000 tanneries in India. In Kanpur about 80 percent of the tanneries use chrome tanning process (Sharma, 1995). It is estimated that 25,000 tonnes of chromium salt in the form of Basic Chromium Sulphate (BCS) are used annually. Out of this, 10,000 tonnes of chromium salt are discharged as wastes increasing the complexity of effluent treatment and sludge disposal systems, and eventually ending up as an environmental contaminant. In addition, chromium is a costly chemical to waste. The recovery of chromium from wastewater is one of the solutions that have been suggested and promoted for implementation.

The technology of chromium recovery: The technology is being developed, mainly, to recover the huge losses in the chromium used in tanning and retanning processes (see tanning process, Appendix 4). CLRI reports that 35 to 40 percent of the chromium is lost during the processing of hides/skin. The economic value of chromium lost is substantial and finding a way to recover it makes good economic sense. The technology basically was developed by M’s Haskoning and TNO/ILS of the Netherlands and transferred to India through CLRI (CLRI, 1992). Some modifications were further made on the technology to suit India’s tanning conditions. In principle, chromium can be recovered by precipitation as a hydroxide using alkali, followed by an acidification process. Regenerated chromium then can be used in a liquid form or further processed into a dry – powder form. Figure 10.1 diagrammatically present the process of chromium extraction.

Environmental aspects: The environmental aspects of chromium (Cr) are complex and of more immediate concern to tanners. In its trivalent form (Cr³⁺) chromium is an essential trace element in human nutrition while there is reasonable evidence that some hexavalent salts (Cr⁶⁺) can be carcinogenic (Sykes, 1994).
Tanners use the trivalent chromium (Cr\(^{3+}\)) salt for processing hides and skin. In tanneries, chromium wastes are found in both the liquid discharge as well as in the solid wastes generated (see Table 10.3). For example, chromium can be found in leather shavings which are re-used to make leather board and leather splitting, which are then re-used to make cheap leather products. Chromium-containing sludge from Effluent Treatment Plants (ETP) has no re-use value and is currently landfilled.

### Table 10.3 Sources of Chromium Contamination in Tanneries.

Source: (Ahmed, 1995).

<table>
<thead>
<tr>
<th>Source</th>
<th>Re-use value</th>
<th>Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solid:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leather shavings</td>
<td>Leather board</td>
<td>-</td>
</tr>
<tr>
<td>Trimming wet blue</td>
<td>Leather board</td>
<td></td>
</tr>
<tr>
<td>Splitting</td>
<td>Cheap leather products</td>
<td>-</td>
</tr>
<tr>
<td>Buffing</td>
<td>No re-use value</td>
<td>Landfill</td>
</tr>
<tr>
<td>Sludge</td>
<td>No re-use value</td>
<td>Landfill</td>
</tr>
<tr>
<td><strong>Liquid:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanning</td>
<td>Recovery</td>
<td>ETP</td>
</tr>
<tr>
<td>Retanning</td>
<td>Recovery</td>
<td>ETP</td>
</tr>
</tbody>
</table>

**Financial aspects:** Capital cost requirements vary according to production capacity. Table 10.4 gives the standard equipment design costs for different capacity specifications of chromium recovery plant as supplied by CLRI. In-plant modification is enormously variable and can determine, to a great degree, the suitability of the technology. In principle, waste chromium liquor should be separated from other waste streams through a different drainage system. It is reported that the large tanneries have properly designed drainage system which reduces initial development costs (Garg, 1995). For some small tanneries, the technology may be technically unfeasible unless the unit undertakes major changes in machine positioning and drainage systems.
Figure 10.1: Chromium Recovery Plant.
Table 10.4: Standard Capital Cost For CRP.
Source: (Garg, 1995).

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Unit (per day)</th>
<th>Cost (lakh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000 – 6,000</td>
<td>litre of Cr. liquor</td>
<td>5 - 6</td>
</tr>
<tr>
<td>10,000</td>
<td>litre of Cr. liquor</td>
<td>8</td>
</tr>
<tr>
<td>20,000</td>
<td>litre of Cr. liquor</td>
<td>12</td>
</tr>
</tbody>
</table>

Super Tannery Kanpur – Model Case
On average, the tannery processes 900 to 1,200 hides per day, with chrome tanning being the major operation (Siddique, 1995). Quality leather destined for the international market has led the tannery to be the most important leather exporter in northern India. Basic chromium sulphate is used extensively by the firm, at a rate of 1,250 kg per day. Through process optimisation the tannery has increased the fixation of chromium in hides/skin, and therefore decreased its chromium waste from an average of 40 percent of the total amount used daily to 25 percent. In terms of weigh, the tannery has been able to reduce chromium loss by 187 kg/day out of average production rate 1,050 hide.

Wastewater management: The state of Uttar Pradesh Pollution Control Board (UPPCB) has set a minimum standard for contaminants in tannery wastewater. The maximum quantity of chromium allowed in wastewater is set at 2 mg per litre of water discharged. Table 10.5 gives characteristics of tannery composite wastewater, including chromium levels prior to treatment compared to UPPCB standard.

To meet the above standard, the tannery built an ETP in 1985 to treat all wastewater before final discharge. The plant treats 700 m³ of wastewater every day and operates around the clock. The ETP proved effective in keeping the tannery operation within regulatory limits.
Table 10.5: Characteristics of Tannery Composite Wastewater Compared to Indian Standard.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tannery</th>
<th>Indian standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.4</td>
<td>6.5</td>
</tr>
<tr>
<td>BOD mg/litre</td>
<td>0.0</td>
<td>350</td>
</tr>
<tr>
<td>COD mg/litre</td>
<td>3,050</td>
<td>n/a</td>
</tr>
<tr>
<td>Total solid mg/litre</td>
<td>45,300</td>
<td>100</td>
</tr>
<tr>
<td>Chlorides mg/litre</td>
<td>3,680</td>
<td>1,000</td>
</tr>
<tr>
<td>Chromium mg/litre</td>
<td>120</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The process of chromium extraction: The tannery, in its effort to reduce raw material losses, has installed a chromium recovery plant (CRP). Technical expertise was provided by the CLRI under the Indo-Dutch Sanitation Project in Kanpur. The technology is simple and easy to adopt. Effluent containing chromium is screened and collected in a treatment tank. A calculated quantity of magnesium oxide is added to the chromium liquor and stirred. During this stirring period the alkalinity (pH) gradually rises to the required value of about 8. After stabilising the pH, the stirring is stopped. The chromium precipitates and settles at the bottom of the treatment tank (reactor). The chromium sludge is dissolved in sulphuric acid to produce basic chromium sulphate which can in turn be re-used as a tanning agent (see Appendix 4).

Reasons behind the initiative: It was reported by the tannery management that the cost of chromium being lost was one of the key reasons why it implemented this LWT. Concerns about potential waste management problems were also cited as a reason for taking the initiative. Good publicity for the company was another motivating factor mentioned frequently by the management staff. Wastewater management costs, however, were not substantially reduced due to the fact that the ETP has to operate at the same capacity in order to dilute the other waste chemicals to their required levels.
The Evaluation Approach
To evaluate the financial profitability of the technology, the framework shown in Table 10.2 was used. The section of the evaluation approach was based on the following considerations:

(a) the technology is simple and easy to isolate and evaluate separately
(b) the technology generates benefits which can be directly linked to the LWT employed (i.e., the value of recovered chromium)
(c) indirect benefits and costs were either insignificant or easy to quantify and relate to the technology (for e.g. ETP cost saving);
(d) the large scale of operation meant that the benefits and costs of CRP could easily be masked or lost during calculations if the approach was to incorporate the technology as part of the manufacturing process (with-without approach), and
(e) comparing the costs and effectiveness of the existing waste management practice with the costs and effectiveness of the chromium recovery plant is impossible due to the lack of common criteria for effectiveness (all waste streams including chromium liquor are treated collectively).

Therefore, it was deemed unnecessary to undertake a cost-benefit analysis using the “with-without comparison” even though the company was willing to share all information. Based on the above considerations, a separate cost-benefit analysis method was selected for the evaluation of the financial viability of LWT, i.e., costs and benefits were quantified separately and compared in isolation from the other manufacturing operations and processes.

The Analysis
The data used for this financial analysis was collected during a site visit to the study area in February, 1995. Using Lotus 123, the model for the data analysis was constructed based on the following assumptions:

• the project (i.e., chromium recovery plant) would generate a uniform stream of costs and benefits (see Appendix 3), and
• inflation is treated by assuming constant prices. The assumption of constant prices takes the effect of inflation out of the analysis:
Project analyses are usually done at constant prices because the analyst is concerned with the real return to the project when he is looking at the financial analysis. Thus it is common practice for the analyst to assume that general inflation will exert the same relative effect on both costs and benefits and to work in constant prices (Gittinger, 1982, p.400).

All costs unique to the technology were determined. Costs were divided into two: initial capital cost (i.e., the complete cost of purchasing and installing the equipment). Based on the assumption of uniform costs and benefits over the life of the project, capital cost is annualised using the assumption of a 20-year term of analysis and 18 percent rate of discount. The selection of the discount rate is based on the actual cost of capital (market borrowing rate) in India as of 1995. For each cost item identified, cost per unit of material recovered is calculated (i.e., cost per kg of chromium recovered). Cost per unit of final product is also calculated (i.e., cost per hide and ton of hide). Total annual costs are determined by adding total recurrent costs to total annualised capital cost.

Benefits are treated in the same way as costs. All direct and indirect benefits associated with the technology are determined. The total benefit is the value of direct material recovered plus the indirect benefit of cost reduction in the ETP. Benefits per unit of material recovered are calculated (i.e., benefits per kg of chromium recovered), and are also reflected on the final product (i.e., benefit per hide and ton of hide processed). The net benefit is calculated by subtracting the total annual cost from the total annual benefit.

The concept of annuity in cost-benefit analysis is based on the assumption that all payments are made at fixed intervals for a given length of time. The present value of the stream of payments to be received in the future is simply the sum of the discounted payments over the length of the project. It can be calculated using the equation below. The total present value is divided by the number of years of the effective life of the investment to get annualized estimates.

\[
P = \frac{A \left(1 - (1+r)^{-n}\right)}{r}
\]

where

- \(P\) = present value of annuity
- \(A\) = initial investment
- \(r\) = discount rate
- \(n\) = no of years
Given the assumption of annuity, the Net Present Value (NPV) is calculated by discounting the net benefit over the life of the project using an 18 percent discount rate. The result is then subtracted from the initial capital outlay (see Appendix 3). To avoid double counting, the net benefit is calculated by subtracting only recurrent costs from annual gross savings. Subtracting annualised capital cost from annual gross savings would result in double counting. Alternatively, since the net benefit is constant over time, the same NPV result can be obtained by discounting net benefits (i.e., benefits minus recurrent cost minus annualised capital cost) over the life of the project.

Identification of Costs

(a) Investment Cost: For the construction of the CRP, the tannery made an investment of 8 lakh (800,000 rupees). This covered all capital equipment, building, land and installation costs. Technical expertise was provided by CLRI under the Indo-Dutch Sanitation Project. Table 10.6 gives a summary of all capital costs (for details, see Appendix 2).

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (lakh)</th>
<th>[%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land &amp; building</td>
<td>3.36</td>
<td>42%</td>
</tr>
<tr>
<td>Equipment</td>
<td>2.72</td>
<td>34%</td>
</tr>
<tr>
<td>Installation</td>
<td>1.27</td>
<td>16%</td>
</tr>
<tr>
<td>In-plant modification</td>
<td>0.65</td>
<td>08%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8.00</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Capital costs vary according to production capacity and the need for in-plant modification. For large tanneries, land is almost always available with no opportunity cost associated with the LWT. The quantity of Exhaust Chromium Liquor (ECL) generated by the firm required the installation of two reactors. However, changing plant conditions and some problems with the technology delayed the installation of the second reactor for almost a year.
Building and land constituted the major cost component (42%). Equipment costs made up 34% of total capital cost. In-plant modification, which constituted 8 percent of total capital cost, was required to separate the chromium liquor from other wastewater to avoid contamination of the recovery stream. For large and medium-sized tanneries, financing investment associated with the size of CRP can easily be managed without difficulties. However, for small-sized tanneries, the decision to implement the technology may depend on the availability of financing. Currently CLRI is trying to negotiate soft loan terms with the government to assist the smaller tannery owners who expressed interest in adopting the technology.

(b) Recurrent Costs: The inputs required for the operation and maintenance of the plant are: chemicals for chromium extraction, labour for operation and maintenance, and energy for pumping and stirring (see Appendix 2 for details).

The plant operates 8 hours a day 6 days a week. Chemical inputs are added according to quantity of ECL. Chemical prices are relatively cheap and stable. The current market prices for magnesite and sulphuric acid are 5.5/kg, and 1.6/kg rupees respectively. The labour requirement is a major variable and depends, to some extent, on the location of the (CRP) units relative to the main tanning section. The unit requires two semi-skilled labourers to add chemicals and monitor the plant, and six unskilled labourers for operation and maintenance work. No skilled labourers are required. The cost estimates for labourers are based on the actual number of labourers involved and current market rate\(^2\) (40 rupees per day for unskilled and 50 rupees per day for semi-skilled workers, respectively). Powers is also needed for stirring and pumping the ECL from the collection pit to the reactor and from there to the storage tank. One item of recurrent cost that proved difficult to estimate accurately is the cost of electricity. First, the CRP has no separate power circuit and energy consumption is totalled for the whole tannery operation.

\(^{2}\)An interesting point is that the standard requirement for labour to operate the plant provided by CLRI is two times higher than the one actually employed. Workers in the tanning industry are usually under-paid and over-worked as indicated by CLRI.
Second, there are a regular power cut during which time the company generator is used. For the above reason, the calculation is based on the manufacturer specifications of the motors and pumps.

(c) Total Costs: The estimates of capital, operation and maintenance costs were based on data collected from the tannery files and interviews with the director. Some of the operation and maintenance data were obtained from direct monitoring of the operation. Table 10.7 which is extracted from Worksheet #1 (Tanner base case) provides a summary of total annual costs. A pictorial distribution of the same data is presented in Figure 10.2.

The items of the highest cost to the tannery are: chemicals (31%), capital cost (29%), and labour cost (19%). Total cost per kg of chromium recovered is found to be around 7 rupees. By considering the cost only, Table 10.7 also shows a 1.49 rupees increase in hide processing cost.

Identification of Benefits
(a) Quantifiable Benefits: The primary benefit of CRP is derived from the value of chromium recovered. Based on the data collected from the operation of the plant, 250 kg of chromium is the amount recovered per day. Using the market price for chromium (18 rupees/kg), 4,500 rupees is the total value of material saved. The value of chromium recovered represent 95 percent of total savings. Secondary savings come from wastewater treatment. The CRP reduces the cost of operating the ETP by 225 rupees a day which represent 5 percent of total savings. The details on CRP savings are presented in Table 10.8. The same information is pictorially presented in Figure 10.3.

Table 10.7: Total Cost Summary (Chromium Recovery Plant).

<table>
<thead>
<tr>
<th>Cost items</th>
<th>per/d</th>
<th>per/y</th>
<th>Cost (Rs) per/kg of Cr</th>
<th>per/hide</th>
<th>per/ton of hide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>498</td>
<td>149,456</td>
<td>1.99</td>
<td>0.42</td>
<td>19.41</td>
</tr>
<tr>
<td>Chemicals</td>
<td>532</td>
<td>159,600</td>
<td>2.13</td>
<td>0.45</td>
<td>20.73</td>
</tr>
<tr>
<td>Labour</td>
<td>340</td>
<td>102,000</td>
<td>1.36</td>
<td>0.29</td>
<td>13.25</td>
</tr>
<tr>
<td>Energy</td>
<td>278</td>
<td>83,400</td>
<td>1.11</td>
<td>0.24</td>
<td>10.83</td>
</tr>
<tr>
<td>Maintenance</td>
<td>93</td>
<td>27,873</td>
<td>0.37</td>
<td>0.07</td>
<td>03.62</td>
</tr>
<tr>
<td>Total</td>
<td>1,741</td>
<td>522,328</td>
<td>6.98</td>
<td>1.49</td>
<td>67.86</td>
</tr>
</tbody>
</table>

Source: (Appendix 1).
The secondary savings related to the operation of the ETP are actually difficult to estimate accurately. The ETP was constructed to treat all waste streams including waste chromium liquor, i.e., it is part of the plant’s water pollution control equipment. The management of Super Tannery
indicated that due to the fixed costs of operating the ETP, its cost could not have been reduced through the installation of a CRP. After an exhaustive and time-consuming interview session the investigation revealed that the quantity of one of the major chemicals used in ETP treatment had been reduced after the installation of the CRP. The costs that remain unaffected by installing the CRP include the cost of monitoring the treated wastewater exiting the ETP. The effect of the CRP on the ETP sludge quality is substantial because it removed almost all chromium contamination. However, due to the presence of other contaminants, (i.e., sulphides) the sludge still has no re-use value for the tannery.

(b) Benefits that can not be Quantified: Some reduction in administrative cost was reported but not quantified by the staff. The space and cost of storage of large quantities of chromium salt was reduced due to the reduction in quantities purchased and delivered to the plant. Other benefits include: fewer visits by UP pollution control enforcement, labour used for handling ETP sludge were less exposed to chromium contamination, and, as indicated by the tannery director, the benefits of good publicity to the tannery.
Benefits generated as a result of the CRP installation but which are not part of financial analysis are summarised below:

(a) employment generation  
(b) reduction in chromium pollution lead  
(c) savings of valuable natural resources  
(d) health benefits to workers and community in general  
(e) enhanced firm’s image with government, community, consumer, and  
(f) enhanced investor’s confidence

Financial Results
Based on Worksheet #1, the Chromium Recovery Plant generates net savings of 8.95 lakh (895,171 Indian rupees) annually. For each kg of chromium recovered, a net saving of 11.93 rupees is realised. Cost per hide processed is also reduced by 2.55 rupees due to implementation of CRP. Table 10.9 summarises CRP financial costs and benefits. The same information is pictorially presented in Figure 10.4.

<table>
<thead>
<tr>
<th>Financial</th>
<th>per/d</th>
<th>per/yr</th>
<th>per/ton</th>
<th>per/hide</th>
<th>per/Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Rs]</td>
<td>[Rs]</td>
<td>[Rs]</td>
<td>[Rs]</td>
<td>[Rs]</td>
</tr>
<tr>
<td>Gross saving</td>
<td>4,725</td>
<td>1,417,500</td>
<td>184.17</td>
<td>4.05</td>
<td>18.90</td>
</tr>
<tr>
<td>Total cost</td>
<td>1,741</td>
<td>522,328</td>
<td>67.86</td>
<td>1.49</td>
<td>6.96</td>
</tr>
<tr>
<td>Net saving</td>
<td>2,984</td>
<td>895,171</td>
<td>116.31</td>
<td>2.55</td>
<td>11.93</td>
</tr>
</tbody>
</table>

**Pay-Back Period:** It is necessary at this point to indicate that tannery owners in most cases base their financial decisions on capital cost requirement rather than life cycle expenses. Applying pay-back period criteria, the plant can recover its full capital cost in less than one year (nine months).
The short pay-back period means that the uncertain future of the technology can be reduced as quickly as possible to a known and a certain position: complete recovery of the investment. Thereafter, uncertainty is of no consequence to the firm since the investment has been fully recovered and any proceeds derived after the pay-back period are simply profit. This is important to the tannery owners since the technology is new and its success is not certain.

Net Present Value: The Net Present Value can be calculated by discounting the net benefits minus the discounted costs over the life of the project. As presented in Table 10.10 the chromium recovery plant shows a positive net present value of 40.60 lakh which is equivalent to 4,060,000 rupees. A positive NPV means that the present worth of the benefit stream is more than the present worth of the cost stream. Obviously from the result of the pay-back period (less than one year pay-back) the Internal Rate of Return (IRR) is more than 100 percent which is far more than the cost of capital (18 percent).
Sensitivity Analysis

Variation in quantity of chromium loss: As the quality and quantity of EVL varies, so do the costs and quantities of chromium recovered. Some of the large, well developed tanneries using up-to-date technology have succeeded in reducing chromium losses and thus reducing the quantity of chromium in their ECL. In small tanneries, however, the chromium losses are still very large. CLRI estimates that average losses amount to 35 percent to 40 percent of the total quantity of chromium used in tanning. Details of the variations in costs and benefits due to this variation in chromium lost is presented in Table 10.11. As can be seen from Table 10.11, the net savings per year will vary from 8.95 lakhs to 17.05 lakhs as a result of a change in percentage chromium loss (from 25% to 40%). The same variation will result in a pay-back period of five months, which is three months less than the base case (nine months). For the large tanneries the percentage losses are likely to be lower as they are more likely to be using advanced technologies.

In-plant modifications: The cost of in-plant modifications required for CRP implementation varies from tannery to tannery. Size, technological sophistication, machine positioning and the tanning techniques currently used were cited as main factors affecting variations in cost. A rough estimate suggests that the required investment can be as low as 0.5, and as high as 1.2 lakhs.

Table 10.10: Cash Flow (Chromium Recovery Plant).

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenue</th>
<th>Costs</th>
<th>Cash flow</th>
<th>NPV (18%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>00</td>
<td>08</td>
<td>-8</td>
<td>40.60</td>
</tr>
<tr>
<td>1</td>
<td>14.17</td>
<td>3.72</td>
<td>10.44</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>14.17</td>
<td>3.72</td>
<td>10.44</td>
<td></td>
</tr>
<tr>
<td>3 - 20</td>
<td>14.17</td>
<td>3.72</td>
<td>10.44</td>
<td></td>
</tr>
</tbody>
</table>

Source: (Appendix 3)
A 10 percent increase in capital cost will decrease the net savings by almost 2 percent while an increase of 50 percent in capital cost requirements over the base case assumption will decrease net savings by 10 percent. Table 10.12 gives details of variations in capital costs based on the base case shown in Appendix 1.

### Table 10.12  Variation in Capital Cost.

<table>
<thead>
<tr>
<th>Parameter [capital cost]</th>
<th>NS/d [Rs]</th>
<th>NS/yr [Rs]</th>
<th>NS/hide [Rs]</th>
<th>NS/ton of hide [Rs]</th>
<th>NS/kg [Rs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>00% increase</td>
<td>2,984</td>
<td>895,171</td>
<td>2.55</td>
<td>116.93</td>
<td>11.93</td>
</tr>
<tr>
<td>10% increase</td>
<td>2,932</td>
<td>879,478</td>
<td>2.51</td>
<td>114.27</td>
<td>11.72</td>
</tr>
<tr>
<td>20% increase</td>
<td>2,879</td>
<td>863,785</td>
<td>2.46</td>
<td>112.23</td>
<td>11.51</td>
</tr>
<tr>
<td>30% increase</td>
<td>2,827</td>
<td>848,093</td>
<td>2.42</td>
<td>110.19</td>
<td>11.30</td>
</tr>
<tr>
<td>40% increase</td>
<td>2,775</td>
<td>832,399</td>
<td>2.37</td>
<td>108.15</td>
<td>11.09</td>
</tr>
<tr>
<td>50% increase</td>
<td>2,723</td>
<td>816,707</td>
<td>2.33</td>
<td>106.11</td>
<td>10.88</td>
</tr>
</tbody>
</table>
IV. LWT IN MILK PROCESSING INDUSTRY: 
THE CASE OF PARAG DAIRY

Background

The Parag Dairy is the only organised milk processor in the city of Kanpur. It is a cooperative located in the densely populated area of Harala Nagar. The Dairy was established in 1969 with 1.5 lakh (litre per day) total installed capacity. Its mandate is to help small farmers and milk producers economically by establishing a direct backward link, thus eliminating the role played by middlemen in past years. Parag Dairy produces a wide variety of milk products which are destined primarily to meet local demand. The total daily production varies according to the season. Average summer production is estimated at around 75,000 litres per day whereas winter production can be as high as 100,000 litres/day (Agarwal, 1995). The mix of products varies widely and depends on consumer demand and feedback from distributors. The plant operates 24 hours a day, 7 days a week and it employs over 400 unionised workers.

In recent years and due to the influence of India’s new liberalised industrial policy, Parag underwent a major overhauling of its operation and working system. New products have been introduced and marketed with promising results. The restructuring operation proved successful in putting the dairy operation back on the profit side.

Waste Generation: According to the Central Pollution Control Board classification of highly polluting industries, the dairy industry is not on the priority list although it generates a sizable quantity of wastewater. Staff estimates of the quantity of wastewater generated suggest that three litres of water is required for every litre of raw milk processed. Wastewater which originates mainly from cleaning operations contain high BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) levels. Table 10.13 gives a detailed description of the dairy wastewater composite compared to Indian standards.

Solid waste generation accounts for 10 percent of the total waste produced. Dairy estimates suggest that 2 percent of the poly-film milk bagging material is lost during the process. Power cuts and machine operator error are blamed for most of this loss. Other solid wastes generated include sludge from the ETP and milk powder lost due to bad storage.
Table 10.13: Wastewater Composition Compared to Indian Standard
(Parag Dairy, Kanpur).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concentration</th>
<th>Indian Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>300 mg/l</td>
<td>30 mg/l</td>
</tr>
<tr>
<td>COD</td>
<td>1,500 mg/l</td>
<td>250 mg/l</td>
</tr>
<tr>
<td>pH</td>
<td>8.5</td>
<td>7</td>
</tr>
<tr>
<td>suspended solid</td>
<td>400 mg/l</td>
<td>10 mg/l</td>
</tr>
<tr>
<td>oil &amp; grease</td>
<td>200 mg/l</td>
<td>10 mg/l</td>
</tr>
</tbody>
</table>

Waste Management Practices: An effluent treatment plant constructed in 1990 is used for water treatment before it is discharged to the main sewer system. About 150,000 to 300,000 litres of wastewater is treated every day. The ETP operates 20 hours a day, 7 days a week. Regulatory pressure was cited as the key reason behind its construction. The Dairy management expressed real concern about the high cost of running the ETP.

Solid wastes are primarily recycled off-site. Plastic wastes are sold to a recycling company. Sludge from the ETP is recycled on-site in the plant nursery. Other solid wastes are dumped at the plant site.

Low Waste Technology: Several LWT have been identified as being in place at Parag Dairy. They range from simple process change (e.g. changing the time schedule of milk delivery), to major process change (e.g. installation of a solar system as an alternative for the existing furnace system) entail investment in capital equipment. Table 10.14 gives a detailed description of the LWT already in place.

Financial Analysis
(a) Installation of Voltage Stabiliser: Plastic waste mainly originates from the milk bagging and sealing machine. It is estimated that 2 percent of the total bagging capacity (67,500 litres/d) is lost daily.
The company management indicates that with each bag of milk wasted, approximately 5 percent of its milk content is also lost. Very rough back-of-the-envelope calculations would bring the amount of milk lost to 135 litres per day. The general manager considered this as a loss to the national milk supply and national economy.

After intensive monitoring by dairy staff, two factors were identified as begin the sources of the problem. One source was the unstable power supply which usually breaks the smooth flow of milk bagging and results in milk bags being either incompletely sealed (leaking) or containing less than the required quantity. Machine operator error was identified as the second source of the waste problem.

After examining a number of alternatives, the dairy management decided to install a voltage stabiliser. The process of recognising the problem, identifying sources, identifying solutions, selection of the appropriate alternative, and implementation is a good example of how an economic incentive guided the company in its decision making process. Due to the voltage stabiliser, plastic waste generated has been cut by 50 percent.

### Table 10.14 LWTs Already in Place, Parag Dairy (Kanpur).

Source: (Agarwal, 1995)

<table>
<thead>
<tr>
<th>LWT</th>
<th>Waste</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-site recycling [nursery]</td>
<td>Plastic waste</td>
<td>10% reduction in waste generated</td>
</tr>
<tr>
<td>Off-site recycling [recycling of plastic]</td>
<td>Plastic waste</td>
<td>100% reduction in waste generated</td>
</tr>
<tr>
<td>On-site recycling [nursery]</td>
<td>ETP sludge</td>
<td>50% reduction in waste generated</td>
</tr>
<tr>
<td>Resource recovery [V. stabiliser]</td>
<td>processed milk</td>
<td>5% reduction</td>
</tr>
<tr>
<td>Process change [change timing of milk delivery]</td>
<td>plastic bags</td>
<td>50% reduction in waste generated</td>
</tr>
<tr>
<td></td>
<td>sour milk</td>
<td>25% reduction in waste generated</td>
</tr>
</tbody>
</table>
(b) The Evaluation Approach: A cost-benefit approach is used for the evaluation of the technology. The large scale of the main operation plus the simplicity of the technology dictated the use of limited cost-benefit analysis (i.e., technology in isolation).

(c) The Costs: The cost of the voltage stabiliser (capital cost) was the only cost item identified. Labour for installation and materials were included in this figure. No operation and maintenance costs are required. For the annualised capital cost calculation, a 20-year life of equipment and 18 percent discount rate (bank borrowing rate) were used.

(d) The Benefits: Savings on the plastic material were calculated based on the number of pouches per kg. The price of a kilogram of plastic sheet (55mm thickness) is 74 rupees. The average quantity of pouches is given as 390 per kg. Processed milk savings was calculated based on a 5 percent average loss from a milk bag of 500 ml. The 5 percent loss is the lower limit estimate, and this quantity might be as high as 10 percent. Milk is valued according to the price of raw milk which is 9.25 rupees per litre. However, this valuation may not reflect the actual prices because of the value added to the raw milk during processing. Table 10.15 gives details of material savings and net benefits.

Financial Result
Pay-Back Period And Net Present Value: As indicated in the calculation presented in Table 10.15, the company can recover all its investment costs in one year. A net savings of 139,070 rupees per year would also be realised. Assuming a constant flow of benefits over the life of the project, the NPV can be calculated by discounting the net benefit and then subtracting this from the total capital cost. Using 20 year term of analysis and 18 percent discount rate, the present value of benefits can be obtained by multiplying the net benefit by the discount factor (i.e., 5.35). The net result is then subtracted from total capital cost to obtain NPV.

Table 10.15 shows a positive NPV of about 6 lakhs. This means that the technology generates benefits in excess of costs over the life of the project.
Table 10.15: Financial Result (V. Stabiliser).

<table>
<thead>
<tr>
<th>Financial valuation</th>
<th>Rs/yr</th>
<th>Rs/day</th>
<th>Rs/litre of milk processed/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost [A]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital cost [1.6 lakh]</td>
<td>31,424,45</td>
<td>104.74</td>
<td>0.001</td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>000,00,00</td>
<td>000.00</td>
<td>0.000</td>
</tr>
<tr>
<td>Benefits [B]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic material saving</td>
<td>76,846.15</td>
<td>256.15</td>
<td>0.003</td>
</tr>
<tr>
<td>Product saving (milk)</td>
<td>93,656.25</td>
<td>312.18</td>
<td>0.004</td>
</tr>
<tr>
<td>Net savings [B - A]</td>
<td>139,078.0</td>
<td>463.59</td>
<td>0.007</td>
</tr>
<tr>
<td>PV of savings (20 yr, 18% DR) = 7.44 lakh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV (20 yr, 18% DR) = 5.84 lakh</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION

The application of the approach to the tannery and dairy cases showed the utility of the evaluation method and the financial viability of LWT. In the case of the tannery, the application of the technology (i.e., Chromium Recovery Plant) has reduced the level of chromium in wastewater by almost 80 percent and saved the company 8.95 lakh annually. The Dairy case also showed a similar result. The application of the technology has significantly reduced the amount of waste generated (poli-film by 50%, milk waste by 10%) while saving the dairy 1.4 lakh annually. The results obtained from the two cases can be utilised to demonstrate to other industries the financial viability of LWT.

Drawing upon the experience from the case studies and selected literature, this section proposes a broader approach for evaluating the financial profitability of investing in LWT. The approach would allow researchers to identify and select the appropriate method for evaluating the profitability of LWT. The approach includes 10 recommended steps for identifying a method and calculating the financial benefits of LWT.
Steps To Follow In Evaluating Investments In LWT:

(1) Identify what type of LWT is employed, for example: resource recovery, recycling, process change, good housekeeping. This will give you a lead towards identifying costs and benefits.

(2) Try to figure out the reasons which motivate the initiative, for example: economic reasons, liability insurance, green-minded management. This will narrow your search for process or processes that have been affected by the LWT.

(3) If you decide to undertake a “with-without comparison”, make sure that you have reasonable data on products, output, and waste generation before implementation of the LWT. A lack of data comparing various production levels with the quantities of waste a plant produces will make it impossible to know whether increases or decreases in the quantities of waste generated over a period of time stem from the LWT or simply from production changes.

(4) Before you proceed with your evaluation, very roughly, try to calculate the ratio between the LWT benefits/or income generated and annual turnover from products sale (assuming that you have complete access to relevant information). The result will tell you, roughly, how significant the effects of the LWT on final products or outputs have been.

(5) It is futile to proceed with your evaluation approach (with-without comparison) if step 4 indicates that the change is too insignificant and can easily be missed during calculations. Don’t panic, as two options are still available.

(6) Try to isolate the technology from other processes and evaluate it as a single investment. Step one will determine how easily you can isolate the LWT. Resource recovery and recycling, and simple process change are both examples of technologies that can be easily isolated. Once you isolate all costs and benefits associated with the LWT, then it will become a straightforward, typical cost-benefit evaluation process.
(7) In cases where isolation of the LWT is not easy, try to find an intermediate product or products that is affected most by the LWT, and then reflect on those particular products. This is particularly easy when the plant produces a wide range of marketable by-products from different processing sections.

(8) If all attempts to isolate the LWT from the process fail or quantifying its benefits becomes impossible, it is not over yet; you still have a chance to produce a good result. The cost-effectiveness analysis is a technique designed primarily to overcome such a problem. A waste stream that is targeted by both EOP technology and LWT can be used as a common goal for effectiveness. For example a LWT employed to reduce levels of sulphide in wastewater can be compared to the EOP used to treat sulphide in wastewater after being generated.

(9) Try to estimate all costs and benefits. Direct costs and benefits are not a big problem in most cases. The troublesome ones are those which cannot directly be related to the LWT. Cost reduction in environmental protection is always difficult to detect. Some companies keep separate records for their money transaction with the government, including those dealing with environmental protection issues. Try to access them! You may be able to identify some payment for exchange of waste related services that are provided by the government. Experience with the tanneries in Kanpur, India showed that such information is very hard to get. Answer to questions with regard to the reduction in environmental costs due to the application of LWT was always “No”. By following closely, we discovered later (by going through the records) that the tannery used to pay 275 rupees to the municipal government for ETP sludge removal which no longer exists. Other leads can come from disposal licenses, fees, liability insurance, and so forth. In some cases where the cost of waste management seems unaffected, try to look for a major cost item used for managing the waste. You are more likely to find your answer there.

(10) After you have selected the evaluation method, identified the costs and benefits, the next step is to select the right criteria to make your financial decision.
Financial text books are full of all fancy names: Net Present Value (NPV), Internal Rate of Return (IRR), Pay-Back Period (PBP), Cost-benefit Ratio (CBR), Return On Investment (ROI). Here is a list of things you should check first:

- Check step 2 for the reason behind the initiative.
- Check the company’s general financial health. That might give you a good idea of how urgent the need is to have a pay back on its investment.
- See if the product has a short lifespan in the marketplace. A firm knowing that its product will not last for long may want a project with a short pay-back period.
- Check the level of risk involved.
- Check on what bases the company decides on financial issues, i.e., capital investment or life cycle costs.
- Finally, see how detailed the information you have got is and compare it to the requirements of the method you have selected.

REFERENCES

### APPENDIX 1: DATA ANALYSIS SPREADSHEET (TANNERY MODEL CASE).

#### Assumptions [general] vs. Financial

<table>
<thead>
<tr>
<th>Assumptions [general]</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>349831 Total process capacity/yr/hides</td>
<td>0.00 Loan rate</td>
</tr>
<tr>
<td>300.00 days of operation/year</td>
<td>0.00 Loan amount</td>
</tr>
<tr>
<td>100.00 Total capital investment [crore]</td>
<td>0.00 Loan term</td>
</tr>
<tr>
<td>1233.00 Annual turnover [crore]</td>
<td>0.00 Tax on equipments</td>
</tr>
<tr>
<td>average weight of hide (kg)</td>
<td>22.00 Exchange rate [Rs/US$]</td>
</tr>
<tr>
<td>40.00 wage rate unskilled [Rs]</td>
<td>18.0% Disc. Rate (bank)</td>
</tr>
<tr>
<td>50.00 semi-skilled [Rs]</td>
<td></td>
</tr>
<tr>
<td>1.39 Energy cost/kwh [Rs]</td>
<td>taxes are included in all equipments</td>
</tr>
</tbody>
</table>

#### LWT Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Rs</th>
<th>kg/day</th>
<th>kg/yr</th>
<th>kg/ton of hide</th>
<th>kg/hide</th>
<th>per kg of Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>capacity of collection pit [kl]</td>
<td>30.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>capacity of treatment tank [kl]</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>settling period/hour</td>
<td>20.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hours of operation</td>
<td>8.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Cr Sulphate per hide</td>
<td>1.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Chromium (Cr) loss</td>
<td>25.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Recovery rate [Cr]</td>
<td>80.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>life of equipment (yr)</td>
<td>20.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quant. Of exhau. Cr. Liquor p</td>
<td>20.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process capacity per day [kl]</td>
<td>25.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesite</td>
<td>5.50</td>
<td>40.00</td>
<td>12000</td>
<td>1.56</td>
<td>0.03</td>
<td>0.16</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>2.60</td>
<td>120.00</td>
<td>36000</td>
<td>4.68</td>
<td>0.10</td>
<td>0.48</td>
</tr>
<tr>
<td>B. Cr. S.</td>
<td>18.00</td>
<td>1250.00</td>
<td>375000</td>
<td>48.72</td>
<td>1.07</td>
<td>-</td>
</tr>
<tr>
<td>Aluminum S.</td>
<td>3.00</td>
<td>375.00</td>
<td>112500</td>
<td>14.62</td>
<td>0.32</td>
<td>-</td>
</tr>
</tbody>
</table>

---

Note: All values are in Rs unless specified otherwise.
<table>
<thead>
<tr>
<th>Output/benefits</th>
<th>Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>kg/day  kg/yr  kg/ton hide kg/hide</td>
</tr>
<tr>
<td>Material saving [Cr]</td>
<td>250.00  75000.00  9.74  0.21</td>
</tr>
<tr>
<td>Indirect</td>
<td>day     year [Rs]  ton/hide output [Rs]  hide/output [Rs]  kgCr output [Rs]</td>
</tr>
<tr>
<td>Reduction in Aluminum Sulphate use</td>
<td>75.00  22500.00  2.92  0.06</td>
</tr>
<tr>
<td>Reduction in sludge disposal cost</td>
<td>-     -        -        -</td>
</tr>
<tr>
<td>Sub-total [C]: Gross savings</td>
<td>4725.00 1417500.00 184.18 4.05 18.90</td>
</tr>
<tr>
<td>Total cost [A + B]</td>
<td>1741.10 522328.78 67.87 1.49 6.96</td>
</tr>
<tr>
<td>Net savings (income) = [[C] [A+ B]]</td>
<td>2983.90 895171.22 116.31 2.56 11.94</td>
</tr>
<tr>
<td>Cost item</td>
<td>Unit</td>
</tr>
<tr>
<td>------------------------</td>
<td>------</td>
</tr>
<tr>
<td><strong>Capital [A]</strong></td>
<td></td>
</tr>
<tr>
<td>- Land</td>
<td></td>
</tr>
<tr>
<td>- Building</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td></td>
</tr>
<tr>
<td>Reactor</td>
<td>1.00</td>
</tr>
<tr>
<td>Holding tank</td>
<td>1.00</td>
</tr>
<tr>
<td>Treatment tank</td>
<td>1.00</td>
</tr>
<tr>
<td>Storage tank</td>
<td>1.00</td>
</tr>
<tr>
<td>Pumps</td>
<td>2.00</td>
</tr>
<tr>
<td>Pipes &amp; fittings</td>
<td></td>
</tr>
<tr>
<td><strong>Labour</strong></td>
<td></td>
</tr>
<tr>
<td>Skilled</td>
<td>2.00</td>
</tr>
<tr>
<td>Unskilled</td>
<td>8.00</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td></td>
</tr>
<tr>
<td>[platform]</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>5000.00</td>
</tr>
<tr>
<td>Engineering &amp; Consultant</td>
<td>15000.00</td>
</tr>
<tr>
<td>Contingencies</td>
<td>14000.00</td>
</tr>
<tr>
<td>In-plant Modifications</td>
<td>65000.00</td>
</tr>
<tr>
<td><strong>Sub-total [A]</strong></td>
<td></td>
</tr>
<tr>
<td>O &amp; M</td>
<td>Unit</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
</tr>
<tr>
<td>Chemicals</td>
<td></td>
</tr>
<tr>
<td>Magnesite</td>
<td>Kg</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>Kg</td>
</tr>
<tr>
<td>Others</td>
<td>Kg</td>
</tr>
<tr>
<td>Labour</td>
<td></td>
</tr>
<tr>
<td>Skilled</td>
<td>Wage</td>
</tr>
<tr>
<td>Unskilled</td>
<td>Wage</td>
</tr>
<tr>
<td>Energy</td>
<td>KWH</td>
</tr>
<tr>
<td>Adm. overhead</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>Loan Repayment</td>
<td>Rs</td>
</tr>
<tr>
<td>Sub-total</td>
<td>[B]</td>
</tr>
</tbody>
</table>

Results [financial]

<table>
<thead>
<tr>
<th>Financial indicators</th>
<th>Waste reduction indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discounted pay-back period [DPP] 11 month</td>
<td>Reduction in pollution load 0.40</td>
</tr>
<tr>
<td>Pay-back period [years] 6.96</td>
<td>Quant. of Cr. In waste water exiting CRP (with CRP) 2 mg/L</td>
</tr>
<tr>
<td>9 month 895171.20</td>
<td>Quant. of Cr. in waste water (without CRP) 120 mg/L</td>
</tr>
<tr>
<td>Cost/Kg of Cr. Recovered [Rs] 0.00</td>
<td></td>
</tr>
<tr>
<td>Annual profitability/savings [Rs] 75000.00</td>
<td></td>
</tr>
<tr>
<td>Ratio of annual cost to annual turnover</td>
<td></td>
</tr>
<tr>
<td>Reduction in annual consumption (B.C.S.) [kg]</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2: COST ASSUMPTIONS

The following paragraph outlines the cost assumptions for the two cases of LWT. Costs are given in Indian rupees [lakh] as of 1995 unless otherwise indicated.

<table>
<thead>
<tr>
<th>CAPITAL COST</th>
<th>COSTS</th>
<th>SOURCE OR JUSTIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>[CRP] Super Tannery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>building</td>
<td>3.00</td>
<td>based on interviews with super tannery director</td>
</tr>
<tr>
<td>material</td>
<td>0.36</td>
<td>same source</td>
</tr>
<tr>
<td>labour</td>
<td>0.14</td>
<td>same source</td>
</tr>
<tr>
<td>Contingencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>holding tank</td>
<td>0.75</td>
<td>tannery records</td>
</tr>
<tr>
<td>reactors</td>
<td>0.57</td>
<td>same as above</td>
</tr>
<tr>
<td>pumps</td>
<td>0.90</td>
<td>same as above</td>
</tr>
<tr>
<td>motors</td>
<td>0.24</td>
<td>same as above</td>
</tr>
<tr>
<td>sludge dissolving</td>
<td>0.15</td>
<td>same as above</td>
</tr>
<tr>
<td>tank pipes &amp; fittings</td>
<td>0.48</td>
<td>interview with the director</td>
</tr>
<tr>
<td>platform</td>
<td>1.00</td>
<td>records</td>
</tr>
<tr>
<td>boiler (optional)</td>
<td>0.50</td>
<td>records</td>
</tr>
<tr>
<td>steam pipe line</td>
<td>0.25</td>
<td>records</td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tray with steam</td>
<td>0.75</td>
<td>records</td>
</tr>
<tr>
<td>drying</td>
<td></td>
<td></td>
</tr>
<tr>
<td>drying drum (optional)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>chimney for boiler</td>
<td>0.34</td>
<td>records</td>
</tr>
<tr>
<td>storage tank for regenerated Cr.</td>
<td>0.10</td>
<td>records</td>
</tr>
<tr>
<td>Installation (foundation fixing the reactor fixing the agitator)</td>
<td>0.70</td>
<td>Interview with the director</td>
</tr>
<tr>
<td>in-plant modification</td>
<td>0.65</td>
<td>same as above</td>
</tr>
<tr>
<td>electrical (starter main switch wires panel)</td>
<td>0.35</td>
<td>same as above</td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemicals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnesite</td>
<td>0.12</td>
<td>interview with tannery chemist and direct</td>
</tr>
<tr>
<td>sulphuric acid</td>
<td>0.36</td>
<td>observation same as above</td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>skilled</td>
<td>0.30</td>
<td>personnel supervisor records</td>
</tr>
<tr>
<td>unskilled</td>
<td>0.72</td>
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<tr>
<td>Energy</td>
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<tr>
<td>electricity</td>
<td>0.80</td>
<td>based on equipment specifications</td>
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<tr>
<td>coal</td>
<td>0.90</td>
<td>director estimates</td>
</tr>
<tr>
<td>Parag Dairy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cost of raw milk [litre]</td>
<td>9.25</td>
<td>interview with the GM</td>
</tr>
<tr>
<td>cost of kg of plastic material</td>
<td>74.0</td>
<td>same as above</td>
</tr>
<tr>
<td>voltage stabiliser [capital]</td>
<td>1.60</td>
<td>interview with dairy GM</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>0.00</td>
<td>same as above</td>
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</table>
APPENDIX 3: CHROMIUM RECOVERY PLANT CASHFLOW (lakh).

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenues</th>
<th>Costs</th>
<th>Net Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>8</td>
<td>-8</td>
</tr>
<tr>
<td>1</td>
<td>14.175</td>
<td>3.728728</td>
<td>10.44627</td>
</tr>
<tr>
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APPENDIX 4: SUPPLEMENTAL INFORMATION SUPPLIED BY SUPER TANNERY (INDIA) LIMITED (Siddique, 1995).

(A) TANNING PROCESS

Soaking: It is done in pits/paddles. Chemicals used are detergents and preservatives.

Washing: Hides/skins are washed with plain water.

Liming: In this process, the hair roots are removed from hides/skin after saponifying the fatty material.

Washing: The purpose of this process is to wash away the alkali.

Fleshing: Loose flesh is removed without damaging the hides/skin.

Scudding: The tied fibres are loosened in this process.

Deliming: Lime and other alkalis left on hides/skin are removed either by washing or by the use of chemicals.

Pickling: pH is lowered in this process by the use of common salt or sulphuric acid.

Tanning: In this process basic chromium sulphate penetrates the leather at pH 2.8 to 3 and forms a compound with collagen at pH 4.

Basification: In this process the chrome fixes on collagen at pH 4 or above.

Piling: Hides/skin are piled up for 24 to 48 hours for the complete reaction to take place.

Selection: Segregation of tanned leather is done as per its end use.

Sammying: Excess moisture is removed either by sundrying or by the use of the sammying machine.

Splitting: Uneven surfaces of the hides/skin are removed by passing the hide through the splitting machine.

Shaving: The surface of the hide/skin becomes smooth in this process. This is achieved by the use of a shaving machine.

Trimming: This is done manually to give the leather proper shape.

Weighing: In this process drum load weight is made for processing in the dye house.

Washing: The moisture spreads out uniformly by washing.

Neutralising & Washing: Chrome-tanned leather is acidic in nature. This is made neutral in this process.

Retanning: In this process the properties from other tannage are imparted to chrome-tanned leather. By this process uneven surfaces become even.

Dyeing: The leather is dyed to the required shade by the use of special dyes in this process.

Fat Liquoring: During this process the surface of fibres and fibrils are coated with a thin layer of oil. If this process is not done, the leather becomes dry and hard.

Piling: The leather is piled for 24 hours. By this time the oil is equally distributed on the surface of the leather.

Sammying: In this process the excess water is drained out. This is done by the use of sammying machine.

Setting: By the use of the setting machine, wrinkles and folds are removed from the grain side of the leather.

Vacuum Drying: By the use of a vacuum drying machine, wrinkles on the leather are removed and the moisture content remains at only 45%.

Toggling: This is a combined process of stretching and drying the leather.

Stacking: In this process the leather becomes soft. Stacking and stretching operations are achieved by the use of the vibration stacking machine.

Buffing: This is done by the use of hydraulic/pneumatic buffing machine. The leather is worked on the flesh side only.

Dedusting: In this process the surface of the leather is cleaned by the use of dedusting machine.

Coloured: In this process emulsion is applied on the leather. It is done either manually or by the use of a curtain coater roller coating or padding machine.

Plating: In this process the leather is hot plated to get a smooth embossed surface.

Spraying: Finishing liquid is applied either by hand or by auto spray machine.

Top Sealing: In this process nitrocellulose lacquers and thinner are applied to impart a high degree of gloss, excellent water proofing and good resistance to abrasion, etc.

Trimming: The leather is trimmed to remove odd ends and bits.
Chromium Contamination and Chrome Recovery Plant
Chromium is the main constituent in chrome tanning but 40% of it goes to waste with spent liquor and causes air and water pollution. It is also a source of contamination of subsoil water. Using a chrome recovery plant, the chrome is recycled for reuse. This plant is installed as close as possible to the chrome tanning section. Once the tanning is over, with the help of a hose pipe fitted to a drum at one side and the other side fitted to a conveyer system, spent chrome liquor is collected in a collection tank. These tanks have walls made of brick with cement mortar. The valves and floor of the tank are plastered with sulphate resistant cement and coated with tar paint.

Main Reaction Tank
This is made of mild steel. In this tank, magnesium oxide is mixed with spent chrome liquor and the following chemical reaction takes place:

\[
\text{Cr}_2(\text{SO}_4)_3 + 3\text{MgO} + 3\text{H}_2\text{O} \rightarrow 2\text{Cr(OH)}_3 + 3\text{MgSO}_4
\]

The precipitated chromium hydroxide is drained to a sludge dissolving tank by gravity flow.
Sludge Dissolving Tank
Sulphuric acid is added to the chromium hydroxide and the following chemical reactions take place:

\[ 2 \text{Cr}_2(\text{OH})_3 + 3\text{H}_2\text{SO}_4 \rightarrow \text{Cr}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O} \]
\[ \text{Cr}_2(\text{SO}_4)_3 + \text{H}_2\text{O} \rightarrow \text{Cr}_2(\text{OH})\text{SO}_4 + \text{H}_2\text{O} \]
\( \text{Cr}_2(\text{OH})\text{SO}_4 \) is 33% basic.

Regenerated Chrome Liquor Storage Tank
The generated chrome sulphate is pumped to this tank.

(B) LIMING PROCESS
During this process hair are removed from hide/skin without damaging the flesh tissue. The principle involved in the process is that the epidermis and hair roots are made soft and then the hair is removed. This is achieved by the reaction of chemicals on the epidermis. Chemicals used in the process are hydrated lime, sodium sulphide, hydrosulphide, enzymes and detergents. These detergents saponify the fatty materials and enzymes help in removing the hair roots without making the tissue swell. Most of the tanners use only lime and sodium sulphide.

The inputs and outputs of the liming process are as follows:

- Raw material used - soaked hide (37 kg)
- Water consumption - 34.00 litres
- Effluent discharge - 30.00 litres
- Consumption of hydrated lime - 4.5% by weight of hide
- Consumption of sodium sulphide - 2.5% by weight of hide
- Duration of process - 18 hours
- pH - 12.2
- Moisture content - 100%
- Liquid waste - 29.799 litres
- Solid waste - 200.70 grams
Low Waste Technology Changes in Super Tannery (India) ltd.
In addition to the installation of the chrome recovery plant in the Super Tannery, an additional plant has been installed which converts recycled spent chrome liquor to powder form, keeping the pH and percentage chromium oxide to the same figure as in liquid form. The principle of operation of this plant is as follows:

A drum made of mild steel is used and steam passes through it to keep it hot. A lead-coated-steel tray full of regenerated chrome liquor is kept under this drum. As the drum rotates, its outer surface touches the liquid in the tray. As this surface moves up, the liquid content of this chrome liquor evaporates and the remaining solids fall and accumulate in another tray.

Summary of Reasons that Prompted Super Tannery (India) Ltd. to Introduce Changes
Super Tannery (India) Ltd. is the first tannery in Northern India to install a chrome recovery plant at a cost of 8 lakhs with the technical assistance from the Indo-Dutch team of the Ganga Pollution Control Board. The main idea behind the project was to reduce the water contamination to as low as 20%. Once the plant was put in operation it was found that the plant not only recovered the cost of the plant but also reduced the production cost of leather considerably. More importantly, the quality of leather improved to a very high standard. Less consumption of chemicals, water and power resulted in financial gains, which prompted them to maintain this plant to its highest efficiency. The result was that other tanneries also installed similar plants. Super Tannery went a step further and installed another plant to convert recycled chrome liquor to powder form which is easy to handle, store, and measure accurately.
INTRODUCTION

In low consumption countries, concerns about environmental quality may be sidelined in the push to develop and make economic gains through industrialisation. This problem is expressed in propositions from the 1992 United Nations Conference on Environment and Development (UNCED):

- in the absence of environmentally sound technological change, economic expansion results in environmental degradation and overall efficiency losses affecting firms, national production and the global economy

and,

- if developing countries industrialise by using obsolete, inefficient production techniques that were employed by richer countries to generate their wealth, then environmental deterioration is ensured (OECD, 1994b, p.5).

In India, the problem may be persisting for several reasons, including (until recently) a preference for ‘end of pipe’ (EOP), if any, methods to treat the waste products of industry and mitigate their environmental impacts. Low waste technologies (LWTs), (also known as cleaner production, clean or cleaner technologies and pollution prevention), have been suggested as the next step in the evolution of waste management strategies. These technologies involve “the use of processes, practices, materials and energy that avoid or minimise the creation of pollutants and wastes” (Environment Canada, 1994, p.11).

The evolution of waste management strategies parallels the increase in sophistication of industrial processes. ‘React and cure’ methods (remediation and abatement technologies) are being
replaced (at various rates) in industrialised countries by the ‘anticipate and prevent’ approach (encompassing pollution prevention and sustainable technologies). Countries (Canada, Netherlands, Sweden, Japan, Germany, United States) which have made progress in LWT adoption have built up an impressive collection of case studies that support this approach. Low waste proponents are now suggesting their methods to developing countries as the path they should follow. Cleaner production is being touted as the only viable approach for developing countries (Lykke, 1989); that is the only one that will permit changes to be made ‘sustainably’.

It is possible that there is no one solution to the plethora of industrial waste problems. There may be instances where gas scrubbers, digesters or catalytic converters (all EOP treatments) represent the ‘available practicable solutions’. Furthermore, what have been considered to be EOP treatments are also evolving (for example bioremediation techniques), and the distinction between EOP and LWT is often vague, leading to misunderstanding and confusion. However, because of the potential benefits provided by LWTs (and not EOP technologies), LWT must be among the options considered when decisions about waste management strategies are made.

LWTs include good housekeeping, source segregation, process modification, recycling (both on and off-site), resource recovery, materials reformulation, product substitution and enhanced product durability (Yap, 1988). In waste management strategies, LWTs present an alternative to EOP treatments. LWT seeks to reduce waste creation while EOP methods capture and treat wastes, and manage the resulting pollutants (Environment Canada, 1994). The pollutant management component of EOP stems from the transfer of the waste/pollution problem from one medium to another (i.e., in effluent treatment facilities, some constituents of the effluent stream are transferred to sludge).

The integration of LWT into industrial processes can help to:

• reduce requirements for EOP waste treatments
• achieve compliance with existing laws and regulations
• increase the firm’s environmental awareness
• enhance the public’s perception of the firm and industry
• minimise health risks associated with the wastes, and
• save existing or create new economic resources for the firm.

The progress and obstacles affecting LWT adoption in India, (and contributing to the persistence of the environment/industrialisation trade off) lie at the country, city and firm levels.

In India, the benefits of making the transition to the ‘anticipate and prevent’ approach in industrial waste management are recognised and steps to accomplish the transition are addressed in policy and programs (Government of India, 1992; Luken, 1992). Still, the focus of the majority of industrial firms, industry associations and regulators remains on ‘react and cure’, as represented by EOP technologies,

which involve infrastructural changes to existing plants and the installation of technologies for treatment of pollution after it has been generated (OECD), 1994b, p.14.

At the national level, some of these obstacles or impediments have been analysed by Achtell (1995).

The environmental crisis facing India, and illustrated in Kanpur, is recognised (if not always acted on) by Kanpur’s industrialists, government officials and citizens. However, a sense of helplessness and the pre-occupation with keeping afloat financially is resulting in a maintenance of the status quo, or worse. The scale of the industrial waste problem in the city, and its overshadowing by other concerns has meant that it has not been addressed comprehensively. An unwieldy and convoluted bureaucracy, and the lack of enforcement of existing discharge regulation also contribute to the failure to address the problem. As far as identified, Kanpur had not been the target of previous efforts to encourage industrial LWTs, with the exception of chromium recovery in tanneries, promoted by an Indo-Dutch bilateral project.

This paper makes no attempt to suggest solutions to the social and political problems in Kanpur City. The study is limited to the level of individual firms, and extends to the larger environment only when recognising that outside actors may influence and are impacted by the firm’s waste management activities.
At the firm level, the following factors may be hampering a more rapid spread of LWTs in Kanpur:

- no systematic means in place for identifying waste management problems or opportunities
- lack of awareness that LWT presents an alternative way of addressing waste management problems
- not recognising that LWT may present benefits not associated with EOP, and
- not knowing how to technically integrate LWT into the industrial process.

The development and implementation of planning tools that contribute to the identification of waste problems at the firm level could result in a more effective transfer of LWT as a waste management strategy. Following problem recognition, information about LWTs as candidate solutions must be made available to the firm. Finally, choosing LWTs over other waste ‘solutions’ must be encouraged through policy and financial initiatives as discussed by Yap (1995).

This study is concerned with the identification of specific waste problems in industrial firms. The objective of this paper is to assess and suggest improvements for triggering problem identification by firms. The analysis is done by first describing the research process used to obtain data for this study and then distilling lessons from field observation – what was effective, what wasn’t and why? Recommendations are then made to improve future research efforts.

The full case studies from which data is drawn are not included in this paper. Technical findings concerning the feasibility of selected LWTs in each of the industries have been presented earlier in Part Three of this volume. Instead, the data collection experiences are used to make suggestions that may assist other workers undertaking a similar investigation. Making improvements to the methodologies employed in the current study could result in a more effective tool for transferring industrial LWTs.
I. BACKGROUND

The Study Area: Kanpur

Kanpur is historically renowned as an industrial centre, particularly for textile and leather production. According to Singh (1972, p.84), “Kanpur [was] like a great oasis in the industrial desert of Uttar Pradesh.” However, the city is currently experiencing an economic downslide. This is due to political instability, labour problems, and the inability of outdated industrial installations to compete internationally.

Despite (or perhaps due to) economic hardship, industrial waste generation is a major problem in Kanpur. Mehta (1993) reported that 247.50 million litres of sewage were being discharged directly into the Ganga River each day. Ansari et al. (n.d.) stated that the total volume of combined industrial and domestic effluent generated was 401 million litres per day. Two hundred metric tonnes of hazardous solid waste materials are generated every day; 60 tonnes of these by the tanneries (Routh, 1994).

Kumra (1982) wrote that:
Kanpur city has 24 textile mills including 2 woollen and 2 jute mills. These mills are the biggest sources of pollution in the city (p.45).

The author also described some of the sources of pollution:
the fertilizer factory is also responsible for polluting air as well as water in the city…[its operation] pollutes water of R. Pandu which is without any aquatic life for 5-6 km form [sic] the place, where effluent is discharged (p.51)
and that
“Kanpur Milk Board [the dairy]…also contributes to pollution of water” (p.52).

Mehta (1993) reported that the city of Kanpur had accomplished the least in response to the Ganga Action Plan. Figures from 1992 indicates that under the Plan, biochemical oxygen demand (BOD) had “improved [i.e., decreased] in all towns except Kanpur” (Ministry of Environment & Forests, 1992). The Central Pollution Control Board stated that “Kanpur down-stream [on the Ganga] is critical with respect to dissolved oxygen” (Chakrabarti, 1993, p.20).
However, Mehta (1993) acknowledged that the Ganges case [tannery closures due to a 1987 Supreme Court order] resulted in tanneries and other hazardous industries implementing pollution control measures which, the Boards had been unable to make them do in the last 18 years (p.131).

II. METHODOLOGY

Framework for Analysing Planning Needs

Decisions concerning waste management strategies are ultimately made by the firm’s management. Problem identification is a starting point for decision making activities. The identification of waste problems within the firm is also an important initial step in transferring industrial LWTs, as the problems become candidates for the development and implementation of low waste solutions. The planner therefore needs to understand how the “problem recognition” phase can be triggered.

The Basis – Problem Solving: The steps in problem solving have been described as (adapted from Newman, 1971):

1. Problem Recognition
2. The Search for Alternatives
3. Selection of a Preferred Alternative
4. Implementation of the Selection
In this linear model, the selection of a preferred alternative is a process of decision making accomplished by ranking the alternatives based on their success in meeting stated criteria. In the area of industrial waste management, each firm’s criteria will reflect their motivations for seeking to reduce wastes, and may change or be differently emphasised for different waste problems and at different points in time. The respective criteria could be developed by identifying (for example) the financial costs acceptable to the firm, the existing discharge limits for waste substances, and any reduction targets following from corporate goals.

However, the absence of an orderly, linear, once-through progression from problem recognition to implementation of the preferred solution is also supported in the literature (Bridge and Dodds, 1975; March and Shapira, 1982). Different ‘solutions’ may be tried and found to be unsatisfactory (and the cycle of decision-making entered again), the problem may cease to be recognised as such, be replaced by another problem which is now considered more pressing, or it may be discovered that the problem identified initially is not the ‘real’ or root problem. Rather than conceptualise the process as being linear, perhaps it is better understood as a cycle:

- Recognise Problem
- Search for Alternatives
- Select Preferred Alternative
- Implement Selection

In this case, any of the steps could provide entry to or exit from the cycle, and any ordering of steps within the cycle is possible. The model for decision making therefore may be better described by Cohen et al. (1972) who state that:

Organisations can be viewed for some purposes as collections of choices looking for problems, issues and feelings looking for decision situations in which they might be aired, solutions looking for issues to which they might be an answer, and decision makers looking for work (p.1).
The authors, in outlining their ‘Garbage Can Model of Organisational Choice’, felt that “a theory of organised anarchy will describe a portion of almost any organisation’s activities”.

The decision to address waste management issues and enter into problem solving, as well as the outcomes of each step, is influenced both by the culture inside the firm and by outside actors such as labour, public interest and community groups, business competitors, the scientific and engineering community and informal systems of authority (Yap, 1988). Yap (1995, p.28) also suggests that it is “safe to assume that most of the firms in India are in the problem recognition and search [for alternatives] phase” of the problem solving/decision making process. If so, planning tools whose use accelerate and structure problem recognition or identification should find a wide application. In the next section, the waste audit will be presented as a powerful tool for structuring problem identification.

**Research Techniques**

Preparations for the research in Kanpur included reading about the city and anticipation of case study industries. Familiarisation with the industrial processes and identification of successfully implemented LWTs in other countries was accomplished through a literature review. Materials were assembled describing the waste audit approach, identified as the overall organiser for data collection activities.

Data was collected through interviews and site visits of selected industries between August and December 1994. Participant observation techniques complemented and verified information gathered from interviews and the literature.

**Industry Selection Criteria**

Prior to the Canadian investigators’ arrival in Kanpur, it was assumed that most consideration would be given to the tanneries and textile mills. A list of Kanpur industries received from HBTI identified these and other industries as potential case study candidates.

The identification of industries for investigation was largely a function of the personal acquaintance of the firm’s management with the project’s Indian co-investigators. Other selection criteria identified by the research team were:
• the economic importance of the sector to Kanpur
• the volume of waste
• the hazard of waste
• how easily LWT could be incorporated
• the firm’s willingness to cooperate, and
• the waste’s economic value to the firm.

Data Collection
The waste audit was used to identify information needs and to structure the data collection process. In industrial (as well as commercial and institutional) settings, the waste audit is an accepted way of systematically discerning where waste is being generated and where potentials for implementing low waste options exist (Jacobs Engineering Group, 1988; Richmond, 1989; UNEP/UNIDO, 1991). The procedure allows one to pinpoint specific waste generating steps in the industrial process. Solutions for each identified problem are then collected and assessed.

The waste audit is executed within the firm, and results are firm-specific. This is one way in which the procedure serves to encourage LWT over EOP treatments. Rather than using add-on EOP technologies that treat a waste stream after the process and before it enters the environment, examination of each unique process step highlights the source of the different components of the total waste stream. Reducing the contributions of each step, by employing LWT, can decrease the total waste stream in terms of both volume and toxicity.

Waste audits are used in Ontario, the U.S., Sweden (the TEM project), Netherlands (PRISMA) and by a United Nations Industrial Organisation (UNIDO) study of cleaner production in India (Luken, 1992). Waste audit description also forms part of the “Environmental Audit for Industry” document formulated to guide Indian industries in completing the (since 1993) compulsory Environmental audits (Modak, 1993). Therefore, the selection of this organising tool represented neither a novel approach nor one unknown in the Indian context. The waste audit objectives are to:
• identify and quantify process inputs and outputs
• describe wastes in terms of their constituents
• describe current waste generation, handling and disposal practices, and
• identify where changes could decrease process wastes.

Alternatives for managing the identified wastes are then:
• generated
• examined for their feasibility (technical, economic, environmental, social and cultural)
• contrasted based on their relative merits
• narrowed to the preferred alternative(s), and
• implemented.

Ideally, the alternatives will include one or more low waste options. The steps involved in a waste audit are listed below (Richmond, 1989). These steps formed the organising framework for the researcher’s data collection in Kanpur.

Step One  Understand the process in the plant
Step Two  Define process inputs
Step Three  Define process outputs
Step Four  Carry out a material balance study
Step Five  Identify waste reduction options
Step Six  Implement an action plan

The methods identified to collect data contributing to Steps One, Two and Three were as follows.

Site Visits: Understanding the plant process, either as a whole or as inter-related components, can be an overwhelming undertaking. Site visits permitted observation of the firm’s operations during different times of the day and week, and allowed for discussions with various staff members, almost exclusively at the management level. Photographs were taken during visits to document conditions. Care was taken to obtain permission from management before photographing firm activities.
During these interactions, industrial processes, inputs and outputs were elucidated for the researchers. The researchers contributed to the learning process through participant observation. Site visits were initially arranged by HBTI and later by the researcher.

**Interviews:** Interviews were arranged with management level staff of the selected industrial firms and with industry associations, academics, municipal officials, and local and state level public service environmental staff.

**Questionnaires:** Questionnaires were prepared for the initial industrial site visits and proposed project launch in Kanpur. The questionnaire was general in nature.

In Step Four, the material balance, the appropriate method is *Waste Sampling and Analysis*. Quantitative and qualitative analyses permit the completion of a mass or material balance. The quality of data obtained depends on the available testing facilities (location and equipment) and the rigour of sampling and testing procedures followed.

Step Five, the identification of waste reduction options, was addressed using a *Literature Review*. A review of both published and “grey” literature was completed. As well as allowing the researcher to gain some familiarity with industrial processes before her arrival in Kanpur, the review served to identify existing low waste options. The literature search continued in Kanpur, with emphasis placed on the Indian context.

Step Six involves the results of examining the feasibilities of the options identified during Step Five, and includes the firm’s decision to implement a solution identified for each specific problem.

The researcher did not anticipate completing all of the steps in a waste audit for any of the case study firms during her time in Kanpur. It was hoped that the data collection methods contributing to each step in the waste audit framework would be initiated in the selected firms, make varying degrees of progress, and overall, result in at least one case study contributing to the stated research objective: the identification of specific industrial waste problems suited to LWT application.
III. FIELD OBSERVATIONS

Case Study Selection
After the researcher’s arrival in Kanpur, it was discovered that out of eleven textile mills, only four were currently operating, and these at only 20 percent of capacity (Routh, 1994). This necessitated a re-assessment of the assumption that this industry would be among those selected for study.

Tannery investigation proved more appropriate. One hundred and fifty-one (Rajmani, n.d.) tanneries operate in the Kanpur region, and are concentrated in Jajmau, a district approximately twelve kilometres downstream of the Ganga River from Kanpur. The range of hide processing capacities is from 40 to 1,000 hides per day (Garg, 1994). A Supreme Court (India) Order of January 22, 1987 closed twenty-nine of the Jajmau tanneries for not having effluent treatment plants (ETP) or facilities (Mehta, 1993).¹

The tanning industry was therefore a good choice for investigation. Within this sector, much work had been accomplished and continues under the auspices of an Indo-Dutch cooperative venture. Still, there was scope to study this industry vis-à-vis its awareness and stage of adoption of LWT.

The industries seen during the first round of visits included: an edible oil plant, a dairy producer, two tanneries, a urea fertilizer plant, and a nylon manufacturer. Subsequently, a textile machinery manufacturer with an on-site plating operation was added to the list. The pulp and paper sector was already being investigated by HBTI. The research was not involved with this industry.

One of the stated selection criteria, the firm’s cooperation, was essential for the investigation to proceed. Only the nylon manufacturers was unwilling to participate in the study. One of the tanneries was dropped as a candidate because although management was interested in the study, they could not spare time for new commitments. This left the edible oil, dairy, tannery, fertilizer and plating operations.

¹ One or two of these tanneries remained close at the time of field research.
Based on the criteria, the edible oil and tanning industries scored highest for priority investigation. In the end, case studies were developed by the researcher for the dairy, tannery and edible oil industries. Time constraints, the operation's large scale and the progress already made by the firm, precluded pursuing research at the fertilizer manufacturer.

In the plating industry, attempts to identify and involve more (particularly smaller scale) platers progressed slowly and were ultimately unsuccessful for a number of reasons: incomplete and inaccurate records of registered and unregistered platers, suspicion on the part of some small operators, and time constraints. Difficulty arranging, and even denial of access to industries and factories either having more economic significance or displaying more hazardous waste generating potential (synthetic fibre, defence industry installations, thermal power station), made the inclusion of these firms in the study impossible.

Data Collection Techniques
The methods chosen to contribute to case study construction were not equally successful. The outcome of each method will now be described along with its success in meeting expectations as a data collection device.

Site Visits: As the researcher and co-investigators enjoyed good rapport with the firms’ staff and management, site visits were usually pleasant. However, infrequent visits to the case study firms interrupted research continuity, and made a complete understanding of the industrial process difficult. For example, answers to the same questions often changed from one visit to the next, because of communication problems, the effect of seeing numbers in print, or the uncertainty also meant that research activities had to proceed as efficiently as possible.

During interactions with management and technical staff, illustrations and formulae were used by the researcher to clarify technical concepts and questions when the language barrier hampered communication. Use of these graphical representations was helpful, both at the industry and with HBTI colleagues. Valuable information was obtained and clarified in an informal way.
Photos taken on site at different times of the day helped to ease communication (employees often enjoyed having their pictures taken). The photos also serve to bolster incomplete memories.  

**Interviews:** Interviews for the most part took place as a team, during the initial weeks of data collection. Interviews conducted with officials from outside the firms served to give a good picture of the broader context of industrial waste management. During these visits, the facilities (laboratory, library) available to staff were seen and the project was introduced to a larger audience. Discussions occasionally supplied contacts for further data collection activities.  

**Questionnaires:** The paper questionnaires were never used, after the very first industry visit. The planned project launch, anticipated as a venue for questionnaire distribution was never held. The structure of visits was such that the listed questions could be interspersed in the conversation, and the researcher had no need of a paper reminder.  

**Waste Sampling and Analysis:** In the end, no satisfactory sampling and testing could be conducted. Difficulties with sampling protocol, storage and ethics were encountered. The available laboratory facilities were minimal and suffered from frequent power outages, and there was an incomplete understanding among staff of analytical procedures. The infrequency of firm visits also posed difficulties in terms of sampling. The quantities of raw materials and product were instead estimated through interviews, participant observation and from company records.  

In summary, an understanding of the plants’ processes, definition of process inputs and outputs, and an identification of waste reduction options resulted from data collection activities. While the progress made toward completing the steps of the organising framework (waste audit) did not permit the exact quantification and characterisation of wastes, it did assist in clarifying industrial processes, identifying general waste types and revealing the existence of and further possibilities for implementing LWT in the case study firms.²

² Some of the identified waste problems continue to be monitored by project researchers, who have noted the firms’ subsequent responses to and attempts at dealing with their perceived problems.
Three case studies resulted from the data collected (dairy, tannery, edible oil). In all three of the case study firms, LWTs could be identified as being already in place. This was somewhat unexpected, based on the findings anticipated by the project investigators (emphasis on EOP, waste generators’ resistance to cooperation) (Yap and Awasthi, 1994). The case study firms are in various stages of LWT awareness and adoption, represented by the different steps in the Problem Solving model. This was noted for the firms in reference to each other, and to different waste situations within each firm.

The process of adoption of the in-place LWTs was different for each of the case study firms. One sought consultants’ advice, one generated and tested in-house solutions and one was approached by an outside agency with ‘LWT in hand’.

IV. DISCUSSION

During the research, and upon reflection after returning from Kanpur, a number of specific points emerged as being noteworthy. Some of these may be subsumed under two more general categories: communication difficulties and the need to gain the trust of local participants in the investigation.

Communication difficulties stemming from language, culture, social and gender differences affected research progress. Gaining participant trust is necessary in order to enlist initial cooperation and obtain all needed and available information. When developing a time frame for investigation, the time required to build contacts and make personal connections locally must be a factor. Getting past the initial ‘showcasing’ or presentation of the study area in the best light, as well as overcoming the firm’s reluctance to share sensitive information is imperative and will only result from spending time getting acquainted with the area and people.

In terms of executing the methods organised by the waste audit framework, the following points were noted:
(1) the differing expectations of the firms and the researchers for the investigations’ outcomes
(2) the mismatch of data requirements, as set forth in the waste audit structure, to the informal information environment at many of the firms visited
(3) the difficulty experienced in identifying firms, especially smaller operations, for participation, and
(4) the different perceptions of what should be identified as a waste ‘problem’.

These points will now be discussed in more detail.

**Differing Expectations**

Three out of seven of the Kanpur firms that were toured at least once could identify specific problems involving their wastes. In fact, some firms’ management expressed a preference for project researchers to concentrate on a specific waste problem immediately, in hopes that the investigation would provide a solution. In some ways, this was a time-saver as it facilitated the researcher’s entry into the firm, and if a solution were found, the goodwill of the firm would assist further work. However, this preference also effectively short-circuited the waste audit approach which involves a broader investigation, encompassing the entire industrial process. The identification of a waste problem should trace the problem back as far in the process as possible. Where possible, treating the root, rather than a symptom, will be more effective and the solutions may also represent the preferred category of LWT: reduction, to be preferred to re-use and recycling.

**Informal Information Environment**

Many existing waste audit guides and manuals presuppose a formal, organised information environment in the firm. The procedures focus on filling in forms with readily available quantitative data. The assumption is made that the firms’ records will be exhaustive, up-to-date, and accessible by the audit team. In part, the organisation of this information is prompted by the regulatory requirements (taxation, environmental reporting requirements, accountability to shareholders, and so forth).
When these external influences and expectations are not fully developed or enforced, the incentive or pressure to maintain supporting documentation is decreased. Where this situation exists, records may be scanty and incomplete, not regularly maintained, or maintained in a format that requires manipulation to arrive at the figures needed for the waste audit (for example as pen or pencil ledgers, rather than entered in computerised or standardised forms).

To illustrate this point, each firm was asked: “Do you have a process flow diagram?” The answer to this question was frequently “no”. Therefore, hand drawn diagrams were sketched on-site, or constructed afterwards from visit notes. This added to the time required to obtain the information and delayed comprehension of the processes that relevant flow diagrams would describe.

Data on volumes of process equipment were not always readily available, and metering or other measurement of process inputs not always done. In these cases, back to basics calculations were required to determine input amounts. These difficulties point to a need for assessing the availability and completeness of the firm’s records. Trust is also an issue as firms may be initially unwilling to share their confidential information.

**Increasing Firm Participation**

Most of the firms selected for participation in the project were open to discussion of their situations, and expressed interest in the possible benefits, (environmental and economic), offered by LWTs. The case study firms each had identifiable LWTs in place. This can be contrasted with the lack of awareness and fear of investigation shown by other operations. Involving the latter category in waste management efforts poses a challenge, and is important as they may be major waste generators.

In India, smaller industrial firms contribute a significant amount of pollution (Chakrabarti, 1993; Luken 1992; Nyati, 1994). The Ministry of Environment and Forests (1993, p.185) stated that:

> Nearly 50 percent of the total industrial output in monetary terms is contributed by over 2 million small scale industries which also account for 60 to 65 percent of the total industrial pollution.
Identification of participant small firms in Kanpur was a problem as complete and current listings (names, addresses, telephone numbers) of these operations were not readily available. The industries in Kanpur are divided into registered and unregistered companies. Reporting requirements seem to differ for the two categories. The small operators appeared fearful of investigation and apprehensive of incurring any official disapproval.

The scale of the firms’ operations will also affect how an audit proceeds. Small operations (defined by the number of employees, production or financial indicators) are less likely to be able to commit resources (time, money and staff) to executing audit team responsibilities. The owners and operators may be less willing to schedule initial or return visits for waste auditors, making it necessary to gather as much information as possible in a few brief visits to cooperating firms.

**Differing Perceptions of the “Problem”**

During the research, individual problems that seemed obvious to the researcher (mainly poor housekeeping leading to material losses and excessive water use) were not mentioned by the firms’ management. This led to speculation on how different stakeholders might identify and prioritise different problems.

The discussion could begin at the international level. Capacity building is stressed as an area of focus in current development literature (OECD, 1994a). Creating or strengthening the ability of local, indigenous workers to recognise the need for, suggest and implement appropriate technological changes in their own environments is hoped to be more sustainable than having outsiders parachute in with imported technology. A result of the latter could be that the needed infrastructure to deal with the technology, which includes the supporting culture and its understanding of the technology – ‘software’ as well as the actual equipment – ‘hardware’, is in place.

It is important that the recipient of the transferred technology have input into the process. The Director of the Indian Centre for Science and Development, has suggested that:

OECD countries could help developing countries by providing information about the following, among others: …pollution control management systems, possible adverse impacts of toxic products and substances found in trade and commerce; and available and emerging appropriate and environmentally benign technologies which could be used to solve a variety of urban and rural problems (Agarwal, 1989, p.41).
Therefore, to successfully transfer LWT (or any other technology) internationally, the recipient country’s capacity for assimilating and supporting the new approach into the agendas of industry, research and educational institutes and at various levels of government must be assessed. Where capacity is lacking, training should encompass the whole technology package, including the tools (‘software’) that accompany the technology ‘hardware’. The emphasis should be on ‘training the local trainers’ in order to encourage the sustainability of pollution prevention efforts through fostering indigenous capacity.

It is noted that while capacity building for waste management skills is a need recognised in India (Agarwal, 1989; Chakrabarti, 1993; Government of India, 1993; Ministry of Environment and Forests, 1993 and 1994), there also exists awareness of, and successful efforts at cleaner production, as well as cleaner technologies available from within the Indian context.

The inputs to environmental technology transfer should not come only from the larger national or regional levels. The voices of those that live in the environment as it is now, and will live thereafter the implemented changes should be heard. In developed countries, community or consumer pressure can be an important precursor to the firm making a change to cleaner production. In India, the potential for this pressure is there: the community has been successfully organised around several environmental issues (Allen, 1992; Rahman and Prasad, 1995).

No public consultations on industrial pollution issues were identified by the researcher in Kanpur. Interviews with a representative from one community group indicated that these issues were not on their agenda. In the search for a hazardous waste disposal site for Kanpur, no community discussion was going to be held prior to the site selection phase (Routh, 1994). However, the demonstrated success in organising the Jajmau community (Rahman and Prasad, 1995) shows what is possible. The organisational infrastructure, in the form of mandals, is in place and changes have resulted from their organisation and mobilisation. These include improvements in working conditions.
The perception of the ‘real’ or most important waste management problem is depends on who is asked. Those who live and work in industrial areas and draw from the environment are affected by its quality. These stakeholders in industrial waste management efforts may be able to identify what they perceive as problems stemming from a particular source, without the need for fancy imported problem identification strategies. Industrial operators, workers, and the community as well as agencies (community groups, academic institutions, non-government organisations) located outside of the immediate physical environment of the firm may each be able to give an answer to the question: ‘what do you see as being the (environmental/waste management) problem(s)’? Possibly, these concerns overlap and have a common solution. But, if not, which problem should be addressed first? What are the criteria for prioritising a list of legitimate concerns? How can the concerns of outsiders be bought to the firm’s attention?

In pollution prevention programs, an internal waste audit results in an understanding, identification and quantification of the firm’s wastes. However, the results may not immediately indicate which waste problem should be prioritised. For example, say that excessive water usage is demonstrated. The investigator may conclude that addressing this problem is a priority. What would be the consequences of deceasing the firm’s water consumption? For the community around the firm, it may mean that more of a scarce resource is available to them. For the firm that pays a low water cess or pumps from its own wells, decreasing use would not be an (immediate) priority. Industrial processes may be affected by new requirements to measure, time and adjust water and other inputs. The operation of an on-site ETOP may be impacted by changing the daily volume of incoming effluent. The chemicals carried in the effluent waste stream will show higher concentrations after water reductions, possibly necessitating changes to existing EOP treatments. Compliance problems may ensue where discharge regulations are concentration-based, and this will be of interest to regulators. Therefore, the outcomes of addressing this identified problem will not be the same for all stakeholders, and the different groups will rank the problem’s importance differently.

**Implications for the Decision Making Model**

In examining the case study firms’ previous decisions around waste management issues, it was noted that the decision makers had rarely followed the steps in problem solving sequentially.
As mentioned above, one of the case study firms provided an example of two steps in the problem solving model, problem identification and implementation of a solution, occurring simultaneously. In this case, a LWT in place at the firm had been adopted as a result of the problem and solution being simultaneously identified for the firm. Other examples from Kanpur that pointed to the problem solving steps following a cyclical rather than a linear progression were:

- incomplete problem identification as evidenced in treating the symptom (by EOP methods) rather than the root problem
- a LWT solution being applied without fully investigating its merits
- a shift in definition of the stated waste problem during the Alternatives Generation Step, and
- problems recognised and alternatives generated but not implemented.

If the ‘garbage can’ model (described above) proposed by Cohen et al. (1972) is used to represent decision making, the trick then would be to introduce or recognise a problem at a time when decision makers are favourably disposed to allocating resources for its solution. Formalising the problem recognition step by using the structure provided by a waste audit could help to coordinate the firm’s resources an goals in order to make more effective waste management decisions.

The strength of a planning tool that identifies waste problems within the firm will be in providing a focus on and structure for this problem-solving or decision-making step. Providing a framework and timetable for problem identification and assigning resources to this activity recognises the competing demands placed on the firm’s decision makers and could alleviate some of the confusion of ‘organised anarchy’.
VI. RECOMMENDATIONS

In the discussion, communication difficulties and problems in gaining the trust of local participants were highlighted as obstacles affecting the success of the technical investigation. Communication difficulties were reflected in the differing expectations held by participants in the investigation and in the perceptions of what to identify as a waste problem. Gaining community and industry trust could result in more firms becoming involved and could increase the investigator’s access to sensitive information.

These problems indicate a need for preliminary work to precede the technical investigation within the firm. The purpose of making recommendations that address the specific points discussed above is to acknowledge this need and suggest ways to address it. Clarifying the investigation’s goals, involving other stakeholders, gaining the participation of more firms and making a broader assessment of site conditions will each contribute to more robust problem identification. Few of the recommendations are particularly new or startling (for examples see Backman et. al., 1989; Government of India, 1992; Modak, 1993). However, they reinforce the necessity of assessing how much progress can be made during the research time, and for the adequate preparation of all study participants before a successful technical investigation can commence. The suggestions have been grouped into four steps:

1. precede the technical investigation by on-site preparation
2. clarify the goals of the investigation
3. focus on the larger picture rather than on details, and
4. identify waste study ‘team’ members.

The recommendations for each category will now be described.

**Step One: Do On-Site Preparation Beforehand**

After arrival at the study area, hold information and goal setting sessions that include industry, co-investigators, government and community workers. Allow time to gain the confidence of participants.

Arrange common technical information sessions for industrial sectors. This may be sensitive. Do not expect participants to share their experiences freely.

See that the industrial waste management issue is introduced at a regularly scheduled community (i.e., *mandal*) meeting, or arrange a special meeting.

Try to document what formal information the firm has before the investigation begins. (This may change magically over time, as the trust of the firm is gained and project goals are more commonly understood).
Arrange to have a regular contact in each firm. Know who they are, find out how much time they have to commit, and when. Be sure there is a common understanding of goals.

Provide participants (particularly small firms that do not have regular access to trade journals and publications) with case studies of success in their industries, and arrange small demonstration projects.

**Step Two: Clarify the Goals of the Investigation**
Concentrate on understanding the industrial process and identifying process inputs and outputs for a streamlined, less time-consuming assessment. This approach will not require the comprehensive waste characterisation required for completing a mass balance.

Where it is the case, clarify with all participants that the goal of the investigation is problem identification, not (yet) solution. This may result in a more thorough understanding of the current situation without the pressure to solve problems immediately.

**Step Three: Focus on the Larger Picture**
Investigators should see as many local firms representing one industrial sector as possible, so that the number of visits to any one firm may be decreased. This will help in gaining an overall understanding of processes, variability, operating conditions and differences and similarities among firms.

Consider assessing the industry’s neighbourhood instead of working only with single firms: the wastes, inputs and outputs may interact. This approach may reveal that the waste identified as a problem by the firm is already supporting the informal economic activities of other stakeholders.
Recognise the firms’ previously identified problems, but try to understand their contexts and precursors (the “root” of the problem).

Anticipate having to use informal, estimative quantitative determinations: illustrations, measuring tapes, basic calculations.

Rather than getting bogged down into technical minutiae of chemical and mass balancing, aim for a broader understanding of the industrial processes and their place in the surrounding environment (both in and outside the firms’ walls).

**Step Four: The ‘Waste Team’**
The importance of assembling and maintaining a core waste audit team is stressed in many audit manuals. (Jacobs Engineering Group, 1988; Louis Berger International, 1993; Richmond, 1989). This may prove difficult where worker participation in the firms’ decision activities is not common. Having input from the ‘shop floor’ is very important. Involve a key contact(s) at the firm who is clear on the investigation goals.

Try to expand the ‘team’ to include other stakeholders. This will probably be a sensitive issue. The participation of outsiders may be limited to their attendance at community meetings and providing input to the firm through an intermediary.

**CONCLUSIONS**
In this paper, a waste audit framework was used to structure data collection leading to the identification of specific waste problems in selected case study firms. The results indicate that before focusing on an internal investigation of LWT opportunities within the firm, the investigators should undertake advance preparations on-site. In order to enhance the transfer of industrial LWTs, communication and trust must be established among the participants in the transfer.
Problem identification has been presented as an important step in encouraging the firm’s decision makers to adopt LWTs. The transferred package should therefore include tools that accomplish waste problem identification. To be successful, these tools must recognise:

- the potential mismatches in stakeholder expectations
- the different problems and concerns of those sharing the (inside and outside the walls) environment of the firm
- the challenges of accessing more industries, particularly small firms, and involving them in waste management activities, and
- the difficulties in completing a formal technical investigation in an informal information environment.

This paper recommends that technical investigations into the feasibility of adopting industrial LWTs include ensuring time for the on-site preparation of all participants. Specific suggestions to achieve waste problem identification within a waste audit format are also presented.

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INTRODUCTION

The Kanpur Research Project is predicated on the assumptions that there remain in India opportunities for reconciling industrialisation and environmental sustainability and that Low Waste Technologies (LWTs) present such opportunities.

The potential for adopting LWT in India is immense for at least three reasons. First, it is still in the process of industrialising. Second, the central government continues to play a major role in the economy. Finally, reliable LWTs are available for the biggest waste generators such as tanneries, metal plating and textile dyeing plants. It is also worth reiterating that policies to promote LWT are less intrusive than those which promote end-of-pipe (EOP). This is of great significance in countries where the monitoring and enforcement systems are weak such as those obtaining in India.

What have we learned about industrial waste management practices in India? Assuming Kanpur as representative, at what stage of the decision-making process are most waste generators? How are these practices influenced by policy? What are the prospects for effective integration of environmental sustainability objectives in India’s industrialisation drive? How might the prospects be enhanced through policy?

The conceptual framework (Figure 1.5 in the Introduction of this volume) that guided the design of the Kanpur Research Project will now be used to analyse the research findings and seek preliminary answers to these questions.
I. THE WASTE MANAGEMENT PROBLEM

Relatively little is known about the exact nature and magnitude of India’s hazardous and toxic waste problem. Information is either unavailable or at best inadequate for even a rough quantification to be made. Assuming Kanpur to be representative, the picture that emerges, limited as it is, strongly suggests that the struggle for sustainability in India is daunting.

In Kanpur we visited and observed whole neighbourhoods of two to three-person operated metal finishing, metal plating and galvanising shops. Barrels of liquid wastes, possibly contaminated with heavy metals and cyanide, sit outside presumably for dumping into the sewers and open channels. It appears safe to assume that most of the operations are unregistered.

One of the larger firms visited assaults the senses with an extremely high level of background noise and wreaks with an organic chemical stench indicating leaks in its tanks and pipes. Indeed some of the sources of the leaks were visible. In another plant, brown fumes of a metallic oxide, a suspected carcinogen, emanate from an open plating bath while workers move around without any protective gear except for boots.

As Howland noted (this volume), even the more enlightened industries in Kanpur that the research team worked with were selective in their waste reduction options. A manager at one of the firms spoke highly of its energy-efficient boilers but unlabelled barrels of chemical solutions are visible in the plant premises and grass sprouts over coal piles, indicated long term exposure to the elements. One of the most advanced firms in terms of waste minimisation has many workers half-dressed and handling solid chemicals and acidic solutions with bare hands.

There were a few exceptions. The biggest and cleanest firm visited not only prides itself in having an extremely low incidence of workplace accidents, the management was also the most enthusiastic in asking the researchers to help them examine their water consumption rates.
There is no reason to believe that the waste management practices observed in Kanpur-based firms are atypical. A 1985 eight-sector study of hazardous waste generation and management practices in three states – Gujarat, Maharastra, and Tamil Nadu – concluded that the surveyed units generated some 170,000 tons of hazardous wastes per year from process operations and 37,000 tons from effluent treatment plants. As of 1991 less than 10 percent of 1,500 survey facilities in seventeen pollution-intensive industrial sectors had pollution control equipment. The 1985 study also found that the hazardous waste generation rates of small industries are relatively higher than large or medium scale operations, an observation that has been confirmed in other countries and reported by the United Nations Environment Program (UNEP, 1987; World Bank, 1994). Recent estimates from the National Environmental Engineering Research Institute (NEERI) of 30 percent of the country’s large and medium wastewater generators are sources of hazardous wastes may thus be conservative. Unregistered metal plating and finishing shops alone such as those observed in Kanpur probably number thousands across the country. The 1985 NEERI study further reported that the principal method of hazardous waste disposal was dumping in low-lying areas inside and outside plant boundaries, followed by dumping on municipal land, nearby coastal areas, and in industrial estates, down the sewers (World Bank, 1994).

A survey undertaken by the Central Pollution Control Board (CPCB) in 1988 showed that 241 Class II cities (population less than 100,000) generated 1,300 million liters of wastewater a day of which only 22 percent was treated. Class I cities generated a total of 12,145 million liters a day of wastewater, of which only 2 percent was treated (Mehta et al. 1994). Kanpur city alone discharges 274.5 million liters of untreated sewage a day to the Ganga (Mehta, 1993). It is estimated that while municipal sources generate three-quarters of the volume of wastewater produced in India, industrial waste constitutes over one-half of the total pollutant load. A large portion of toxic pollutants released to aquatic bodies is thus from industrial sources (World Bank, 1994).

In 1990, India’s National Waste Management Council (NWMC) reported that due to “outdated technology” and “an unsystematic and hazardous way of (industrial waste) management”, India was experiencing “serious environmental degradation” (Achtell this volume). Low dissolved oxygen, high biochemical oxygen demand, high concentrations of ammonia, and heavy metals have been recorded along India’s principal river stretches (GOI, 1993).
In 1994, the Government of India (GOI) designated nineteen river stretches as “grossly polluted” under the National River Action Plan (GOI, 1994a).

While the health and economic development implications of poorly regulated industrial air emissions and liquid effluents are beginning to gain attention, the problem of industrial solid waste disposal continues to be ignored. In Jajmau (near Kanpur), home to over a hundred tanneries, heaps of tanner shavings, fleshings, and trimming wastes are visible everywhere.

With restrictions increasingly imposed on air and water discharges, it is anticipated that more hazardous chemical wastes will be diverted to land for disposal (World Bank, 1994). It appears reasonable to conclude that most industries in India have not even recognised that their waste disposal practices pose human and environmental problems. Nor have they realised that industrial wastes imply lost resources and therefore lost profits.

II. RESPONSES BY GOI AND STAKEHOLDERS

Institutional Framework
The Ministry of Environment and Forests (MEF), established in 1985, is the top government agency responsible for environmental management. About seventy percent of its 1993/1994 budget was allocated for conservation and 27 percent for environmental pollution control. Other ministries with environmental mandates include the Ministry of Rural Development (biomass regeneration, rural water supply and sanitation), Ministries of Power, Industry and Non-Conventional Energy Resources (energy conservation and development of alternative energy sources) and Ministry of Urban Development (urban water supply and sanitation issues).

Not unlike high consumption countries (HCCs), policy instruments used by the GOI include environmental quality standards, environmental impact assessment, hazardous waste inventory and management.
Pollution control revolves around three basic statues: the Water (Prevention and Control of Pollution) Act of 1974 (amended), the Air (Prevention and Control of Pollution) Act of 1981, and the Environmental Protection Act of 1986. The first two mandated the CPBC with the task of setting policies and minimum national standards. The State Pollution Control Boards (SPCBs) are responsible for implementation and monitoring for compliance. Penalties for violation include fines and imprisonment. Regulations under the Environmental Protection Act allowed the government to prohibit the establishment or close down and industrial facility on environmental grounds. They also enabled the establishment of Mining National Discharges Standards (MINAS) and restrictions on the management and disposal of hazardous wastes. The Environmental Protection Act not only strengthened the monitoring and enforcement functions of the CPCB but also granted to ordinary citizen legal standing to initiate proceedings against polluters and the pollution control boards.

Two other statues reinforce these mandates, specifically the Water Cess Act of 1977 and the Public Liability Insurance Act of 1991. The former authorizes the central government to levy charges on water consumption by industries and municipal governments, the latter require public liability insurance on those who handle hazardous substances.

Policy Implementation
As in other low consumption countries (LCCs), there is in India a big gap between the demands of the law and the technical and financial resources required to implement them. The Government of India is viewed by some analysts as having the tendency to “legislate away” problems and in the process pushing the costs of enforcement beyond the ability of its own agencies (Achtell in this volume). The complexity of determining the appropriate economic instruments and the lack of information regarding their effectiveness make formulation of new laws simpler by comparison. Because regulations also give the appearance of being more decisive and direct approach they are more attractive to policy-makers.

It is frequently claimed that in countries where the administrative state is weak, reliance on command-and-control approaches may work to the advantage of polluting industries. For example, it is said that often when a firm is ordered to close, it can, by virtue of its access to sophisticated
legal assistance, obtain a stay and thereby continue operating. It can also pay its way out, seek intervention from political patrons or challenge court decisions and delay enforcement. However, there is absolutely no reason to believe, nor evidence to show, that market-based instruments such as pollution charges are immune to these evasive tactics.

What is clear is that India’s environmental problems, including the industrial waste crisis, have grown despite what appears to be a sophisticated environmental policy agenda and an adequate level of environmental regulation. The regulatory regime is ineffective in controlling, let alone arresting, environmental degradation. There are however grounds for optimism regarding India’s prospects for integrating environmental sustainability and industrial development objectives.

III. RECENT INITIATIVES

It is interesting to note that just as the Government of India is embarking on a comprehensive macroeconomic adjustment programme to liberalise its economy and reduce the state’s role in economic decision making, it is at the same time launching a series of government interventions in industrial pollution abatement. A World Bank 1994 document acknowledges “…at the current stage, GOI has elected to strengthen its regulatory and enforcement mechanisms as a sine qua non condition to abate pollution, while the potential for market-based instruments is reviewed” (World Bank, 1994).

Not only has the GOI increased the water cess but has also shifted its environmental standards from concentration-based to pollution load-based standards tied to actual production. More industrial sectors are gradually brought under the purview of source performance standards and increased water cess. The government is also proposing the creation of Environmental Tribunals to facilitate action on noncompliance. Under the 8th National Economic Development Plan, Rs 130 million are earmarked to improve the monitoring capacities of the CPCB and the SPCBs.
Recognising the financial constraints of small- and medium-sized industries, the government is providing some technical assistance and financial incentives to enable these enterprises to reduce their environmental impacts through directed grants for financing of collective effluent treatment plants, and feasibility studies. It is also using industrial zoning to cluster similar industries and facilitate access to common environmental services. The government has concluded that “the conventional EOP control technologies have not been able to curb pollution to the desired effect, nor able to achieve energy efficiency”. The promotion of waste minimisation through improved access to LWTs has thus been identified as a “priority area”. “Waste minimisation” now appears prominently in government programmes.

A policy statement of the Indian government that merits particular attention is one issued in February 1992 [No.H.11013(2)/90-CPW]. The policy statement affirms the GOI’s intention to integrate environmental consideration at all levels of economic development planning and decisions. The strategies specified include: (a) source reduction of wastes, (b) development and application of best available practicable technologies, (c) application of pollution pays principle and exploration of economic instruments, (d) priority attention to heavily polluted areas, (e) public participation in decision making, and (f) safety of industrial operations.

In 1992 the GOI introduced a requirement for industries to annually undertake and submit an environmental audit. The audit requires information such as quantity of raw material used, including water per unit of product, quantity of gaseous, liquid and solid wastes generated and measures for recycling and reuse of such waste. This was followed in 1993 by an Environmental Action Plan. Seven priority areas were identified in the Plan: (a) conservation in selected ecosystems, (b) afforestation, (c) control of industrial and related pollution with an emphasis of minimisation, (d) access to clean technologies, (e) urban environmental issues, (f) strengthening of environmental science education, and (g) an alternative energy plan. In 1994 the government established an “Eco-Mark” label for products produced by “clean” firms.

“Clean technologies” and “waste minimisation” are also being promoted by different stakeholders such as international lenders, research institutes, non-government organisations (NGOs), and industrial organisations.
International lenders are starting to target funds at LWTs initiatives and research. The World Bank funded Industrial Pollution Prevention Project in India emphasises a preventative approach encompassing clean technologies and waste minimisation. It has funded the establishment of Clean Technology Centres across the country and a Central Clearing House for Clean Technologies housed at NEERI in Nagpur. NEERI has started developing an information package on cleaner technologies and has organised workshops on LWTs.

A grant from the Japanese government has been used by the GOI to design a waste minimisation database, to examine the technical feasibility of reusing municipal sewage as industrial water and to design an environmental audit methodology (World Bank, 1994). A five-year project under the Ganga Action Plan (GAP) funded by the government of the Netherlands introduced anaerobic treatment system of industrial and domestic wastewater, reuse of effluents, and the installation of chromium recovery units in tanneries (Shukla et al., 1993; Mehta, 1993). The central government has launched a campaign, with provision of some funding, for the formation of “waste minimisation circles”, akin to “quality circles”, particularly in the small scale sector. The GAP, launched in 1986, has seen the construction of 28 electric crematoria and the release of 36,000 turtles into the river near Varanasi in order to help in pollution abatement by feeding on dead decaying detritus and other organic material (Stackhouse, 1992).

Some of the United Nations agencies are also promoting LWT in India. In 1992 the United Nations Industrial Development Organisation (UNIDO) funded a 15-month research project in partnership with the National Productivity Council (NPC) of India to introduce “cleaner production techniques and technologies” among small scale industries (SSIs) in selected Indian states. Three industrial sectors were targeted: agro-residue based pulp and paper, textile dyeing and printing, and pesticides formulation. Out of 450 waste minimisation opportunities identified, 300 were implemented with estimated savings of Rs 35.8 million (U.S. $1.2 million) (Chandak, 1994). Properly analysed and disseminated the results of the UNIDO-NPC venture should advance the introduction of “cleaner production” in India. As will be shown in a later section, the UNIDO-NPC experience complements and is consistent with the University of Guelph-Harcourt Butler Technological Institute (HBTI) research findings.
Industrial associations are likewise starting to promote LWTs. The Confederation of Indian Industry (CII), with 3,000 member companies, has as its principal objective the provision of consulting services to industry on a number of issues, including customs and excise, environment, quality, technology, and so forth. The CII’s Environment Management Division is actively promoting cleaner production and responsible entrepreneurship among its 3,000 member companies. It has published case studies of initiatives in Indian enterprises that demonstrate that “environment protection makes sound business sense”. It has organised training programmes in waste minimisation for CPCB and SPCB Board personnel (GOI, 1994b, p.51).

In contrast to their counterparts in other LCCs which remain focused on rural resource management issues, an increasing number of Indian NGOs are getting involved in public education and research on LWTs. For example, Delhi-based Development Alternatives (DA) works with small-scale textile dyeing and electroplating units in the Delhi area and has its own plant which produces hand-made paper from scrap paper and cloth. Located in Delhi, the Indian Environmental Society (IES) emphasises environmental awareness-raising, education, and training, as well as the promotion of LWTs. The group has established recycling centres which produce construction bricks from industrial marble slurry, as well as greeting cards made from waste paper (Achtell in this volume).

This is probably where Kanpur differs from other Indian cities. Our inquiry on community-based initiatives around industrial waste issues led us to conclude that none exists. Initial discussions with Kanpur-based civic organisations failed to generate any interest in green issues.

The “awakening” of the NGOs in India to urban waste issues is undoubtedly linked to the astounding success of citizen action in Delhi. In 1985, a Delhi-based environmental lawyer in a petition against “the Government of India and others”, claimed that about 10,000 factories from Uttar Pradesh to West Bengal are daily discharging toxic effluents into the Ganga River. In the course of the case and over the last five years the Supreme Court of India has issued closure orders on several tanneries and foundries for repeatedly failing to meet environmental compliance deadlines. The SPCBs of Uttar Pradesh, Bihar and West Bengal have been directed by the Court to submit their reports on industrial compliance with the pollution control standards in their respective states.
The Court recently set a deadline for a petroleum refinery, and the government mint to comply with air emission limits or face closure. The cases brought before the court under the Water and Air Acts have since tripled with about two-thirds decided in favor of the government. Mehta (1993) observes:

The ‘Ganges Case’ has been most effective in controlling industrial pollution of the Ganga. The judgements delivered have resulted in hazardous industries implementing pollution control measures, which the enforcement agencies had not been able to make them do for the last 18 years (p.130).

The power that comes from organised and collective action is obvious even at a smaller scale. The experience under the Indo Dutch Environment Project in Jajmau described in two papers in this volume demonstrates that economically and socially marginalised communities can be mobilised around and address community environmental concerns. The clean streets and walkways in the poor but organised sections of Jajmau are proof. Another outstanding example is provided by five villages in Udaipur District which are using the Panchayat legislation to exercise their rights over their environment (Agarwal, 1995).

The role of environmental NGOs in India has been steadily growing and increasingly being recognised by donor agencies and by the Government of India. The GOI appears to be making efforts at “opening up” its decision-making process. It has now acknowledged that NGOs, citizen groups and village level institutions like forest Panchayat and Gram Sabha should be granted locus standi and support for mobilising public opinion and participation in development activities” and that an NGO network should interface with government agencies to assist in environmental surveillance and monitoring, and in public education regarding science and technology in general (Dwivedi in this volume).
IV. BARRIERS

Significant barriers remain to the effective diffusion of low waste strategies in India. The barriers as analysed by the Kanpur research team (see for example Howland, El-Tayeb et al., and Achtell) are consistent with those reported by UNIDO-NPC researchers. They can be classified under: (a) problem recognition, (b) search for alternatives, and (c) decision.

Problem Recognition

Weak pressure groups: In HCCs the major triggers to problem recognition among waste generators have been the non-governmental and community-based pressure groups.

The far reaching consequences of the lawsuit filed on the Ganga industries demonstrate that in India pressure groups can likewise force behavioural change in governments and industry. However, the weak enforcement of government pollution control regulations is not as yet adequately counter veiled by strong pressure groups form the communities and labour unions. Sloppy housekeeping and waste disposal practices continue to be accepted by small- and medium-sized firms and by surrounding communities as an inevitable part of manufacturing. Where the plant owners reside outside the community, they are insulated from the unpleasant sight and smell of plant wastes, as well as form any community pressure.

Risk aversion of industry: The benefit to industry of the environmental audit requirement in terms of enabling them to identify waste minimisation and profit-enhancing processes are not being realised. The environmental audit requirement is encountering opposition from industry. Industries fear that the information may not remain confidential, or may be sued by other regulatory agencies for prosecution. Cost is another barrier. Environmental auditors cost between 75,000 to 200,000 Rupees. This is clearly prohibitive for small- and medium-sized industries.

Even where the financial gains from LWT become obvious, the centralised decision-making particularly in small- and medium-sized firms inhibits initiative on the part of the workers and even middle managers to try something new. In one firm visited in Kanpur, the plant manager, who
allowed a visit by the Kanpur research team stalled our request for a follow-up visit by claiming that he would have to get the approval of the corporate headquarters in Delhi. The process appeared so convoluted that we abandoned the outreach effort.

The risk aversion is more intense with small firms. Chandak (1994) quite astutely points out that in small operations jobs are held “at the whims of the owners” so the workers have no incentive to change anything unless sanctioned by their benefactors. Because these operations are small, the profit margins too narrow and vulnerable, the owners are averse to changes that demand resources and introduce even more uncertainties in their operations. It is interesting to note that this is not inconsistent with observations made on Canadian firms (Yap, 1988)

**Search for Alternatives**

**Organisational/Informational:** The search for low waste alternatives is hampered by the perennial lack of technical expertise. The implementation of the environmental audit legislation itself suffers from lack of trained and qualified environmental auditors. Research units attached to teaching institutions are equally if not weaker. In Kanpur for instance, the HBTI is simply not able to mobilise the human resources nor infrastructure needed to deal with the requests for technical assistance in LWT from local firms. Only a handful of industries have independent research facilities. Among those who do few are willing to share the research findings. This is particularly true where research has resulted in LWTs that enhances profitability.

Existing information on LWT is not adequately disseminated. A good example is the body of LWT information deposited in the Environmental Information System (ENVIS). This system is ineffective because no one knows that the service exists. Achtell (in this volume) observes that the ENVIS system has no connection with industry or industrial organisations. NEERI has extensive waste-minimisation information “on-line”, including 510 case studies from fourteen industrial sectors (Asian and Pacific Centre for Transfer of Technology, 1994). As Achtell (1995) notes, it is unclear how this information might be accessed by or of use to small-scale industries.

There is also bureaucratic malaise or indifference. The rapid managerial turnover in Indian public administration leads to a schism in corporate memory and further fragments the information chain.
The government is failing to market what waste minimisation programme it does have. Achtell reports that none of the industries he interviewed in Kanpur had ever heard of the World Bank’s Industrial Pollution Control Project or Industrial Pollution Prevention Project, or any other forms of assistance for waste management initiatives. Not surprisingly the states that were making greater use of government or donor funding were those with more professional, active, and sophisticated chambers of commerce. Without concrete proof of the profitability of LWTs, the perception automatically assumed by industry that the costs of switching to a low waste approach outweigh any possible benefits, persists.

Paradoxically one significant barrier to effective diffusion of LWTs may lie in their profitability. Firms that benefit financially from adopting LWTs are not inclined to disclose the full amount of savings and profits realised because of concerns regarding corporate income tax. Documenting the full profitability potential of LWTs may thus be very difficult. Without adequate documentation credible marketing of low waste strategies suffers.

**Confused policy signals:** The LWT programmes of the Government of India are many but are fragmented; they do not reflect a coherent strategy. Many of the policy instruments continue to have an EOP bias or at least neutral in terms of technology choice. For example, the fiscal incentives that have been introduced such as accelerated depreciation for installation of all pollution control equipment, exemption from capital gains tax for relocation to “less industrialised” areas, and rebates on excise and state sales taxes for specified pollution control equipment, effectively favour EOP. Examination of remediation programmes of major river basins reveals that the emphasis in these programmes remains on treatment rather than reduction of waste. The GAP, the biggest of all the programmes, has consistently emphasised development of infrastructure for effluent treatment as well as monitoring of “grossly polluting industries” discharging effluents into the Ganga and its tributaries.

**Intellectual property rights (IPRs):** Another barrier to transfer of LWT cited by Achtell (this volume) is the concern on the part of technology suppliers regarding India’s commitment to protection of IPRs. In spite of its efforts in establishing a credible investment climate the GOI apparently continues to be perceived by foreign technology suppliers as not yet having developed an institutional framework adequate enough to ensure the protection of IPRs.
Whether or not this is a significant barrier is in question. A study by the Organisation for Economic Cooperation and Development (OECD) on the issue of barriers to transfer of environmental technologies concluded that IPRs are not as significant a barrier as normally perceived. According to this OECD study, a greater barrier is posed by the lack of demand resulting from the weak enforcement of government regulation and ignorance on the part of industry regarding “cleaner production technologies” (OECD, 1993). The OECD conclusion is perfectly consistent with our observation that most firms are not even in the problem recognition stage. Firms do not search for alternatives unless they recognise that a problem exists (Cf. Introduction this volume). Furthermore, IPR concerns will only be a serious barrier if the major source of LWT were foreign firms. The biggest financial and environmental gains reported from LWT adoption however have come from process modifications or equipment redesign, most of which cannot be patented.

**Decision**

El-Tayeb’s work with two medium-sized Kanpur-based firms demonstrate conclusively that LWTs improved the profit margins of the firms. The financial cost, particularly of equipment purchase or redesign, is a real one for small-sized firms. As Chandak (1994) points out, these firms frequently use outmoded if not discarded and highly inefficient technologies. These firms do not have the resources to acquire new equipment much less undertake research. Even where off-the-shelf technologies are available and affordable, the equipment may need adjustments in terms of scale and this requires expertise (Yap, 1988). The personnel hired in small firms are there to maintain, not adjust equipment.

For firms who have the resources and opt for internal recycling and production of secondary materials, the lack of markets is a serious barrier to sustaining low waste initiatives. In Kanpur for example, the plant nursery in a dairy nurtured by the dairy chemist using solid and liquid wastes from the effluent treatment plant (see El-Tayeb et al. in this volume) was reportedly abandoned this year because there was not sufficient market for the herbs and flowers they were producing. The only “benefit”, i.e., improvement of the work environment through beautification of the plant premises and lowering the ambient temperature by about 4 degrees relative to the city, did not have any monetary value attached to it and therefore the inputs and maintenance were seen only as a cost with no return seen on the investment. Without secure markets, the nursery could not be sustained.
The perception that integrating environmental protection and industrialisation is always zero sum game also persists. Pollution control continues to be pitted against the need for jobs. The Uttar Pradesh Pollution Control Board for instance tried in the past to stop the unplanned expansion of tanneries in Kanpur. It was unsuccessful against the argument that “the industry is big and employs many people from as far as Bihar” (El-Tayeb, 1995). The industries in Bengal facing closure orders because of continued non-compliance with pollution control legislation are asking that workers share the cost of compliance. A union leader comments that “industrialists are now trying to rope in the trade unions by counter posing environment with employment” (Dutta, 1995, p.39).

POLICY RECOMMENDATIONS

The advantages of LWTs have clearly been recognised in India. This is evidenced by the plethora of government programs promoting LWTs. Research institutions, NGOs, as well as industrial organisations, are carrying out research and development (R&D) and promotional activities related to cleaner industrial production. Examples of waste reduction, reuse, recycling, and by-product recovery in the textile, tannery, metal finishing, beverage, pulp and paper, and distillery industries have been documented. As a result of studies conducted by the NEERI, the NWMC, and other organisations, concepts of cleaner technology are now being integrated by the MEF into some bilateral funding agency programmes. Even international organisations are funding LWT initiatives.

However, significant barriers remain and the diffusion of LWT has not effectively taken off. Nothing less than strategic planning is required if public policies in India are to be effective in promoting low waste strategies. The government must first analyse how existing policies impinge on the decision environment of the waste generator with regards to technology choice. It must reorient, redesign, and repackate its policy measures to ensure that they:
(a) impinge directly on the technology choice of the waste generator but allow for creativity, innovation and diversity of approaches
(b) creatively redeploy existing ‘carrots’ and ‘sticks’ in the system to effectively trigger problem recognition among waste generators and move them through search and implementation, and
(c) actively engage the other social actors, i.e., religious authorities, industry association, academic and professional associations, non-governmental organisations, and labor unions, so that they too may influence the technology choice of the firm in the same direction.

The policy framework (Figure 1.5 in the Introduction of this volume) shows the direct and indirect ways in which the state can move a firm through this process. Table 11.1 summarises the policy initiatives that could be undertaken.

Engage Other Agents of Change
The government needs to encourage the other agents of change to prod waste generators to recognise that a problem exists and that potentially profitable solutions can be found. This implies genuine efforts on the part of the central government to decentralise not only some of the waste management functions but also its resources. The decentralisation must extend beyond government agencies. The important and legitimate role played by the non-governmental, profit and volunteer sectors in addressing the waste problems must be recognised.

Labour Unions: High standards of safety in the workplace will encourage waste minimisation measures. The government needs to update its occupational health and safety laws. This would help convince labour unions that environmental protection can be made consistent with workers’ welfare.

R&D Institutions: The diffusion of cleaner production will depend ultimately on endogenous capacity. Research and development capability in LWTs must be developed within and outside of government agencies. Science and engineering educational institutions, at least the state-funded ones should thus be prodded to incorporate energy and material efficiency in industrial design and industrial chemistry/biology curriculum. The system of incentives and rewards in academic, professional and research institutions should be systematically reshaped to promote a low waste orientation.
Table 11.1 Summary of Recommendations.

<table>
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<tr>
<th>Decision Stage of the Firm</th>
<th>Policy Instruments</th>
<th>Policy Outputs</th>
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| Problem Recognition        | Information programs | • Support for NGOs’ education programmes on LWT  
|                            |                     | • Workshops/seminars for key initiatives and selected private sector Chief Executive Officers (CEOs)  
|                            |                     | • LWT information in newsletters of industry and professional associations  
|                            |                     | • LWT awards to industry  
|                            |                     | • Case studies of successful LWT  
| Expenditure programs       |                     | • Assistance to small and medium enterprises on waste audits  
| Tax system                 |                     | • Waste tax/effluent charges  
| Regulation                 |                     | • Toxic chemical regulation based on absolute quantities rather than concentrations  
|                            |                     | • Penalties for violation  
| Search Activity            | Information programs | • Pilot project on multi-industry integrated waste management in industrial estates  
|                            | Expenditure programs | • Clean Technology Centres  
|                            |                     | • Waste exchange  
| Decision                   | Expenditure programs | • Government procurement of secondary products  
| Tax system                 |                     | • Tax credit for investments in capacity development  
|                            |                     | • Tax holidays on profit from LWT  
| Regulation                 |                     | • Low waste criterion in foreign investment and industrial location incentive programs  
|                            |                     | • Integration of LWT criterion in environmental impact assessment (EIA) process  

The experience of other countries could reduce the learning curve for India. In the Philippines the government has initiated the standardisation and licensing of private laboratories. The GTZ programme has established an accreditation system for and the pooling of analytical laboratory facilities. Multistakeholder programmes similar to the Netherland’s PRISMA, Sweden’s Landskrona or Canada’s Industrial Research Assistance Programme (IRAP) may also deserve closer examination for potential transferability.

Donors: The government needs to coordinate and direct donor initiatives in “cleaner production”. Bias in favor of imported LWTs should be minimised in favor of endogenous capacity development.

Manage the Risk Perception of Industry
A different term needs to be used for marketing LWTs in India. Referring to the tanneries operating chromium recovery plants (CRP), a government scientist observes that the tanneries “are not concerned about how effective the technology is in reducing waste…They are more concerned about how effective the technology is in recovering chromium…Tannery owners are always looking for more money; waste reduction and minimisation are not in their agenda…The term used should be related to profit or money”. The problem is not unique to India, it might be noted. In the Philippines the term waste audit was deliberately avoided and replaced with “pollution management appraisal” (Government of the Philippines, 1994). Perhaps “waste audits” could be presented as “opportunity audits”, referring to the potential opportunities for enhancing profitability.

The effectiveness and reliability of LWTs must be demonstrated through credible role models. Finding appropriate role models is not difficult in India. Referring to the tanneries, a government scientist comments “this industry is like a family. Just prove it to the head of the family and the others will follow” (El-Tayeb, 1995). El-Tayeb’s research provides the strongest argument for targeting major government efforts at reducing financial costs of capital equipment and R&D on LWT.

To minimise financial risk small- and medium-sized firms should be encouraged to share collective waste reduction facilities. Such inter-industry cooperation is not unprecedented. This is already being done among some Kanpur tanneries under the Indo-Dutch Environment Project and among Philippine metal-plating plants under the GTZ programme (Faensen-Thiebes, 1992).
Waste audits must be simplified to reduce costs. Waste audits for small- and medium-sized industries should be subsidised. Housekeeping practices should be targeted. As seen in the case of the dairy where the simple installation of a voltage stabilizer considerably reduced plastic wastes and changing milk collection schedules reduced souring milk without incurring the costs of refrigeration (El-Tayeb in this volume) good housekeeping practices are low-cost and can lead to significant waste reductions and increased profits.

Target Incentives Directly at Low Waste Technology Choice
The industrial policies pertaining to locational decisions and foreign investment incentives need to be revisited and made consistent with the government policy of promoting LWTs. Concentration of industries with complimentary wastes should be encouraged. This would increase the financial viability of inter-industry waste reuse and recycling similar to the one in Denmark’s Kalunborg (Yap and Heathcote this volume) and Canada’s Burnside Industrial Park (Cote, 1994). The policies on technology import also needs examination. Fiscal incentives should be attached explicitly to cleaner production, not just production technologies. The environmental impact assessment (EIA) process also needs to be used proactively. Mitigation measures should explicitly require that LWTs and strategies be investigated and costed before EOP approaches.

Develop a Coherent and Strategic Low Waste Technology Policy
An effective technology policy for LWT promotion would aim at (a) developing national R&D capacity, (b) enhancing access to international technology suppliers, and (c) diffusion of technology as widely as possible. The first means provision of training and resources to local R&D institutions in government, academic and technical institutions. The second requires establishing an adequate and credible IPR regime. The third would require first of all, an understanding the technology choice decision criteria of firms in order to be able to nudge them towards low waste choices. Small- and medium-sized firms need to be understood better.

What is proposed is nothing less than a comprehensive examination of existing industrial policies and programmes in order to design a coherent and systematic shift to a low waste strategy. Those who are assigned such a task however must have a clear understanding of the nature and characteristics of LWTs. Each of the different low waste approaches (see Yap in the Introduction)
presents different scales of pollution prevention opportunities and requires different levels of resources and expertise. Developing a coherent and effective strategy to bring about such a shift demands technical expertise and clarity regarding the different options.

In the final analysis the potential for LWTs will only be effectively and independently pursued by firms if the true costs of environmental degradation are reflected in pricing policies, information over new technologies is shared, and R&D is supported. All of these conditions are contrary to the operation of competitive markets which encourage secrecy, commercialisation of technologies, and decreased role of the state. Clearly these are policy questions that the Government of India can only effectively examine and resolve with the collaboration and cooperation of the international community.

REFERENCES


El-Tayeb, A. 1995. Personal notes on an interview with Dr. C. Garg of the Central Leather Research Institute, Kanpur, India.


**LIST OF ACRONYMS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>3P</td>
<td>3M Corporations’ Pollution Pays Program</td>
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<tr>
<td>AET</td>
<td>Adult Education Teacher</td>
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<td>APA</td>
<td>American Psychological Association</td>
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<td>ASEP</td>
<td>Asian Society for Environmental Protection</td>
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<td>ASTM</td>
<td>American Society for Testing and Material</td>
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<td>AWW</td>
<td><em>Anganwadi</em> Workers</td>
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<td>BCS</td>
<td>Basic Chromium Sulphate</td>
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<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
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<td>CBA</td>
<td>Cost Benefit Analysis</td>
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<td>CBR</td>
<td>Cost Benefit Ratio</td>
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<td>CEA</td>
<td>Cost Effectiveness Analysis</td>
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<td>CEO</td>
<td>Chief Executive Officer</td>
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<td>CEPA</td>
<td>Canadian Environmental Protection Act</td>
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<td>CHV</td>
<td>Community Health Volunteer</td>
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<td>CIDA</td>
<td>Canadian International Development Agency</td>
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<td>CII</td>
<td>Confederation of Indian Industry</td>
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<td>CLRI</td>
<td>Central Leather Research Institute</td>
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<td>CMC</td>
<td>Calcutta Municipal Corporation</td>
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<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
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<td>CPCB</td>
<td>Central Pollution Control Board, India</td>
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<td>CRP</td>
<td>Chrome Recovery Plant</td>
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<td>CSP</td>
<td>CIDA-Shastri Project</td>
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<td>CV</td>
<td>Community Volunteer</td>
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<td>DA</td>
<td>Development Alternatives</td>
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<td>Development Assistance Committee</td>
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<td>Department of the Environment, Uttar Pradesh</td>
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<td>EAP</td>
<td>Environmental Action Plan</td>
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<td>ECL</td>
<td>Exhaust Chromium Liquor</td>
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<td>Acronym</td>
<td>Full Form</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<td>ENVIS</td>
<td>Environmental Information System</td>
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<td>EOP</td>
<td>End-Of-Pipe</td>
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<td>ESM</td>
<td>Erasmus University Centre for Environmental Studies</td>
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<td>ESSD</td>
<td>Environmentally Sound and Sustainable Development</td>
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<td>ETP</td>
<td>Effluent Treatment Plant</td>
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<td>EU</td>
<td>European Union</td>
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<td>EWS</td>
<td>Economically Weaker Sections</td>
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<td>FAO</td>
<td>Food and Agricultural Organisation</td>
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<td>FFA</td>
<td>Free Fatty Acids</td>
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<td>FRP</td>
<td>Fibro Reinforced Plastic</td>
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<td>GAP</td>
<td>Ganga Action Plan</td>
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<td>GATT</td>
<td>General Agreement on Tariffs and Trade</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GNP</td>
<td>Gross National Product</td>
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<td>GOI</td>
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<td>HBTI</td>
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<td>HCC</td>
<td>High Consumption Country</td>
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<tr>
<td>HVOC</td>
<td>Hindustan Vegetable Oil Corporation Limited</td>
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<td>IES</td>
<td>Indian Environmental Society</td>
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<td>IDP</td>
<td>Indo-Dutch Environmental and Sanitary Engineering Project</td>
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<td>IDR</td>
<td>Inter-Disciplinary Research</td>
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<tr>
<td>ILO</td>
<td>International Labour Organisation</td>
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<td>IPR</td>
<td>Intellectual Property Rights</td>
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<td>IRAP</td>
<td>Industrial Research Assistance Programme, Canada</td>
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<td>IRR</td>
<td>Internal Rate of Return</td>
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<td>ITT</td>
<td>Indian Institute of Technology</td>
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<td>IVAM</td>
<td>Interfaculty Department of the University of Amsterdam</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>KAP</td>
<td>Knowledge, Aptitude and Practice</td>
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<td>KNM</td>
<td>Kanpur Municipal Corporation</td>
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<td>LCC</td>
<td>Low Consumption Country</td>
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<td>LIG</td>
<td>Low Income Group</td>
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<td>Low Waste Technology</td>
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<td>MCH</td>
<td>Mother and Child Health</td>
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<td>MEF</td>
<td>India’s Ministry of Environment and Forests</td>
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<td>MG</td>
<td>Mono Glad</td>
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<td>MIG</td>
<td>Medium Income Group</td>
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<tr>
<td>MINAS</td>
<td>Mining National Discharges Standards</td>
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<td>MLA</td>
<td>Modern Language Association</td>
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<tr>
<td>MSW</td>
<td>Municipal Solid Waste</td>
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<td>MVMA</td>
<td>Motor Vehicle Manufacturers Association, Canada</td>
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<tr>
<td>NAGI</td>
<td>National Association of Geographers, India</td>
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<td>NOTA</td>
<td>Netherlands Organisation of Technological Assessment</td>
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<tr>
<td>NGO</td>
<td>Non-Governmental Organisation</td>
</tr>
<tr>
<td>NEERI</td>
<td>National Environmental Engineering Research Institute, India</td>
</tr>
<tr>
<td>NPC</td>
<td>National Productivity Council, India</td>
</tr>
<tr>
<td>NPV</td>
<td>Net Present Value</td>
</tr>
<tr>
<td>NRC</td>
<td>National Research Council, United States</td>
</tr>
<tr>
<td>NWMC</td>
<td>National Waste Management Council, India</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
</tr>
<tr>
<td>ORS</td>
<td>Oral Rehydration Solution</td>
</tr>
<tr>
<td>PBP</td>
<td>Pay-Back Period</td>
</tr>
<tr>
<td>PMP</td>
<td>Private Medical Practitioner</td>
</tr>
<tr>
<td>PST</td>
<td>Primary School Teacher</td>
</tr>
<tr>
<td>QA</td>
<td>Quality Assurance</td>
</tr>
<tr>
<td>QC</td>
<td>Quality Control</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>ROI</td>
<td>Return On Investment</td>
</tr>
<tr>
<td>SD</td>
<td>Sustainable Development</td>
</tr>
<tr>
<td>SEU</td>
<td>Socio-Economic Unit</td>
</tr>
<tr>
<td>SICI</td>
<td>Shastri Indo-Canadian Institute</td>
</tr>
<tr>
<td>SIND</td>
<td>National Swedish Industrial Board</td>
</tr>
<tr>
<td>SMP</td>
<td>Solid Milk Powder</td>
</tr>
<tr>
<td>SNF</td>
<td>Solid Non-Fat</td>
</tr>
<tr>
<td>SPCB</td>
<td>State Pollution Control Board, India</td>
</tr>
<tr>
<td>SSI</td>
<td>Small Scale Industry</td>
</tr>
<tr>
<td>STU</td>
<td>National Swedish Board for Technical Development</td>
</tr>
<tr>
<td>SWM</td>
<td>Solid Waste Management</td>
</tr>
<tr>
<td>TB</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>TBA</td>
<td>Traditional Birth Attendant</td>
</tr>
<tr>
<td>TCE</td>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>TNC</td>
<td>Transnational Corporation</td>
</tr>
<tr>
<td>TNO</td>
<td>Netherlands Organisation for Applied Scientific Research, Centre for Technology and Policy Studies</td>
</tr>
<tr>
<td>TS</td>
<td>Total Solids</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>UCD</td>
<td>Urban Community Development Programme</td>
</tr>
<tr>
<td>UNCED</td>
<td>United Nations Conference on Environment and Development</td>
</tr>
<tr>
<td>UNEP</td>
<td>United Nations Environment Programme</td>
</tr>
<tr>
<td>UNIDO</td>
<td>United Nations Industrial Organisation</td>
</tr>
<tr>
<td>UP</td>
<td>State of Uttar Pradesh, India</td>
</tr>
<tr>
<td>UPPCB</td>
<td>Uttar Pradesh Pollution Control Board</td>
</tr>
<tr>
<td>USRP&amp;D</td>
<td>University School of Rural Planning and Development</td>
</tr>
<tr>
<td>WB</td>
<td>World Bank</td>
</tr>
<tr>
<td>WWF</td>
<td>World Wildlife Foundation</td>
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</table>
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