Design of a Continuous Water Quality Monitoring System in the Guelph and Waterloo Region of Ontario

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Abstract — In this paper we present a new system for continuously monitoring surface water quality in the Grand River watershed. The main purpose of the system is to detect contaminants in the water in real time and send a signal to the water treatment plant so the downstream water intake can be closed. The design consists of a biological monitoring system using a local mussel species as well as a conventional data sonde measuring physical and chemical parameters of the water. A second onshore component consists of a biological monitoring system using a local mussel species as well as a conventional data sonde measuring physical and chemical parameters of the water. Thorough research, design and calculations show that the system is feasible and superior to any existing technology used in the area of study. Lab testing and prototypes are required as the next steps in implementing the design.

Index Terms — Biological Early Warning System, alarm system, data sonde, water quality

I. INTRODUCTION

To help cope with an increased demand for potable water in the Guelph and Waterloo Region, municipalities are beginning to look at surface water as an alternative source. The level of treatment necessary in order for the water to be deemed potable is determined by the intake water quality. At times, it may be the case that surface waters are economically unfeasible to treat due to high levels of pollutants. In such an instance, the intake of water should be halted by closing the supply lines. Several water contaminants would necessitate this action if found to exist in high enough concentrations.

Warning signals will be sent out by the continuous surface water monitoring system in the event of contamination so that water intake may be temporarily discontinued. To allow the monitoring system to be deployed quickly at various locations throughout the watershed, it must be portable and self-powered. The design must have minimal environmental impact while being easy to access and simple to disassemble. The design must also be capable of operating in all weather conditions.

Conventionally, water quality has been measured using physical and chemical methods. Although these measurement techniques accurately measure specific parameters, all other parameters go undetected. The contaminants that are not looked for will not be found [1].

Applying a fast-reacting biological sensor with a wide-spectrum response to contamination is a valuable combination in detecting spills of unknown composition and concentration [2]. Although the biological early warning system does not provide direct information on the exact pollutant causing the alarm, it can recognize contamination that conventional methods cannot. A continuous biological monitoring system using mussels along with a classical chemical monitoring system is used in this design to detect contamination of the surface water.

Biological early warning systems do exist throughout Europe; however, they have yet to be adapted and implemented in North America [1]. The only mussel biological sensor used in Southern Ontario is a non-continuous version in the Niagara River that samples the tissue of mussels for accumulated contaminants [3]. As a milestone for this project, recommended sites for placement of the monitoring system have been mapped using GIS in addition to detailed CAD drawings of each component of the design.

II. CONCEPTUAL DESIGN

A. Overall Design

Potential surface water contamination is tested using two different devices employed in the water monitoring system: a biological system and a conventional chemical monitoring system. The combination of the two systems allows for both a wide spectrum of detectable contaminants as well as quantitative data on the water quality.

The Eastern complanata (Elliptio complanata) is the mussel species used for the biological monitoring system. When exposed to polluted water, the mussels will exhibit an escape reaction and close their shell. The closing of several mussels simultaneously will trigger the alarm system [2].

The data sonde is the more conventional monitoring technique, measuring various physical and chemical parameters of the water to determine a change indicative of contamination.

B. Major Components

The biological monitoring system casing is made of high-density polyethylene (found to be the ideal material for its strength and minimal impact on the mussels by Kramer and Foekema) [1]. Eight mussels are fastened to the bottom of the casing and protected by an aluminum cage from debris that could potentially hit the mussels. Mounted in the cage, above the mussels, is a data sonde. The power supply and the electronic components for the actual measurement, data evaluation and data communication are all located onshore.

III. DETAILED DESIGN

A. Land based components

As shown in Figure 1, the on-shore component consists of an equipment box mounted on a tripod, which is securely fas-
tended into the ground using stakes. Within the equipment box is the data logger, transceiver and lead-acid battery. Atop the tripod sits a solar panel, used to recharge the batteries, as well as an antenna to transmit the data.

Figure 1: Overall surface water quality monitoring system

B. Water based components

Located within the water is a protective cage enclosing the data sonde and biological monitoring system. The cage is anchored to the riverbed using a typical boat anchor to prevent movement or tipping. Measured data is sent through the communication cables to a data logger located in the equipment box on-shore. The data is passed onto the transceiver every five minutes unless there is a severe contaminant reading, in which case an immediate signal is sent out to the treatment plant.

Sensors are attached to both sides of each mussel's shell and a current is passed through these sensors. Since maximum current strength is reached when the two sensors are in contact, it can be determined when a mussel's shell is closed. When a weak current is observed, then a mussel's shell is open [2]. Five or more mussels closing and remaining closed is an indication of contaminated water.

IV. DISCUSSION

The data sonde component of the design has been implemented in numerous similar situations in the study area. Based on research gathered, the continuous biological monitoring system using the Eastern complanata has not been used in the area of study.

Before such a system can be implemented in the field, a working prototype and extensive research in a controlled laboratory environment must be conducted. Further research would be used to determine the behavioral responses of the Eastern complanata to various pollutants in the water. The assumption was made in the design that the Eastern complanata would behave similarly to the Dreissena polymorpha, (commonly known as the zebra mussel) which is used in mussel monitors throughout Europe.

V. CONCLUSION

Conventional data sondes have limitations as to what contaminants they are capable of detecting. Implementing the use of a continuous biological monitor would be very beneficial to the monitoring of water quality, particularly with the increased dependence on surface water for potable usage. Some technically-oriented engineers may have difficulty accepting that this system partially relies on the biological response of bivalves, but it is a necessary part of the system that allows the rapid detection of a wide range of toxic compounds in the water.

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