Proceedings of the Canadian Society for Mechanical Engineering International Congress 2020
CSME Congress 2020
June 21-24, 2020, Charlottetown, PE, Canada

HAB Hunter: progress toward an *in situ* Lab-on-Chip eDNA sensor

Joshua J. Creelman[1], Gabryelle Beland[2], Benjamin Murphy[1], Mahtab Tavasoli[3], James Dean-Moore[3], Arnold Furlong[3], Julie LaRoche[3,4], Robert Beiko[3,5], Vincent J. Sieben[1,3]

[1]Department of Electrical and Computer Engineering, Dalhousie University, Halifax, Nova Scotia, Canada
[2]Department of Chemical Engineering, Dalhousie University, Halifax, Nova Scotia, Canada
[3]Dartmouth Ocean Technologies Inc., Dartmouth, Nova Scotia, Canada
[4]Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada
[5]Department of Computer Science, Dalhousie University, Halifax, Nova Scotia, Canada

ABSTRACT

Harmful algal blooms, or HABs, are destructive ecological phenomena caused by unchecked growth of specific species of microbes present in fresh, marine and brackish water environments. HABs deprive areas of oxygen and can produce toxins that cause animal, human and environmental harm: an issue that is being reported with increasing frequency as ocean temperature and nutrient concentrations rise due to human impacts. Forecasting and HAB monitoring systems are essential to mitigate their devastating economic and environmental impacts. However, it is extremely difficult to predict the presence of HABs ahead of time. Deployable genomic-based sensor technologies are accurate, but they are currently large, require specialists to operate and are cost prohibitive for scaling to the necessary spatial and temporal ranges.

We present our progress on the development of HAB Hunter™, an innovative microfluidic HAB monitoring sensor. Our approach integrates lab-on-chip (LOC) technologies for *in situ* analyses. HAB monitoring will be achieved in three distinct sections or chips, which can be used collectively or individually. The systems are functionally defined and include: the microfluidic environmental sample preparation (M-ESP) chip, the DNA extraction and purification section, and finally, the quantitative polymerase chain reaction (qPCR) sub-system. The M-ESP is based on an innovative smart filtration approach that sorts incoming microbes and inorganic particles to enrich target collection and to maximize filter efficiency. The M-ESP also contains a custom microfluidic cell lysis section. DNA purification/extraction is performed with a solid phase extraction (SPE) device, making use of a HPLC column. The amplification of DNA and detection of specific DNA sequences is accomplished with a custom qPCR microfluidic device. As part of the qPCR system, rapid thermocycling is achieved with localized and embedded heaters on the microfluidic chip. Fluorescence measurements are completed by directing LEDs onto embedded microprisms in the same microfluidic chip. The analysis chamber is an isolated inlaid cell that prevents background light interference and minimizes the effects of light scattering. The inlaid component contains three optical windows: one for the LED light input, one for collecting fluorescence data and one for collecting absorbance data. Ultimately, we aim to integrate our three parallel developments onto a single device to enable wide-spread HAB monitoring based on low-cost and high-performance lab-on-chip devices.

Word count: 366