International Journal of Environmental Engineering– IJEE
Volume 1 : Issue 4 *[ISSN 2374-1724]*
Publication Date : 27 December,2014

The potential for bioelectrochemical detection of fecal contamination indicator organisms in environmental water

Evelina Jing Ying Han, Victor Bochuan Wang, Joachim Loo Say Chye, Stefan Wuertz, Jamie Hinks

Ingestion of and contact with fecally contaminated environmental waters can cause both enteric and skin diseases. Therefore, many countries have adapted WHO Guidelines for Drinking-water Quality [1] and monitor drinking water supplies and recreational waters for such disease causing microbes [2]. Enteric bacteria, such as E.coli and other coliforms are commonly cultured from surface waters [3] and thus make good proxy organisms for fecal contamination. As the nutrient conditions of environmental waters differs from those in the gut, facultative anaerobes, such as E. coli, are more likely to stay viable than obligate anaerobes when shed from the mammalian gut. Methods like multiple tube fermentation (MTF) [4] and membrane filtration techniques (MFT) [5] were first used to exploit this principle and were developed as a method to determine the number of coliforms in an environmental water sample, and are still considered standard methods in water quality monitoring [6].

Although methods such as MTF and MPN are able to determine the presence of coliforms in environmental water samples, subsequent tests are required to obtain definitive confirmation of fecal contamination in a water sample. This can take up to an additional 72 hours [7]. In the last 30 years, several single step methods have been developed to detect fecal contamination of environmental waters using E.coli as a microorganism representative of fecal contamination. These methods are based either on detection of the presence of uidA gene by PCR [8], or by the ability of β-Glucuronidase, the expressed product of uidA in E.coli, to hydrolyse a substrate conjugated to D-glucuronic acid to elicit a fluorescence, colorimetric [7] or amperometric signal [9, 10].

We demonstrate that E.coli β-Glucuronidase is able to hydrolyse a novel glycoconjugate to give a signal that is detectable amperometrically by electrochemical methods. Furthermore, the onset of the amperometric signal is directly proportional to the initial number of viable E. coli in the sample. The reversible redox chemistry of this glycoconjugate means that it can be applied in a non-culture based self-sustaining biolectrochemical system that would be compatible with automated remote detection. We discuss the results in the context of its potential to speed up the detection of E. coli, and other fecal indicator organisms, in the context of environmental water quality monitoring along with the economic implications.

Keywords—E.coli, fecal contamination, detection, bioelectrochemical

Evelina Jing Ying Han, Jamie Hink, Stefan Wuertz, Victor Bochuan Wang
Singapore Centre on Environmental Life Science Engineering (SCELSE), Nanyang Technological University

Stefan Wuertz
Department of Civil and Environmental Engineering, University of California Davis, USA

Victor Bochuan Wang, Joachim Loo Say Chye
School of Materials Science and Engineering, Nanyang Technological University, Singapore

Acknowledgment

SCELSE is funded by Singapore's National Research Foundation, Ministry of Education, Nanyang Technological University (NTU) and National University of Singapore (NUS), and hosted by NTU in partnership with NUS.

References

[1] Organization, W.H., *Guidelines for drinking-water quality - Volume 1: Recommendations 3rd ed.* 2008: Geneva, Switzerland : World Health Organization, 2008.

[2] Organization, W.H. and W.H. Organization, *Guidelines for Drinking-water Quality: Addendum to Volume 2: Health Criteria and Other Supporting Information*. 1998: The Organization.

[3] Cabral, J.P.S., *Water Microbiology. Bacterial Pathogens and Water.* International Journal of Environmental Research and Public Health, 2010. **7**(10): p. 3657-3703.

[4] American Public Health Association., et al., *Standard methods for the examination of water and wastewater : including bottom sediments and sludges*. 1960, American Public Health Association: New York. p. volumes.

[5] Shipe, E.L. and G.M. Cameron, *A Comparison of the Membrane Filter with the Most Probable Number Method for Coliform Determinations from Several Waters.* Applied Microbiology, 1954. **2**(2): p. 85-88.

[6] Spellman, F.R., *Handbook of water and wastewater treatment plant operations [electronic resource] / Frank R. Spellman*. 2009: Boca Raton : CRC Press/Taylor & Francis, c2009. 2nd ed.

[7] Edberg, S.C. and M.M. Edberg, *A Defined Substrate Technology for the Enumeration of Microbial Indicators of Environmental Pollution.* Yale Journal of Biology and Medicine, 1988. **61**(5): p. 389-399.

[8] Bej, A.K., et al., *Detection of Escherichia-Coli and Shigella Spp in Water by Using the Polymerase Chain-Reaction and Gene Probes for Uid.* Applied and Environmental Microbiology, 1991. **57**(4): p. 1013-1017.

[9] Laczka, O., et al., *Amperometric detection of Enterobacteriaceae in river water by measuring β-galactosidase activity at interdigitated*

SEEK DIGITAL LIBRARY

microelectrode arrays. Analytica Chimica Acta, 2010. **677**(2): p. 156-161.

[10] Perez, F., et al., *Rapid detection of Escherichia coli in water by a culture-based amperometric method.* Analytica Chimica Acta, 2001. **427**(2): p. 149-154.

SEEK DIGITAL LIBRARY