Water quality control and shortcomings due to the use of bacterial indicators

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Abstract

A brief review is presented on the value of bacterial indicators in assessing the safety of water. No single microbial indicator parameter is adequate to determine the water quality in all circumstances. Thus, it is necessary to gain a better understanding of the usefulness of the traditional parameters for water monitoring and the methods available for their analysis.

Introduction

Despite the remarkable success of water treatment and sanitation programs in improving public health, sporadic cases and point-source outbreaks of waterborne diseases continue to occur. Several different factors contribute to the spread of waterborne pathogens and outbreaks of disease from drinking water supplies often results from chance of events.[1] Also the poor hygiene caused by the lack of water results in an increased transmission of infectious diseases.

As a result of the risk to public health due to the presence of pathogens, it is extremely important to determine the microbiological safety of waters. The ideal manner for doing this would be to analyse the waters for the presence of specific pathogens of concern. However, hundreds of different microorganisms have been shown to be involved in waterborne disease outbreaks; thus, it would be impractical to look for every pathogen potentially present in water. In addition, a fundamental limiting factor in the assessment of microbial quality of waters, and especially drinking water, is often associated to the fact that pathogen microorganisms appear intermittently in natural waters at low concentrations, and the techniques available for their selective recovery and enumeration are, generally, complex, time consuming and scarcely selective.

Thus, the use of surrogate bacteria has been standard practice in water quality monitoring and indicator organisms of faecal contamination are used globally as a warning of possible contamination. They are considered as an index of theoretical risk for public health and of water quality deterioration. Heavy reliance has been placed on the coliform and enterococci groups of bacteria to determine the safety of drinking water, recreational water and shellfish-harvesting water.

However, the presence of the indicators is not an absolute indication of the presence of pathogens and, on the other hand, their absence is not a guarantee that other, more resistant microbial forms are not present. In fact, the bacterial indicators' greatest weakness as a public health monitoring tool for water and wastewater is their greater sensitivity to disinfection relative to viruses and protozoan parasites.[2] No consistent relation has been observed between indicator bacteria levels and density of viruses and (oo)cysts of *Cryptosporidium* and *Giardia.*[3-4] In particular, investigations of commonly used water treatment technologies indicate that both the parasites are more resistant to water treatment processes.[5] In addition, the indicator bacteria are not able to signal the presence of pathogens or opportunistic pathogens that do not have an oro-faecal transmission route (*Pseudomonas, Aeromonas, Legionella, Mycobacterium avium* complex).

Furthermore, the presence or the absence of bacterial indicators has no diagnostic value for biological agents deliberately introduced in water.

Ideally, microbial indicators should provide a measure of health risk associated with the exposition to contaminated water (ingestion or contact). Nevertheless, these groups of micro organisms have many limitations as predictors of risk of waterborne disease. In fact, there are non-faecal sources for these indicator organisms, and in contrast to most enteric pathogens, coliforms may multiply in aquatic environments with sufficient nutrients and optimal temperatures. Such characteristic may result in false-positive reports of water contamination.

One of the requirements of choice for an ideal faecal contamination indicator is that it needs to be easy to identify, isolate and enumerate.Thus the monitoring and the statutory assessment of the

hygienic quality of drinking water are based on their determination.

Classically and routinely, the detection and the enumeration of indicator microorganisms is based on cultural methods. In these methods, the microorganisms are grown on either a solid (agar) or liquid (broth) medium, which supplies the nutritional requirements of the organism. Cultivation needs the growth/multiplication of microorganisms. However, the viability of a microorganism may affect detection and for a long time the failure of some bacteria to grow on solid media has been recognised.[6]

Conclusions

Conventional methods for detecting indicators, and also pathogenic bacteria, in water may indeed underestimate the actual microbial population due to sub-lethal environmental injury, inability of the target organisms to take up nutrients and other physiological factors which reduce bacterial culturability. In fact, it is recognised that only a small proportion, possibly less than 1%, of the number of viable bacteria may be enumerated in water.[7] A requirement for reproductive ability is for the cell to be metabollically active and possess an intact cell membrane and cellular components. An intact, metabolically active cell may not necessarily grow, due to non-lethal injury. The concepts of bacterial injury[7] and 'viable but non-culturable' cells (VBNC)[8-9] have been demonstrated by molecular techniques.

Besides, stressed microorganisms, even able to multiply, can lose the ability to express some metabolic characteristics. In the case of coliforms and *Escherichia coli* present in water: a relatively high percentage of strains are non-gas producing and lactose negative, features which are typically exhibited by these bacteria when traditional cultivation methods are used.[10]

Whether testing for indicator organisms or directly for pathogens, there is a common need for rapid analyses. Typically, the drinking water treatment processes are continuous processes where by water is consumed within a few hours after its treatment. Real-time analysis would be ideal for the management and control of microbial water quality and the safeguard of public health. Currently, the nature of the microbial testing, with the use of conventional cultural methods, allow that the assessment of the hygienic quality of drinking water is only available after a minimum of 24 hours. If results have to be confirmed, another one to two days may be required.

Despite the numerous shortcomings of the traditional microbial indicators, they will likely continue to be used as satisfactory criterion for water quality. Nevertheless the exigency arises to better define their specific roles, especially related to different circumstances; furthermore particular attention would be given to the development and use of optimal and more rapid methods for the recovery of these microorganisms.

References

1) Deere D, Stevens M, Davison A, Helm G and Dufour A. In: Fewtrell L and Bartram J (Eds.) Water Quality: Guidelines, Standards and Health. Assessment of risk and risk management for water-related infectious disease. London. IWA Publishing, 2001.

2) Fricker CR. Detection of Cryptosporidium and Giardia in water. In: Protozoan parasites and Water, Betts WB, Casemore DP, R. Fricker CR, Smith HV and Watkins J (eds.), Cambridge: Royal Society of Chemistry, 1995.

3) Bonadonna L, Briancesco R, Ottaviani M, Veschetti E. Occurrence of Cryptosporidium oocysts in sewage effluents and correlation with microbial, chemical and physical water variables. Environ Monit Assess 2002;75:241-52.

4) Campos C, Guerrero A and Cardenas M. Removal of bacterial and viral faecal indicator organisms in a waste stabilisation pond system in Choconta, Cundinamarca (Colombia). Water Sci Technol 2002;45:61-6.

5) Fricker CR and Smith HV. Cryptosporidium and cryptosporidiosis. Sgm quarterly 1997;24:52-3.

6) Roszak DB and Colwell RR. Metabolic activity of bacterial cell enumerated by direct viable count. Appl Environ Microbiol 1987;53:2883-9.

7) McFeters GA Enumeration, occurrence and significance of injured indicator bacteria in drinking water. In: Drinking water Microbiology: progress and recent developments. McFeters GA. New York: Springer-Verlag, 1990.

8) Desmonts C, Minet J, Colwell R, and Cormier M. An improved filter method for direct viable count of Salmonella in seawater. J Microbiol Methods 1992;16:195-201.

9) Colwell RR and Grimes DJ, editors. Viable but nonculturable micro-organisms in the environment. Washington, DC: ASM Press, 2000.

10) Dufour AP, Strickland ER and Cabelli VJ. Membrane filter method for enumerating Escherichia coli. Appl Environ Microbiol 1981;41:1152-8.