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Water assessment using ultra-weak bioluminescence

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ABSTRACT

In this paper a method to evaluate the presence of microorganisms of the coliform group in water samples using the ultra-weak bioluminescence (UWB) is proposed. A series of UWB measurements and optical density measurements from cultures of both a set of standard *E. coli* strain samples, and a set of water samples from a river near Curitiba City in Brazil were performed. All samples were previously incubated at 37 °C for 11 h in nutritive medium before the temporal UWB emission profiles data were acquired for a period of 24 h inside a dark chamber of an especially implemented instrumentation capable of doing photon counting measurements. For the optical density measurements, a spectrophotometer was used to acquire the growth kinetics of those cultures for a period of 13 h, and the results compared to the UWB profiles. Periodic time-components analysis of the UWB data from both the set of standard *E. coli* samples and the set of the river's water samples were performed and compared to each other. The results have shown that the UWB temporal profiles resemble in some way the growth kinetics curve and the periodic time-components analysis is an effective way to discriminate between contaminated and non-contaminated samples, therefore the method may be viable for detecting coliforms in water samples in less time than usual methods.

1. Introduction

Pathogen contamination in water bodies and related diseases are a major water quality concern for the society nowadays. Direct wastewater discharges in surface waters are the main source of fecal microorganisms, including important disease-causing pathogens such as *Vibrio Cholerae*, the genus *Salmonella* and *Shigella* that causes cholera, salmonellosis and shigellosis [1,2,3]. Since several pathogens occur in feces, water is commonly monitored for microbial contamination using indicator organisms such as total coliforms, fecal coliforms and enterococci [4].

Total coliforms are Gram-negative, oxidase-negative, non-spore, forming rods, which ferment lactose with gas production between 24 and 48 h at 35–37 °C, in a medium containing bile salts and detergents [1]. Traditional tests for total and fecal coliforms are carried out either by the multiple-tube fermentation technique or by the membrane filter technique. However, in general, these current methods have a long response time that can also depend on the length of biochemical tests used for the confirmation step. For example, the membrane filter technique commonly used for the enumeration of coliforms in drinking water requires at least an overnight incubation period and additional 24–72 h to the confirmation test [5]. Therefore, there is an important demand for the development of new rapid methods for a better assessment diagnostic for the microbiological quality of water.

All living organisms emit very weak light that is observed as a series of individual photon emissions in which the resulting luminescence, together with the process itself, is known as biophoton emission – BE, ultra-weak bioluminescence - UWB, or ultra-weak photon emission - UWPE [6,7,8]. This phenomenon differs from the bioluminescence, a biochemical reaction involving specific substrates and oxidative enzymes (luciferin-luciferase systems) observed in vertebrates, invertebrates and bacteria [9].

Biophoton emission in organisms can be induced by various abiotic (e.g. heat shock, wounding and elicitor molecules in plants) and/or biotic stresses (e.g. microbial infection) that can elicit an overproduction of reactive oxygen species (ROS) in mitochondria as by-products of cellular respiration [10,11,12,8]. It also can occur spontaneously in living cells without any influence of external stressors or stimuli as, for example, the growth of cell populations [13] and potential role in neural signal transmission and processing [14,15]. Biophotons intensities vary from tens to hundreds of photons·cm^{-2}·s^{-1}, with frequencies centered at the visible light spectrum, ranging from

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