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Application of an Ultra-Weak Bioluminescence Measurement System for *Escherichia coli* Detection in Sanitary Control

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***Abstract*—Detection and measurement of ultra-weak photon emission (UWPE) from biological samples is a promising tool with potential use in several fields such as agriculture, environmental science, food science and biomedicine. A measurement system especially designed to detect UWPE, and an application in sanitary control of natural water resources is presented here. The system was implemented based on a dark-chamber with a photomultiplier module (PMT) cooled by a microprocessor controlled thermoelectric device coupled. The PMT detects the UWPE from the biological sample under measurement. The performance evaluation of the measuring system in terms of dark-noise and bacteria detection was performed in order to assure that it is able to realize UWPE measurements for the proposed application. The samples under test were comprised of a series of 3 control cultures of standard *Escherichia coli* strain, used as control, and other 3 water samples collected from a river close to a metropolitan area in Brazil. The comparison between the control and test samples has shown that the proposed application is feasible for *Escherichia coli* detection tests in water samples from natural water resources to assure the evaluation of their microbiologic quality.**

***Index Terms*—Ultra-Weak Bioluminescence, Escherichia coli, Sanitary Control.**

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I. Introduction

ULTRA-WEAK photon emission (UWPE) detection and measurements has been a subject of research by many groups, and it has a potential use in diverse areas such as agriculture, environmental sciences, food sciences, and biomedicine [1].

UWPE is present in all biological processes, and it only ceases after organism death. Its spectrum ranges from the ultraviolet to the near-infrared, from around 350 to around 850 nm, and its intensities typically are from tens to thousands photons per $cm^2 \cdot s$ [2], or from 10^{-20} to 10^{-15} $W \cdot cm^{-2}$ [1].

The UWPE can be divided in spontaneous and stimulated emission or delayed luminescence (DL). DL is produced after stimulating a biological sample by some type of physical or chemical stress, or by a light source stimulus, and its response is quite distinct for biological samples from non-living samples, as demonstrated by Zeiger in [3]. While the spontaneous emission presents intensities from tens to hundreds photons$\cdot cm^{-2} \cdot s^{-1}$, or from 10^{-20} to 10^{-17} $W \cdot cm^{-2}$, the stimulated emission ranges from hundreds to thousands photons per $cm^2 \cdot s$, or from 10^{-17} to 10^{-15} $W \cdot cm^{-2}$.

The UWPE phenomenon was first observed by Alexander Gavrilovitch Gurwitsch in the 1920's [2], when he theorized the existence of a kind of radiation, which he called mitogenetic radiation. Only in 1951, Strehler and Arnold, using the recently invented photomultiplier tube (PMT), and using as biological samples a kind of algae [4] positively confirmed the existence of the mitogenetic radiation. Short after, in 1954, Colli and Facchini made the first UWPE measurements from seedlings using a PMT [5, 6].

Since then, many groups studied the UWPE correlation between the development capability and germination rate of different seeds: barley [7], rice [8], soya [9]. In addition, a general patent was registered in 2001 [10].

In the case of microorganisms, the UWPE from *Escherichia coli* [11, 12, 13, 14, 15], *Lactococcus lactis lactis* [14, 15],