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Elemental analysis of wastewater effluent using highly sensitive fiber Bragg grating sensor

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ABSTRACT

Industrial effluent is largely being used for irrigation of crops. Hence, monitoring its pollution level is essential to check its suitability for the purpose. We propose a simple and highly sensitive Fiber Bragg grating (FBG) sensor to determine the concentration of Chloride (Cl) and Lead (Pb) ions present in the treated waste water effluent of sugar factories. It is based on the principle of shift in the Bragg wavelength of an etched FBG with change in the ambient refractive index. The etched FBG was calibrated by known concentration of solutions containing the element under study and then was used to quantify the element in the waste effluent. Proper reagents were used for selective determination of the element. The concentrations of Cl and Pb ions in the effluent sample determined by our designed FBG sensor are 95.73 ppm and 0.008 ppm respectively which are in good agreement with the results obtained by APHA (American Public health association) standard techniques employed for wastewater analysis. Sensitivities of Cl and Pb sensors are calculated as 0.76 pm/ppm and 38.6 pm/ppm respectively. Sensitivity of the sensor for Pb ions being about 50 times greater than that for Cl ions, suggests a higher sensitivity of sensor in lower range of concentration in ppm. Limit of detection of our sensor for Cl and Pb are 1.2 ppm and 0.003 ppm respectively which are lower than that of APHA techniques, suggesting the superiority of our sensors. Simple working, miniaturization, cost-effectiveness and ability of online measurement are the most important features of FBG chemical sensors that give them an edge over existing techniques for continuous effluent monitoring.

1. Introduction

Industrial effluent has a significant contribution in environmental pollution which is identified as one of the major global problems today. Rapid urbanization and population growth as well as scarcity of fresh water has resulted in rising dependence of agriculture on Industrial waste water [1]. Sugar industry being an economically important agro based industry in our country produces a huge amount of waste water (1000 dm^3 of waste water per ton of sugarcane crushed) [2,3], which is mostly dumped into water bodies, either in the treated or untreated form which is then used for irrigation of crops [4]. This effluent consists of oil and grease, dissolved solids, micro-organisms, organic and inorganic chemicals. Although some of these are useful micronutrients and are beneficial for crop yield, an excess of any of the constituents may lead to soil deterioration and may have toxic effect on crop yield and hence on human health [5,6]. The suitability of effluent for agriculture and reuse is determined by measurement of physico-chemical parameters like pH, color, temperature, odor, COD (carbon oxygen demand), BOD (biological oxygen demand), TSS (total suspended solids), TS (total solids), TDS (Total dissolved solids), heavy metals and trace elements. TS, TDS and TSS are composed mainly of carbonates, bicarbonates, chlorides, sulphates, nitrates, Ca, Mg, Na, K, Mn and organic matter silts and other particles. Heavy metals in the effluent may include Cu^{2+}, Fe^{2+}, Zn^{2+}, Cr^{3+}, Ni^{2+} and Pb^{2+}. Many research papers have reported that the values of parameters, specially dissolved salts and heavy metals of treated sugar factory effluent exceeded the limits specified by the water regulatory bodies [1,3,7,8]. Hence, it is essential to monitor the quality of the effluent by checking the concentration of individual parameters as each one has its own ill effects on crop and soil quality when present in excess of upper limits specified for them.

We have designed Fiber Bragg grating (FBG) sensor to detect and quantify two of the elements, namely Chloride ions (Cl) and Lead ions (Pb) in sugar factory effluent. These are present in trace

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