Sensors and Actuators B 258 (2018) 850–856

Contents lists available at ScienceDirect

Sensors and Actuators B: Chemical

journal homepage: www.elsevier.com/locate/snb

Quantification of chloride and iron in sugar factory effluent using long period fiber grating chemical sensor

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ARTICLE INFO

Article history:
Received 17 May 2017
Received in revised form
17 November 2017
Accepted 22 November 2017
Available online 23 November 2017

Keywords:
LPG sensor
Cl
Fe
Waste-water
Sugar factory
Sensitivity

ABSTRACT

This paper is an effort to introduce application of Long period fiber grating (LPG) sensors in perpetual monitoring of industrial waste water effluent. A change in ambient refractive index (RI) of an LPG causes a shift in its resonant wavelength. This RI sensitivity of LPG has been used to design a simple and highly sensitive chemical sensor to determine the concentration of Chloride (Cl) and Iron (Fe) ions present in the treated waste water effluent of sugar factories. The concentrations of Cl and Fe ions in the effluent sample determined by our sensor are 97.85 ppm and 0.274 ppm respectively. The results are in good agreement with that of two standard techniques used for the purpose, thus proving the reliability of the LPG sensor. Limit of detection of Cl and Fe ions are found to be as low as 0.038 ppm and 0.007 ppm per pm shift in wavelength respectively, reflecting enormous potential of the sensor in detection of trace elements in waste water with accuracy. Sensitivity of the sensor for Fe ions being about 5 times greater than that for Cl ions, suggests a higher sensitivity of sensor in lower range of concentration in ppm. Miniaturization, cost-effectiveness and ability of online measurement are the most important features of LPG chemical sensors that give them an edge over existing techniques for the purpose.

1. Introduction

India being the second largest producer of sugarcane as well as sugar in the world, a huge amount of polluted effluent, about 600 dm^3 of waste water per ton of cane crushed[1], from sugar factories and distilleries is either being dumped into rivers and other water bodies or used as a potential source of irrigation[1,2]. Wastewater, produced as a by-product by Sugar industries, consists of contaminants like oils, grease, solids, micro-organisms, organic and inorganic chemicals. However, long term use of such polluted sugar mill effluent for irrigation proves to be toxic to plants and causes deterioration of soil, thereby posing serious problems to plant life, animal life as well as the environment [3–6]. Hence, monitoring of waste water effluent is the need of the hour. The important physicochemical parameters to be determined to check the suitability of sugar factory effluent for reuse and agriculture are pH, color, temperature, odour, 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 heavy metals. Heavy metals in the effluent may include Cu^{+2}, Fe^{+2}, Zn^{+2}, Cr^{+3}, Ni^{+2} and Pb^{+2}. Chemicals like heavy metals and dissolved solids have been reported to be present in excess of their specified limits in the treated effluent too [7–10]. A large number of sugar factories and small scale industries, especially in developing countries, do not have effluent treatment plants and do not adhere to the regulations imposed to keep a check on the level of pollution, either due to lack of awareness, space, technical manpower or due to shortage of funds [11]. Many sugar factories having treatment plant consider only a few parameters like COD, BOD and total dissolved solids to be important enough to be tested for presence in the treated effluent. However, each individual parameter, causing ill effects on the growth of crops, must be maintained below an upper limit, specified by WHO and other national pollution regulatory bodies to make the effluent irrigation friendly. The present methods of quantifying waste water parameters like APHA standard methods [12], Spectrophotometric methods, Open and

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https://doi.org/10.1016/j.snb.2017.11.139
0925-4005/