Research Article

Removal of chemical oxygen demand from agro effluent by ZnO photocatalysis and photo-Fenton

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Abstract
The direct discharge of improperly treated effluent from sago industry poses a great threat to water bodies due to the high amount of organic matter. This work investigated ZnO photocatalytic degradation under aerated and non-aerated conditions, and photo-Fenton aiming to reduce the chemical oxygen demand in sago effluent. Photolysis of sago effluent in the presence of ultraviolet irradiation and aeration resulted in 68% of the chemical oxygen demand removal. The results indicate high chemical oxygen demand reductions for different concentrations of sago effluent at 1:10, 1:100, and 1:1000 diluted with distilled water following the ZnO photocatalytic treatment under the aerated conditions. The chemical oxygen demand reductions of 90–95% and 85% were obtained using 3 g/L of ZnO, after 2 h of aerated and non-aerated photocatalytic treatments, respectively, for the sago effluent ratio of 1:1000. On the other hand, the combination of the most concentrated sago effluent at 1:10 and non-aerated ZnO photocatalytic treatment resulted in no appreciable chemical oxygen demand reduction at only 8%. The concentrations of Fe^{2+} (10–60 mM) and H_2O_2 (50–150 mM) greatly influenced the degradation rates of chemical oxygen demand. The optimum parameters of 10 mM of Fe^{2+} and 50 mM of H_2O_2 were able to reduce 97% of the chemical oxygen demand of the 1:1000 sago effluent under the photo-Fenton treatment with 2 h of ultraviolet irradiation. Thus, both ZnO photocatalysis and photo-Fenton can be applied as the possible treatment methods to reduce the chemical oxygen demand in effluent from sago processing.

Keywords Advanced oxidation process · Degradation · Organic matter · Wastewater treatment

1 Introduction

Advanced oxidation processes (AOPs), such as photocatalysis, ozonation, Fenton, and photo-Fenton are regarded as appropriate to degrade organic pollutants. All AOPs are characterised by a common chemical feature, known as reactive oxygen species (ROS) that can react with non-biodegradable or recalcitrant compounds in water [28]. Of the various ROS, the hydroxyl, ·OH radicals have attracted the most attention. The efficiency of AOPs in treating wastewater depends on the (i) composition and concentration of wastewater; and (ii) pollutant load, as the heavier the pollutant load, the stronger the treatment conditions must be applied [32]. Photocatalytic oxidations using titanium dioxide (TiO_2) and zinc oxide (ZnO) and photo-Fenton are more distinctive compared with the other AOPs for the removal of organic pollutants from wastewater. The photo-Fenton process which uses Fenton reagents, H_2O_2 and Fe^{2+} in the presence of light to produce ·OH radicals has shown to be a cost-efficient process as solar energy can be utilised for its activation [36]. Photo-Fenton oxidation has been reported to be efficient in treating different types of wastewaters [21, 22, 48]. ZnO with a band gap energy of 3.2 eV (similar to TiO_2) can serve as an alternative photocatalyst in organic pollutants degradation due to its high quantum efficiency, high chemical stability, high photosensitivity, low cost, and ability to absorb larger fraction of solar spectrum than that of TiO_2 [30, 34]. Several studies

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