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Intensification of degradation of methomyl (carbamate group pesticide) by using the combination of ultrasonic cavitation and process intensifying additives

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ABSTRACT

In the present work, the degradation of methomyl has been carried out by using the ultrasound cavitation (US) and its combination with H_2O_2, Fenton and photo-Fenton process. The study of effect of operating pH and ultrasound power density has indicated that maximum extent of degradation of 28.57% could be obtained at the optimal pH of 2.5 and power density of 0.155 W/mL. Application of US in combination with H_2O_2, Fenton and photo-Fenton process has further accelerated the rate of degradation of methomyl with complete degradation of methomyl in 27 min, 18 min and 9 min respectively. Mineralization study has proved that a combination of US and photo-Fenton process is the most effective process with maximum extent of mineralization of 78.8%. Comparison of energy efficiency and cost effectiveness of various processes has indicated that the electrical cost of 79892.34 Rs./m^3 for ultrasonic degradation of methomyl has drastically reduced to 2277.00 Rs./m^3, 1518.00 Rs./m^3 and 807.58 Rs./m^3 by using US in combination with H_2O_2, Fenton and photo-Fenton process respectively. The cost analysis has also indicated that the combination of US and photo-Fenton process is the most energy efficient and cost effective process.

1. Introduction

Methomyl is a broad spectrum insecticide which belongs to the family of oxime carbamate pesticides [1]. It has been widely used all over the world because of its powerful control against many insects and pests. It can easily cause contamination of both ground and surface water resources, due to its high solubility (57.9 g/L, 20 °C) in water and a low-sorption affinity to soils [2]. Presence of methomyl in water bodies can cause potential impact on the human health and environment because of its toxic and hazardous nature [3].

Various studies have been reported in the literature for the degradation of methomyl, which mainly includes the application of advanced oxidation processes such as photocatalytic [2–5] and Fenton, photo-Fenton processes [1,5,6]. Tamimi et al. [1] have investigated the degradation of methomyl in aqueous solutions by using Fenton (H_2O_2/Fe^{2+}) and photo-Fenton (H_2O_2/Fe^{2+}/UV) process. Complete degradation of methomyl was achieved after 60 min of operation with 23% and 48% of TOC reduction in case of Fenton and photo-Fenton processes respectively. In other study, Tamimi et al. [2] have reported that photocatalytic degradation of methomyl using Degussa-P25 TiO_2 could lead to 80% TOC removal in less than 4 h. Tomasevic et al. [3] have studied the photocatalytic degradation of methomyl in water using Fe-ZSM-5 zeolite and AlFe-pillared montmorillonite catalysts under halogen lamp light and obtained 100% TOC removal within 4 h using 5 g/L Fe-ZSM-5 zeolite. Malato et al. [5] have also carried out photocatalytic degradation of water-soluble pesticides (diuron, imidacloprid, formetanate and methomyl) by the application of photo-Fenton and solar light driven photocatalytic process using TiO_2. Photo-Fenton process was found to be more efficient than the photocatalysis process on the basis of both, the extent of degradation as well as extent of mineralization of methomyl. Mico et al. [6] have reported enhancement in the performance of photo-Fenton reaction at high salinity conditions when applied for the oxidation of methomyl. However, the degradation of methomyl by the application of ultrasound cavitation is not yet reported in the literature, to the best of

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