USE OF POLYTETRAFLUOROETHYLENE RASCHIG RINGS AS A CARRIER IN MALATHION BIODEGRADATION

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Abstract:
Untreated wastewater potentially contains a variety of chemical constituents such as pesticides, which are hazardous to human health, and the environment. Malathion S-[1, 2- di(ethoxycarbonyl) ethyl] dimethyl phosphorothiolothionate; CAS No 121-75-5; C10 H19 O6 PS2] is one of the most widely used organophosphate insecticides throughout the world because of its efficacious control of insects. Several studies have examined the degradation of malathion by microbes and most of these studies were carried out using pure cultures. Little information is available concerning degradation of malathion by activated sludge culture. The purpose of this investigation was to study the biodegradation of malathion using indigenous activated sludge culture. In addition, no studies have examined the biological degradation of malathion using immobilized microbial cells or biofilm reactors. Therefore, the performances of a laboratory scale reactor (Packed Bed Reactor) treating malathion using polytetrafluoroethylene raschig rings as carrier for cell immobilization were investigated. The results showed that the degradation capacity of the reactor packed with polytetrafluoroethylene raschig rings was higher than the performance obtained with the batch reactor. Malathion removal efficiency observed for the carrier tested was affected by the flow rates. In fact, the maximum degradation rates of malathion by activated sludge culture were found to be 67%, 77.5%, 87.5%, and 94% for flow rate values of 2, 1.5, 0.6, and 0.2 cm^3/min, respectively.

Keywords: Activated sludge, biodegradation, malathion, packed bed reactor, polytetrafluoroethylene raschig rings.

I. INTRODUCTION

At the present time, the most widely used pesticides belong to the organophosphorus group. These pesticides are an important source of environmental contamination owning to their widespread use in agriculture. Malathion (figure 1) S-[1, 2- di (ethoxycarbonyl) ethyl] dimethyl phosphorothiolothionate; CAS No 121-75-5; C_{10} H_{19} O_6 PS_2] is a toxic pesticide. It is one of the most widely used organophosphate insecticides throughout the world

Because of the problems associated with pollutant treatment by conventional methods, such as incineration or landfill, increasing consideration has been placed on the development of alternative, economical and reliable biological treatments. Microbial degradation is considered to be a major factor determining the fate of organophosphorus insecticides in environment. Several studies have examined the degradation of malathion by microbes (Kamal et al., 2008; Mohamed et al., 2010; Zhao X-H and Wang, 2012). However, the majority of these studies have been performed using pure cultures, and a few studies have focused on malathion biodegradation by activated sludge culture. In addition, no studies have been reported on biological degradation of malathion using immobilized cells or biofilm reactors. So, in this study, the performances of a laboratory scale reactor (Packed Bed

Reactor) treating malathion using a carrier (Plastic Raschig Rings) for activated sludge immobilization were investigated.

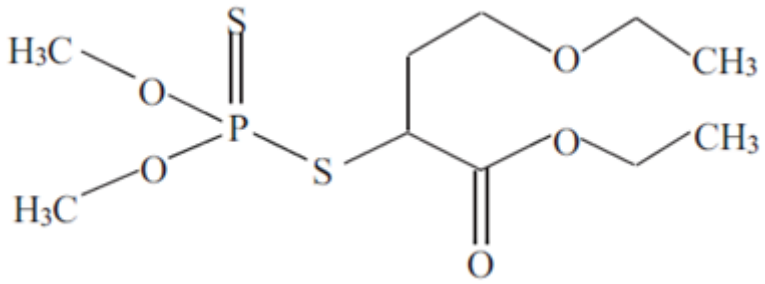

Figure 1. Structure of malathion.

II. MATERIALS AND METHODS

II.1. Microorganism and culture conditions

Synthetic wastewater was consisted of 0.038g KH_2PO_4, 0.05g $MgSO_4$, 0.05g $CaCl_2$ and 0.2g urea, dissolved in 1dm3 of distilled water. A mixed activated sludge culture, obtained from the aeration unit of wastewater treatment plant in Staouali - Algiers, was used in this study. The activated sludge culture was grown in the aeration tank using the same synthetic wastewater in the presence of malathion. The culture was performed at room temperature (25°C, max. deviation ± 1°C) with a moderate agitation (100 rpm) using magnetic stirrer and was supplied with oxygen by fine bubble air diffuser ($2.5dm^3/min/dm^3$).

II.2. Acclimatization procedure

The microorganisms used for malathion degradation were required to be acclimatized to the malathion environment because malathion removal was not observed with an unacclimated activated sludge culture. To initiate the acclimatization, an aerobic sludge of about 7 L was incubated in an Erlenmeyer ask (capacity: 9 L) at room temperature and fed with the synthetic wastewater (mineral salt medium + glucose + malathion) for, the appropriate growth of microorganisms. The concentration of glucose was decreased gradually to 0, and the concentration of malathion was increased in small stepwise increments for a period of 1 month to allow the culture to acclimatize.

II.3. Reactor and operation conditions

The laboratory scale Packed Bed Reactor (PBR) was used with an aeration tank containing synthetic wastewater. It was made using PVC tube with an internal diameter of 2 cm, an overall height of 100 cm, wall thickness of 3mm and 9 sampling ports. The reactor was streamed by upflow in the column to increase the degradation

efficiency and was working in room temperature (25°C, max. deviation ± 1°C). The total volume of packed bed reactor was 314 cm^3. Polytetrafluoroethylene raschig rings (Sigma-Aldrich®) were used as carrier material and were packed at 90% of the working volume. Microorganisms were then adsorbed onto the carrier. Five dm^3 of synthetic wastewater solution containing 10 mg/dm^3 malathion used as the sole source of carbon and energy was pumped into the bottom of the column at different flow rates, ranging from 0.2 to 2 cm^3/min using a peristaltic pump.

II.4. Analytical procedures

II.4.1. Malathion determination

Samples were removed at various time intervals. Malathion concentrations were carried out using colorimetric method proposed by Naidu et al. (1990).

III. RESULTS AND DISCUSSION

Results obtained in the present study demonstrate that PBR can promote enhanced malathion removal from synthetic wastewater. According to the data obtained (Figure 2), it is noted that the removal efficiency of malathion for the biofilm carrier tested is affected by the flow rate. This could be explained, by the fact that an increase in flow rate resulted in a decrease in reaction rate because of insufficient residence time of the reactants in the column . Results obtained show obvious performances of PBR for malathion degradation in which biomass adsorbed on Polytetrafluoroethylene was able to degrade malathion with maximum degradation rate of 94% for flow rate value of 0.2 cm^3/min.

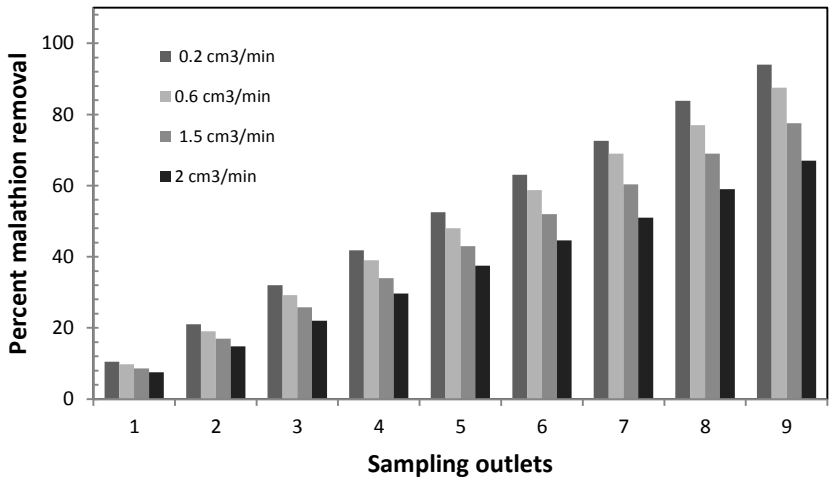

Figure 2: Variation of malathion removal efficiency at the various height of the column with different flow rates (initial malathion concentration was 10 mg/dm^3).

The biomass on the carrier material was monitored at the end of the operation time. Results obtained show that cell mass adsorbed onto the carrier was about 0.0037±

0.00054 *g* biomass /*g* carrier, indicating that cell colonization probably due to its surface properties and to its specific surface area.

IV. CONCLUSIONS

The results of this study allowed to demonstrate that:

The acclimated activated sludge was able to degrade malathion and to use it as the sole carbon source, as indicated by the fact that the degradation was accompanied by concurrent bacterial growth, suggesting that the mixed culture used was growing at the expense of malathion.

A possible strategy to increase malathion degradation is to use the laboratory-scale PBR of which the effectiveness was clearly demonstrated in this study. Polytetrafluoroethylene raschig rings used as the carrier in PBR permitted considerable increase in malathion biodegradation in comparison with the batch reactor. The maximum degradation rate of malathion by activated sludge culture were found to be 94% for flow rate value of 0.2 cm^3/min. This result may be explained by the relative high cell mass adsorbed on this carrier. The advantages related to this carrier make it a suitable option as a cell carrier.

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