Original Article

Removal of Malathion Insecticide from Water by Employing Acoustical Wave Technology

M Shayeghi [1], *MH Dehghani [2], AM Fadaei [2]

[1]Dept. of Medical Entomology and Vector Control, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

[2]Dept. of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Institute for Environmental Research, Tehran, Iran

Abstract

Background: Organophosphorus pesticides are one of the most prevalent usages for pest control in the country. Such pesticides enter into water sources by different routes. Since drinking of contaminated water at the higher doses than the standard level, may causes undesirable effects to human health and ecosystem. The object of this research was to investigate the effect of various parameters including time, power and concentration on sonodecomposition of malathion insecticide in the water.

Methods: The sonochemical degradation of malathion was investigated using acoustic wave technology (AWT). AWT with 130 kHz was used to study the decomposition of insecticide solution. Samples were analyzed using HPLC at different intervals times. Effectiveness of AWT at different times (20, 40, 60, 80, 100, and 120 minutes), concentrations of malathion at 2, 4 and 8 mg/L as well as powers of device (300W, 400W, 500W) are compared.

Results: These findings showed that the degradation of the malathion insecticide at lower concentrations was greater in comparison to higher concentrations. Also, there was positive correlation between power increasing and the ability to malathion degradation

Conclusion: The sonodegradation of malathion at different concentrations and powers was successfully achieved. It has been shown that acoustical wave technology can be used to reduce the concentration of dissolved insecticide using high frequency.

Keywords: Malathion insecticide, Acoustic wave technology, Sonochemical decomposition

Introduction

Malathion insecticide is moderately mobile to very highly mobile in soils, creating the potential for it to move through the soil profile and into groundwater. Malathion is an organophosphate pesticide and is generally not very persistent in the environment. Since malathion insecticide is widely used for industry and insect control in agricultural crops, its fate in the environment is very important. Insecticide contamination of water has been recognized as a major contaminant in world because of their potential toxicity to human and animals (1-4). Its chemical structure is ($C_{10}H_{19}O_6PS_2$).

Many methods for insecticide waste treatment have been considered (5- 8). A variety of physical and chemical methods are employed for the removal of aqueous insecticides. Several techniques to eliminate insecticides have been so far considered, like ozonation (9- 11), adsorption by activated coke (3, 12, 13), ultraviolet irradiation and hydrogen peroxide (14- 24).

AWT has been used to induce or accelerate a variety of reactions. These reactors have a board range of industrial applications, including water treatment (25- 28). Since 1990, there has been increasing interest in the sonochemical decomposition of aqueous solutions both in

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*Corresponding Author: Fax: (+ 98 21 6641 9984), E-mail: hdehghani@tums.ac.ir

water decontamination (29). The chemical effects of AWT of aqueous environment are believed to be related with acoustic bubbles (30-34).

The present research deals with the sonochemical decomposition of selected malathion insecticides in the AWT. The objective of study was to determine the potential of batch reactor for decomposition of malathion in different conditions such as power, concentration and decomposition time.

Materials and Methods

Sonochemical experiments were carried out in a sonoreactor equipped with two piezoelectric. Transducers (5cm diameter) fixed at the bottom of the vessel. In sonoreactor the vibrational energy is transferred to the reaction mixture via two parallel stainless-steel plates that are bolted together. Each plate is driven by magnetostrictive transducers. Magnetostrictive materials transducer or convert magnetic energy to mechanical energy and vice versa. Characteristics of the reactor were as following: Power: 300 W, 400 W, 500 W; Frequency: 130 kHz; Reactor type: Basin, Flow type: Batch; Capacity: 1.5 L. Also, Experimental conditions for decomposition operations are shown in Table 1.

Procedures
Sample was prepared by dissolving a known volume of insecticide with %95 concentration in 1000 ml of distilled water in a volumetric vessel. All organic solvents (acetone, hexane) were of analytical reagent grade, supplied by Merck Company. Homogenized samples pretreated at temperatures 18–20 ^{0}C were placed in reactor. Reactor temperature was controlled with the flowing of condensation water surrounding the reactor. Therefore, temperature did not exceeded 18–20 ^{0}C in any experiment. Malathion insecticide samples were exposed to a fixed frequency of 130 kHz. All sonicated solutions were analyzed for malathion and decomposition operation by HPLC at different time intervals. Characteristics of the HPLC system were as following: Column Inertsil: ODS – 2; 150 × 4.6 mm chromSep: stainless steel Cat.No.2922; Mobile phase: CH_3CN/H_2O (65:35, V: V); Temperature: 40 ^{0}C; Detector UV: wavelength 210 nm; Flow rate: 1mL/min.

All the analyses were performed according to the procedures outlined in standard methods (35).

Calculation method
The definition of malathion decomposition percentage (DP) is as follows:
$$DP = (C_1 - C_2) / C_1 \times 100$$
Where:
DP (%) is the degradation percentage of the reactor,
C_1 is the initial concentration of malathion (mg/l),
C_2 is the concentration of malathion (mg/l) after reaction for (t) time

Results

An aqueous solution of malathion was sonicated in a batch reactor for different concentration, power, fixed frequency and different times. During the sonochemical decomposition, the concentrations of malathion were determined and the ultraviolet absorption spectra of the aqueous solution were measured.

Effect of initial concentration
The effect of initial malathion concentration on the removal percentage is shown Fig. 1, 2 and 3. Different initial malathion concentrations resulted in different removal percentage. The removal percentage decreased with increasing initial concentration in the range of 2 mg/L, 4 mg/L and 8 mg/L under sonication after 120 min. Clearly, the rate of sonochemical decomposition is slow in the presence of high concentration of malathion. i.e.; the increase of malathion concentration in the solutions significantly decreased the rate of decomposition after120 minutes. As expected, the decomposition

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percentage is the highest for the lowest concentration as shown in Figures. In our experiments we found that the appropriate insecticide decomposition is 2 mg/L after 120 minutes. One way ANOVA and Post hoc tests indicated that mean difference is significant at the 0.05 level.

Effect of time

The effect of time on the decomposition of malathion was shown in Fig. 1, 2 and 3. The decomposition percentage of malathion was 91.11 % (2 mg/L), 89.67 % (4 mg/L) and 80.23 % (8 mg/L) for 300 W (Fig. 1). Also, decomposition percentage was 98.55 % (2 mg /L), 91.76 % (4 mg/L) and 89.78 % (8 mg/L) for 400 W (Fig. 2). However, decomposition percentage was 99.98 % (2 mg /L), 95.47 % (4 mg/L) and 92.65 % (8 mg/L) after 120 min for 500 W (Fig. 3). The results indicated that with an increase in the time, a growing degree of solution decomposition is not observed.

Effect of pH

The results showed that sonolysis had no considerable effect on pH of insecticide samples, although the minor change occurred were no significant.

Effect of temperature

With an increase in the decomposition time, temperature increase. For example, in 120 minutes was within 40°C and it is due to acoustic cavitation (36-46). In this study, the reaction temperature was controlled with the flowing of condensation water surrounding the reactor bath. Therefore, experiments showed that temperature increase of insecticide samples during sonication had no considerable effect on decomposition of insecticide.

Effect of acoustic power

The effect of power on the malathion decomposition was also studied for 300 W, 400 W and 500 W. One way ANOVA and Post hoc test showed the mean difference is significant between removal efficiencies ($P<0.05$).

Table 1: Experimental conditions for decomposition operations

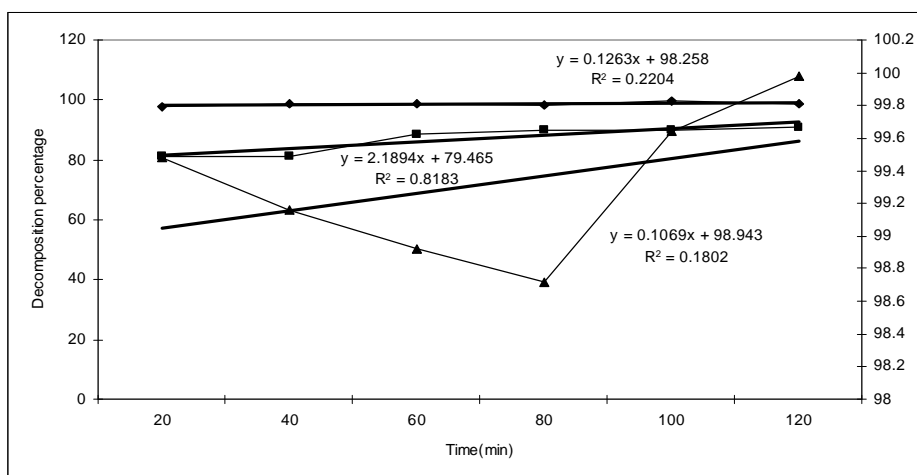| Frequency (kHz)	Power (W)	Sonication time (min)	Initial concentration (mg/L)	Sample volume (mL)	Temperature (^{0}C)	pH
130	300, 400 , 500	20, 40, 60, 80, 100, 120	2, 4, 8	200	18-20	6.8-7

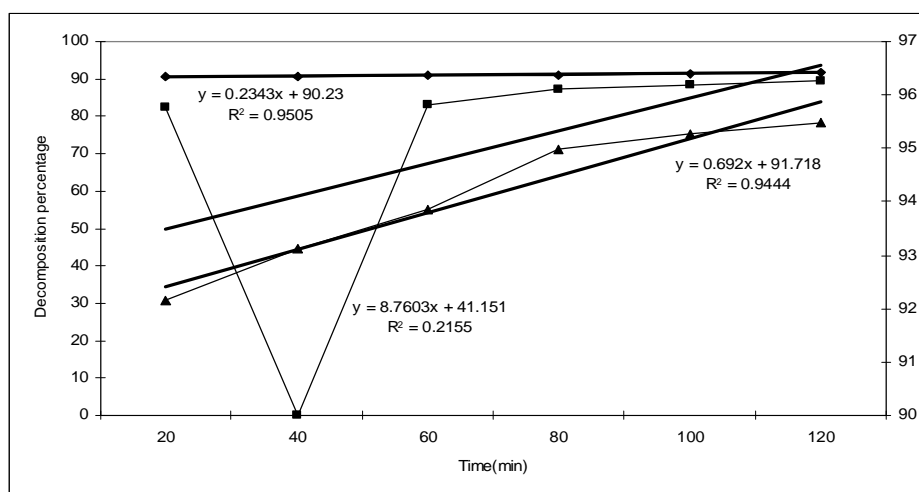**Fig. 1**: Comparison of decomposition percentage at different powers for 2 mg / L

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Fig. 2: Comparison of decomposition percentage at different powers for 4 mg / L
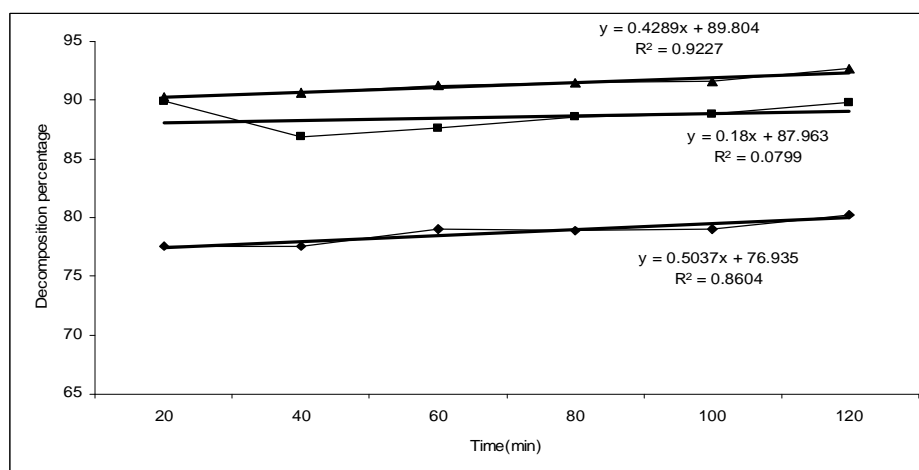
Fig. 3: Comparison of decomposition percentage at different powers for 8 mg / L

Discussion

The malathion insecticide decomposition process can be described using the effectiveness of ultrasonic irradiation by the formation the OH radicals. The OH radicals, which are produced in the hot vapor phase, may react there or they may diffuse into and react within the surrounding liquid phase. The hydroxyl radicals react with malathion by hydrogen abstraction or electrophilic addition to double bonds were also reported previously (40- 46).

This research revealed that is the possibility of degrade efficiently of malathion insecticide in water, by AWT. The sonodecomposition of malathion insecticide at different concentrations and powers was successfully were achieved. It has been shown that AWT can be used to re

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duce the concentration of insecticide using 130 kHz. Statistical analysis shows that power and initial concentration are effective parameters for decomposition of malathion.

Researches (38-43) indicated that percentage of decomposition rate of malathion varies with initial concentration after exposing to irradiation which is basically the steady state phase. Matouq et al. (2008) reported that initial malathion concentration decreases with decomposition time, and as time reached certain period, meaning that the steady state phase has been achieved (38). Kotronarou et al. (1992) explained that if the reactants were unbuffered, the pH of the solution changed during ultrasonication. After 30 min of sonication, the pH dropped from 6 to 4 (41). In addition, Hua et al. (2001) indicated that a low pH is not required for sonodecomposition of insecticide (36).

Hua et al. (2001) reported that faster decomposition rates are observed at higher power (36). Hua et al. (1995), Henglein and Gutierrez (1990) showed that faster decomposition rates at high powers were observed because the number of cavitation bubbles in solution depends upon the power (39, 40).

The best circumstance for sonodecomposition was provided for lower initial concentration and the highest power after 120 min, i.e.; an increase in concentration results in decrease in the decomposition efficiency. Also, when the power increased, the ability of decomposition process will be increased.

Ethical Considerations

Ethical issue principles including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the authors.

Acknowledgements

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