

APPLICATION OF ELECTROCHEMICAL PROCESS FOR DIAZINON REMOVAL FROM CONTAMINATED WATER

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ABSTRACT

Nowadays extended and enhancing use of organo-phosphoric pesticides has intensified the possibility of their presence in water supplies. Therefore with regard to their capability to be hazardous for human and environment, it is essential to research on their appropriate treatment methods. Hence, this research has been conducted with ambition of Diazinon removal from synthetic contaminated water. This experimental study was conducted on synthetic Wastewater (S.W.) sample in a batch system. In each run 1700ml of the S.W. decanted in an electrolytic cell and subjected to 4 steady state electrical current intensities (0, 1.8, 3.6 and 5.4 amps) by means of stainless steel electrodes. In each electrical current, 5 samples of 50 ml in volume picked on hydraulic retention times of 0, 15, 30, 45 and 60 minutes. Each process retried for 3 times. Accordingly total number 60 samples concentration of residual Diazinon measured with a Thin Layer High Performance Liquid Chromatography apparatus after filtering with a 45 micrometer membrane filter. Removal of Diazinon was increased with addition of hydraulic retention time and intensity of electrical current as a 100% of Diazinon removal observed in current density of 9.55 A cm^{-2} and hydraulic retention time of 15 minutes. A removal efficiency of 94.7% also observed after a period of 60 minutes, for a current intensity of 3.6 amperes, while where the current intensity was 1.8, the efficiency only was 91.6%. Results from variance analysis with repeated measurements showed a meaningful relationship between removal performance, current intensity and reciprocal effect of current intensity and time ($p < 0.001$). Electrochemical process using stainless steel electrodes in electric current density of 9.55 A cm^{-2} has this ability to remove Diazinon up to 100% and to be an effective reliable treatment for Diazinon contaminated waters.

Keywords: Pesticide, Diazinon, Electrochemical

INTRODUCTION

Chemical biocides yet are recognized as the easiest method in controlling of pests and nuisances both in agriculture and human health. In spite of approved hazards of these compounds consumption, use of chemical pesticide still is common yet (Nasirian *et al.*, 2006). Pesticide pollution not only affects human health, but also involves multiple other environmental factors, for example soil, surface and ground water, crop productivity, micro and macro flora and fauna, etc (Atreya, 2008). Acute effects of Pesticides on human include headache, nausea, muscle spasms, dermal irritations and breathing problems and its chronic effects include cancer, neurotoxic effects, reproducing system harms and endocrine disruption (Nougadère *et al.*, 2011). In recent years organophosphoric pesticides have been replaced for Organochlorine Pesticides and currently these types of pesticides because of their effectiveness for a wide range of pests and their inexpensiveness have a greater consumption in compare to other pesticides. On the other side global statistics showed that most of pesticides related mortalities are due to this kind of pesticides (Kazai *et al.*, 2010; Shayeghi *et al.*, 2008; Muff *et al.*, 2009). Diazinon is one the most popular organo phosphoric pesticides, which is not persistence in ambient environment under UV light (Ćolović *et al.*, 2010, 2011). Inspections which implemented in Greece showed the amounts of several pesticides were more than 0.1 micrograms per liter (as WHO Standard) in surface waters (Vryzas *et al.*, 2009). In the same manner, it's unveiled by inquiries that concentrations more than WHO standards has been

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observed in groundwater (Bruggen *et al.*, 1998). Results of studies on pesticides residuals in surface water resources of Hamedan, Kashan and Karaj, showed that concentration of pesticides at least in several months of the year were higher than WHO standard (Khdoadadi *et al.*, 2010; Shayeghi *et al.*, 2007; Dehghani *et al.*, 2012).

Some studies showed that common water treatment processes have had no significant effect on removal of pesticides additionally regarding to extension of pesticides application in agriculture and their diversity, it can be stated that proposal of an appropriate method for removal of them is logically accepted (Diagne *et al.*, 2007). Several methods have been investigated for removal of pesticides from water so far. Nano filtration, reverse osmosis, biological methods, activated carbon adsorption, ozone oxidation, combination of Nano filtration and adsorption and co-application of ion-exchange and powdered activated carbon are some examples of these methods. Despite implemented studies, seeking for an effective, simple and in-expensive method is undergoing yet (Boussahel *et al.*, 2000; Plakas and Karabelas, 2012; Sarkar *et al.*, 2007; Fuentes *et al.*, 2010; Gupta *et al.*, 2011; Humbert *et al.*, 2008; Chelme-Ayala *et al.*, 2011). In recent years tendency for electrochemical treatment increased significantly due to their unsophisticated apparatus requirements, simple operation, high efficiency, in-expensiveness and lesser sludge production (Brillas *et al.*, 2003; Bazrafshan *et al.*, 2010). Also, this process have been evaluated with success for treatment of domestic wastewaters, landfill leachates, tannery textile-dyeing effluents, and removal of phosphorous from treated wastewaters and synthetic aqueous solution (Muff *et al.*, 2009). With reference to the above mentioned statements, this study conducted with ambition of Diazinon removal from synthetic contaminated water.

MATERIALS AND METHODS

This bench scale experimental study was executed on synthetic aqueous Diazinon pesticide contaminated samples with fixed initial concentration of pollutant in laboratory temperature (about 20 °C). It was preferred to take initial concentrations of Diazinon equal to 2.5 milligrams per liter based on Dehghani *et al.*, (2012) and raw water samples supplied from Sad-abad spring of Brarzak city located in Kashan. Since this spring water did not observed to be polluted by Diazinon pesticide at study time, this toxicant manually added to the raw water.

In each run 1700 ml of synthetic contaminated water with Diazinon initial concentration of 2.5 mg/l poured in a 2 liter Plexiglas electrolytic cell which was square in cross section and subjected to electrochemical process with avoid of adjustment of initial pH (7.98) and temperature. Initial electro conductivity of samples was 1020 μ Mohs. Utilized electrodes were 8 pieces of stainless steel with lengths, widths and thicknesses of 150, 25 and 2 millimeters respectively which were used isochronously as anode and cathode with intermittent. During operating time, cells contents mixed with a magnetic stirrer in rotational speed of 300 rpm.

Electricity supplied from an external power supply while electrical potential and intensity of its current, controlled by the corresponding apparatus (e.g. Ampere meter, Volt meter, Rheostat etc.). The process executed in 4 steady states current intensities of 0, 1.8, 3.6 and 5.4 amps. Each process was retried for 3 times. For each electrical current, 5 samples of 50 milliliters in volume collected subsequent to hydraulic retention times of 0, 15, 30, 45 and 60 minutes. Therefore for total number 60 samples concentration of residual Diazinon was measured with a Thin Layer High Performance Liquid Chromatography apparatus subsequent to filtering with a 45 micrometer membrane filter.

RESULTS

Results of this study showed that with increment of current intensity, Diazinon removal would be efficiency enhanced. Electrochemical process with stainless steel electrodes has had this ability to abate Diazinon residual concentration down to zero. Table 1 represents the average values for residual Diazinon concentrations in different current intensities and various reaction times.

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Table 1: Diazinon residual concentrations mean values for different current intensities and various reaction times

Reaction time (min)	Electrical Current (Amp)		
	1.8	3.6	5.4
0 (n=3)	2.49±0.40	2.48±0.69	2.48±0.69
15 (n=3)	0.81±28.60	0.44±3.89	0.00±0.00
30 (n=3)	0.48±33.48	0.18±12.47	0.00±0.00
45 (n=3)	0.44±30.25	0.18±12.47	0.00±0.00
60 (n=3)	0.21±14.54	0.27±9.23	0.00±0.00

As mentioned above removal of Diazinon increased with addition of hydraulic retention time and intensity of electrical current as a 100% of Diazinon removal was observed in current density of 9.55 mAcm^{-2} (5.4 A current intensity) and hydraulic retention time of 15 minutes. A removal efficiency of 92.8% also observed for a current density of 6.4 mAcm^{-2} (3.6 amperes current intensity). Figure 1 illustrates the trend of Diazinon removal by electrochemical process in different current intensities.

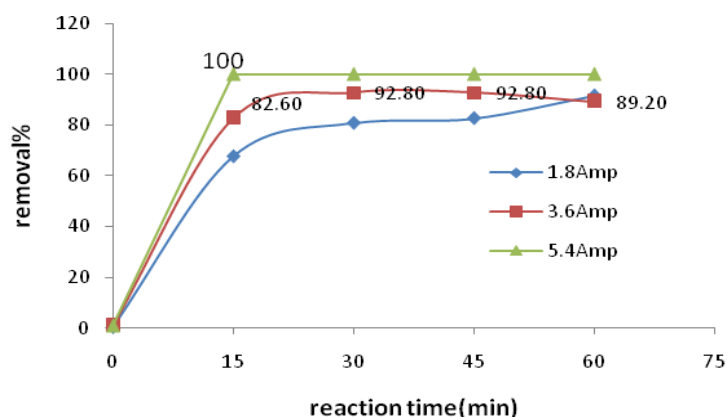


Figure 1: Trend of electrochemical Diazinon removal in different current intensities

Investigations of logarithmic variations of residual Diazinon concentrations with regard to reaction times in different current densities, revealed that these variations stilled in direct relationship only where the current density was 3.9 mAcm^{-2} (1.8 ampere current intensity).

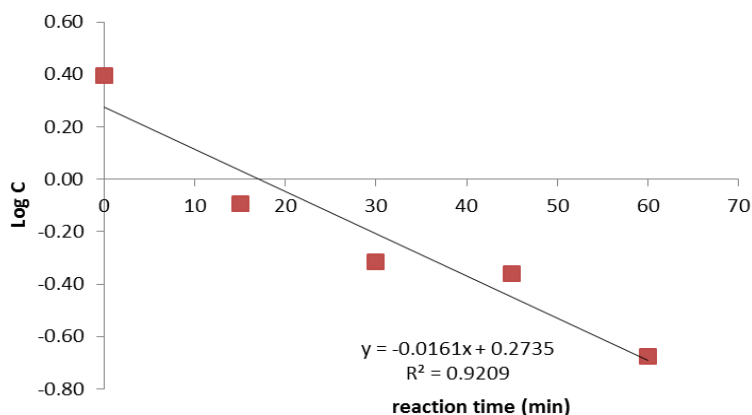


Figure 2: Logarithmic variations trend for residual Diazinon concentrations with regard to reaction times in 1.8 ampere current intensity

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Results from variance analysis with repeated measurements showed a meaningful relationship between removal performance, current intensity and reciprocal effect of current intensity and Time ($p < 0.001$). Implementation of Bonferroni Sequential Test showed a meaningful discrimination between current intensities of 5.4, 1.8 and 3.6 amperes ($p < 0.05$).

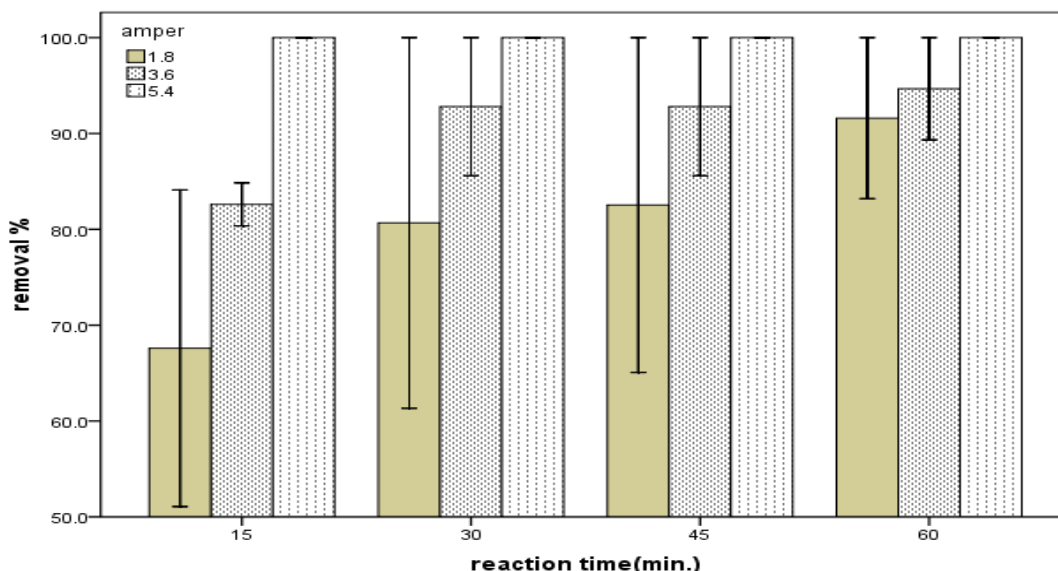


Figure 3: Diazinon removal percentage in various reaction times and different current intensities

DISCUSSION

Results showed that electrochemical process by means of stainless steel electrodes have this ability to remove Diazinon up to 100%. Operation time and current intensity were two efficacious parameters which could affect Diazinon removal with direct. As by addition of operation duration, process efficiency rise. With accord to Vlyssides *et al.*, (2005) Diazinon removal by electrochemical process with Ti/Pt electrode as anode and 304 stainless steel electrode as cathode has had a COD removal percentage of 55% in electro current density of 22 mA.cm^{-2} and operation time of 120 minutes. In accord to Miwa *et al.*, (2006) Carbaryl pesticide removal by electrochemical process with Ti/Ru 0.3TiO_2 electrode has had a 100% removal in electro current density of 32.5 mA.cm^{-2} and operation time of 120 minutes. In accord to Muff *et al.*, (2009) Electrochemical process with Ti/Pt $_{90}$ -Ir $_{10}$ electrode as anode and 316 stainless steel electrode as cathode approximately has had a pesticide removal percentage of 100% in electro current density of 310 mA.cm^{-2} and operation time of 30 minutes for removal of several pesticides (e.g. Ethylaminoparathion, paraxon) (Muff *et al.*, 2009). While in the current study Diazinon removal of 100% was observed in electro current density of 9.55 mA.cm^{-2} and operation time of 15 minutes and so this process is a more eligible process since it requires less reaction time and electro current density while it results a higher performance. This difference could be caused by diversity of pesticides and electrodes. As it was shown by figure 3 range of deviation for Diazinon removal in current intensity of 1.8A was much more than those for other current densities. Also range of deviation for removal gets down to zero at current intensity of 5.4 Amps. With accord to figure 3 it can be comprehended that with addition of reaction time the range of deviation has been suppressed, identically this range was reduced where the current intensity invigorated. This fact shows that in lesser reaction times and lower current intensity, the interfering parameters are able to deteriorate the process performance more aggravatingly in compare to longer reaction times and higher current intensities. This phenomenon shows that the system is more reliable in higher current intensities and longer reaction times. It is inferred that the optimal conditions for Diazinon removal would be take place in a current intensity of 5.4 Amps and a reaction time of 15 minutes.

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Conclusion

It can be stated, that the electrochemical process by means of stainless steel electrodes can be served as an effective, fast and reliable treatment method for purification of Diazinon contaminated water. It can remove Diazinon up to 100% and the process can be implemented applicably in all conditions (esp. in emergency situations).

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