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Degradation of pesticide atrazine in water by high voltage electrical discharges

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Abstract - In recent years, the widespread use of pesticides has increased agricultural output, but it has also caused many problems. For instance, atrazine, the most commonly used herbicide, has been reported to not only pollute the water environment, but also affect the reproductive system of humans and other animals as an endocrine disrupting chemical (EDC). It is thus urgent to find an efficient way to degrade atrazine. Here, we investigated the degradation of atrazine by high voltage electrical discharges and compared it with traditional Fenton oxidation and ultrasound treatment.

Keywords: Pesticide, Atrazine, Degradation, Electrical discharges.

I. INTRODUCTION

Atrazine is an herbicide used primarily for the control of grassy and broadleaf weeds such as maize, sugar cane and sorghum. Atrazine pollutes surface water because it is relatively soluble in water [1]. Atrazine is also found in underground waters, due to its low absorption from the soil [2]. The chronic toxicity of atrazine is of concern. Atrazine interferes with the endocrine system, causing a series of pathological changes and reproductive abnormalities [3]. Atrazine causes breast, ovarian and uterine cancers as well as leukemia and lymphoma [4]. Therefore, it is very important to find clean and economical processes to degrade atrazine.

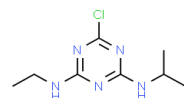


Figure 1. Atrazine.

In this study, high-voltage electrical discharges (HVED) were used for the degradation of atrazine. This process was compared to chemical treatment with oxidation Fenton as well as physical treatment with high-frequency sonication. An analytical monitoring of the degradation process was carried out, by High-

performance liquid chromatography (HPLC) and Liquid chromatography–mass spectrometry (LC-MS). Degradation metabolites were identified and compared for each process.

II. EXPERIMENTAL METHODOLOGY

Fenton oxidation was performed under the following conditions: 10 mg FeSO₄•H₂O, 5 mL H₂O₂ (30%) were added in 45 mL atrazine aqueous solution (20 mg/L), incubated for 2 h, on a magnetic agitator at 200 rpm (room temperature). Two frequencies were studied (50 kHz and 525 kHz) in ultrasound treatments. The duration of ultrasonic treatment was 2 h. The treatment with HVED (40 kV, 10 kA and 10 ms) was performed. The initial concentration of atrazine aqueous solution prior to ultrasound and HVED treatment was 20 mg/L. The degradation products of atrazine were identified by HPLC.

III. INFLUENCE OF TREATMENTS ON ATRAZINE DEGRADATION

The work carried out as part of this study has shown that the degradation rate of atrazine by Fenton oxidation is the highest (95% degradation of atrazine after 2 h). The use of low-frequency ultrasound at 50 kHz slightly degraded atrazine (23% degradation of atrazine after 2 h). The use of high-frequency ultrasound at 525 kHz degraded 87% of atrazine after 2 h. The HVED treatment was much more efficient, as 10-ms electrical shocks degraded atrazine by 83%. During the degradation of atrazine, eleven compounds were identified. The formation kinetics of these compounds were studied for all the treatments applied. The result showed that the degradation products of atrazine are related to the nature of the treatment applied.

In addition, the generated compounds vary in their toxicity. In the case of low-frequency ultrasound at 50 kHz, deethylatrazine (DEA) and deisopropylatrazine (DIA) are the main degradation products of atrazine. In the case of Fenton oxidation, ammeline (AM) and didealkylatrazine (DDA) are the

main degradation products of atrazine. And in the case of HVED treatment, hydroxyatrazine (HA) is the main degradation product of atrazine. The substrate atrazine is of low acute toxicity in rats exposed via the oral route (LD_{50} , 1870-3090 mg/kg). For DEA, DIA, DDA and HA, the value of LD_{50} were 1890, 2290, 2310-5460 and 5050 mg/kg, respectively. Therefore, the toxicity order is $ATZ \approx DEA > DIA > DDA > HA$. In addition, AM does not have an LD_{50} value, but its toxicity is close to that of atrazine. Although Fenton oxidation has the highest degradation rates of atrazine, it generates a greater diversity of degradation products whose toxicity is, for some (e.g. AM), similar to that of the initial compound (atrazine).

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







toxicity: $ATZ \approx DEA > DIA > CDIT > AM > DDA > HA > CDET > CDAT$							
Deethylatrazine (DEA)	Deisopropylatrazine (DIA)	Atrazine amide (CDIT)	Ammeline (AM)	Didealkylatrazine (DDA)	Hydroxyatrazine (HA)	Simazine (CDET)	Deisopropylatrazine amide (CDAT)
							

Figure 2. Degradation products of atrazine.

IV. CONCLUSION

The study showed the feasibility of high voltage electrical discharge (HVED) treatment, as an alternative technology, for the degradation of atrazine. Hydroxyatrazine (HA) is the main degradation product in HVED treatment, and it has a lower toxicity than other degradation metabolites of atrazine. This research paves a way for the development of a new clean and economical technology for wastewater treatment.

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