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EXTENDED ABSTRACT

Using Electro-peroxone Process to Remediate stabilized clay

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1. Introduction

Industrial processes are among human activities that cause the production of a large volume of wastewater containing organic pollutants such as phenol and its derivatives. These pollutants are among the substances that are considered a serious threat to the health of the environment, soil and humans. Soil remediation is crucial for enhancing environmental quality for both humans and other living organisms. This study investigated the use of an electro-peroxone system to remove environmental pollutants from soil. In conjunction with ozonation, the study employed electrochemically generated hydrogen peroxide using a carbon electrode, addressing concerns about transportation and storage. Experiments were structured using response surface methodology (RSM) with three variables: ozone dosages ranging from 4 to 8 l/hr, initial pollutant concentrations from 20 to 50 mg/kg, and treatment durations between 7 and 14 days. The effectiveness of phenol removal from soil was assessed by applying a consistent voltage of 2 V/cm to the soil samples in all experiments.

2. Methodology

The soil used in this study was collected from Amol County in northern Iran, with its physical characteristics presented in Table 1.

Table 1 Physical properties of the soil

Parameter	Sand % >0.074mm	Silt or Clay % <0.074mm	%LL	%PL	%PI	Maximum dry unit weight KN/m³	Optimum moisture content %	Gs	pH
Value	3	97	56	24	32	15.72	22.86	2.72	7.66

In order to prepare the contaminated sample, the soil was first thoroughly dried. Acetone was employed as a solvent for soil contamination, and a mixture of acetone and phenol was gradually added to 250 grams of soil. The mixture was meticulously combined to obtain a soil sample with a phenol concentration ranging from 20 to 50 milligrams per kilogram of soil. The soil sample was then densely packed into a plexiglass cell under static conditions. A direct current power supply was utilized to apply a potential difference between two carbon electrodes in the pilot. A direct current of 15 volts was administered for all experiments, taking into account the voltage gradient of 1 v/cm. Fig. 2 depicts the comprehensive schematic of the experimental system.

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Fig. 1 General view of the electro-peroxone system

3. Results and discussion

3.1. Phenol removal rate

Figures 2 display the concurrent effect of the three variables on phenol removal efficiency. The highest value achieved was 61.21% for a duration of 14 days, an ozone dose of 8 l/hr, and a pollutant concentration of 20 mg/kg in the soil, while it reached 94.59% in the cathode reservoir.

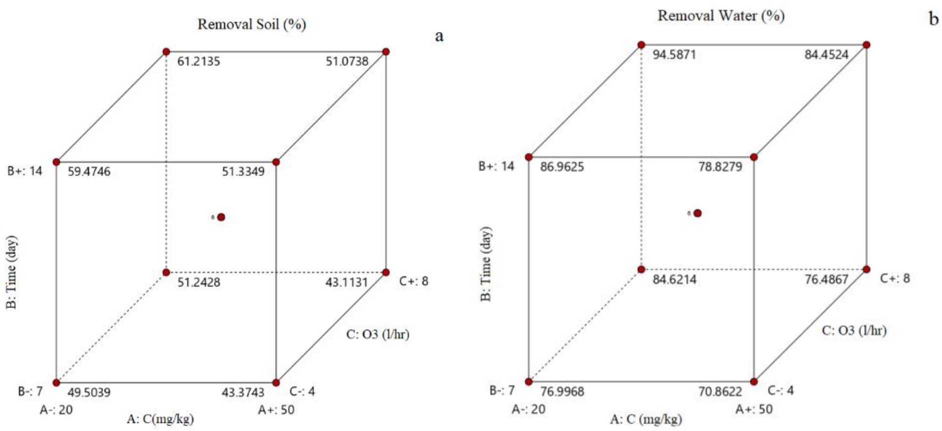

Fig. 2 Three-dimensional optimization for increasing pollutant removal efficiency, a soil, b Water

3.2. *Changes in pH*

Upon initiating the experiment, electrolysis occurs in both the anode and cathode compartments, generating large amounts of H+ and OH- ions in their respective compartments. As a result, the pH of the anode compartment becomes acidic, while the pH of the cathode compartment turns highly basic. These ions then move towards their opposite poles, impacting the soil's pH. Figure 3 illustrates the pH changes in various sections of the pilot, where the soil near the anode experiences a decrease in pH, and the soil adjacent to the cathode sees an increase in pH. Similar results have been reported in previous studies

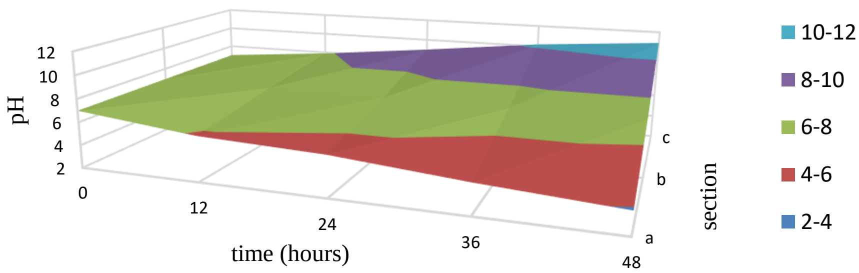

Fig. 3. pH changes in different parts of the pilot a) soil near the anode, b) middle soil, c) soil near the cathode

3.3. Variance analysis of the results of phenol removal

the quadratic model was proposed to predict the results. P value less than 0.05 indicates the significance of the model.

The final equation in terms of real factors in soil and water is shown in equations 1 and 2, respectively.

$$\text{Removal Efficiency in Soil} = +40.9027 + 0.1330\,A + 0.5184\,B - 0.0917\,C - 0.0072\,AB - 0.0125\,AC - 0.0536\,BC - 0.0035\,A^2 + 0.0646\,B^2 + 0.1094\,C^2 \quad (1)$$

$$\text{Removal Efficiency in Water} = +62.8454 + 0.3906\,A + 0.1636\,B + 0.5770\,C - 0.0119\,AB - 0.0208\,AC + 0.0536\,BC - 0.0057\,A^2 + 0.0609\,B^2 + 0.0982\,C^2 \quad (2)$$

4. Conclusions

Employing the electro-peroxone method for in situ pollutant removal is a cutting-edge approach. This technique eliminates concerns and costs associated with hydrogen peroxide safety during transportation and storage while continuously generating hydroxyl radicals near the cathode. The results of the RSM experiments reveal that phenol removal efficiency is inversely related to the initial pollutant concentration and directly related to both ozone dosage and time. The maximum removal efficiency was attained at an initial concentration of 20 mg/kg, an ozone dosage of 8 l/hr, and a duration of 14 days.

Moreover, pH is significantly impacted due to electrolysis in the electrolyte compartments. As H+ ions increase in the anode compartment and OH- ions increase in the cathode compartment, the pH of these respective regions becomes acidic and basic.

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