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Biological and Electrochemical Techniques for Remove Organic Contaminants in Soil

[1]K.Hema Latha , Asst. Professor of Chemistry, Dadi Institute of Engineering and Technology
[2]Dr.P.Pavitra, Asst. Professor of Chemistry, Dadi Institute of Engineering and Technology

Abstract
Persistent organic pollutants, which are synthetic organic chemical compounds, either intentionally or unintentionally produced, have widely aroused public concern in recent years. These chemicals are toxic and major environmental concern due to their persistence, long range transportability, bioaccumulation, and potentially adverse effects on living organisms. Uncontrolled inputs combined with poor environmental management often result in elevated levels of persistent organic pollutants in affected estuaries. Since the Stockholm Convention on POPs was adopted, different techniques have been extensively developed. A major focus revealed the need for low-cost methods that can be implemented easily in developing countries such as electrochemical techniques. Persistent organic pollutants.

Introduction
In the past decades, the health effects of environmental pollution on the population have been a growing source of worry around the world. According to the WHO (World Health Organization), one-third of the diseases afflicting humanity are caused by extended exposure to pollution. Since World War II, scientists have identified several chemical contaminants that are toxic, persistent in the environment, bio accumulative, and prone to long-range atmospheric transboundary migration and deposition, and are expected to have serious health consequences for humans, wildlife, and marine biota both near and far from their source of emission. These toxins are chemical contaminants, also called the dirty dozen [1]. Being volatile substances, POPs evaporate into the air in warm regions of the globe, are transported by air currents up to cold regions and in mountainous regions where they condense [2, 3]. Most POP chemicals are non-polar organic compounds,

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consequently hydrophobic, with extremely low water solubility. In marine and terrestrial systems, they bind strongly to solids, particularly organic matter, evading the aqueous segment [4]. They are also lipophilic, which means that they accumulate in the fatty tissue of living animals and human beings. The stockpiling in fatty tissue allows the compound to persevere in biota, where the metabolism rate is low [5, 6, 7, 8]. Due to the bioaccumulation and bio magnification.

Methodology

Preliminary, primary, secondary, and tertiary wastewater treatment stages are in sequence of increasing treatment level, with final pH adjustments as needed. The chosen conventional approach must be able to meet the regulatory authority's recommended microbiological and chemical criteria while operating and maintaining at a low cost. Conventional treatment methods such as flocculation, coagulation, filtration, and oxidant chemical treatment are ineffective against POPs. The chemical properties of POPs, such as,

low water and high fat solubility, stability to all degradation processes and low vapor pressure, are the main components for their efficiency as pesticides and for their persistence in the environment The inability in some instances to remove POPs from wastewater using conventional methods have prompted scientists to develop other methods. Various advanced wastewater treatment technologies such as, activated carbon adsorption, biodegradation using membrane bioreactor and advanced oxidation processes have been applied in the treatment of POPs. This is because of growing number of emerging POPs that are being identified in water and the concerns that are accompanied by human and environmental health hazard Various setbacks such as cost, sophisticated instrumentation, low degradation efficiency, generation of toxic secondary chemicals and massive sludge production have recently been addressed using advanced methods and technologies. Below is the short discussion of biodegradation and advanced oxidation processes wastewater treatment technologies.

Biodegradation

Biodegradation is an evolving technology that comprises the application of selected living microorganisms to degrade, metabolize/immobilize any unwanted substances such as pesticides, organic pollutants and hydrocarbons from soil and water, to improve its quality [67]. Although every microorganism can eradicate pollutants, only few particular or engineered microorganisms are used broadly to eradicate pollutants efficiently. Bioremediation technology, applied in perspective to POPs removal, takes into consideration the following methods: (1) bioventing: aerating water to stimulate *in situ* biodegradation of organic **contaminants** and promote bioremediation, (2) bio stimulation: modification of contaminated media to provide the nutrition to soil microbiota by adjusting pH, addition of limiting nutrient to improve C: N: P ratio, and (3) bioaugmentation: addition of microbial community (bacteria and fungi) and any biocatalyst (gene and enzyme) to degrade organic/inorganic pollutants.

The flushing solutions were SDS (5% m/m), Tween 80 (5% m/m), and sodium cholate (5% m/m), and the electrolyte solution was distilled water. All the tests employed an initial concentration of 100 mg/kg PFOA kaolin mixture. SDS and NaC, cationic surfactants, were placed into the cathode chambers, while Tween80, a nonionic surfactant, was loaded into the anode chamber; additionally, the fluid level in the inflow reservoir was kept constant to guarantee a constant steady hydraulic gradient throughout the soil. To evaluate the effect of EK remediation on PFOA removal from kaolin, E1 and E2 were performed without any enhancement, as indicated in Table 3. It was then utilized to examine the efficacy of surfactant-enhanced EK tests carried out under identical experimental settings. For one week, E4, E6, and E8 EK tests were carried out with a 20mA constant current gradient and E3, E5 and E7 EK tests were carried out at a 10mA.

The PFOA content in the soil was determined using a triple methyl alcohol extraction method, in which 5mL of methyl alcohol was mixed with 5g dry soil, shaken at 250 rpm and 220C for 60 minutes, sonicated at 300C for 30 minutes, and then centrifuged at 9000 rpm for 10 minutes. The supernatants after each extraction were combined, diluted, filtered (PTFE syringe filter), and put into vials for UHPLC-MS/MS analysis (LC/MS 8060, Shimadzu, shim pack column 1.6 m, 2.0 mm 50 mm). Recovery of the extraction was tested.

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Therefore, the data were calculated to determine the mass balance and removal efficiency. The removal efficiency was calculated from (Eq. 1), where Ci (mg/kg) is the initial concentration of PFOA, and Cf (mg/kg) is the final PFOA concentration after EK experiments

Results and discussion

1.1 Experiment with soil results with PFOA

S.No	Target contamination	Concentration of target contamination	Electric current	Surface concentration	duration
E1	PFOA	100	10	-	7
E2	PFOA	100	20	-	7
E3	PFOA	100	10	5	7
E4	PFOA	100	20	5	7
E5	PFOA	100	10	5	7
E6	PFOA	100	20	5	7
E7	PFOA	100	10	5	7
E8	PFOA	100	10	5	7
E9	PFOA	100	20	5	14
E10	PFOA	100	20	5	14

Soil charecteristics	values
Clay	47.8
Silt	52
Sand	3
Permeability (m/sec)	4×10^{-10}
Density (g/cm^3)	1.45
Porosity (kg/m^3)	633

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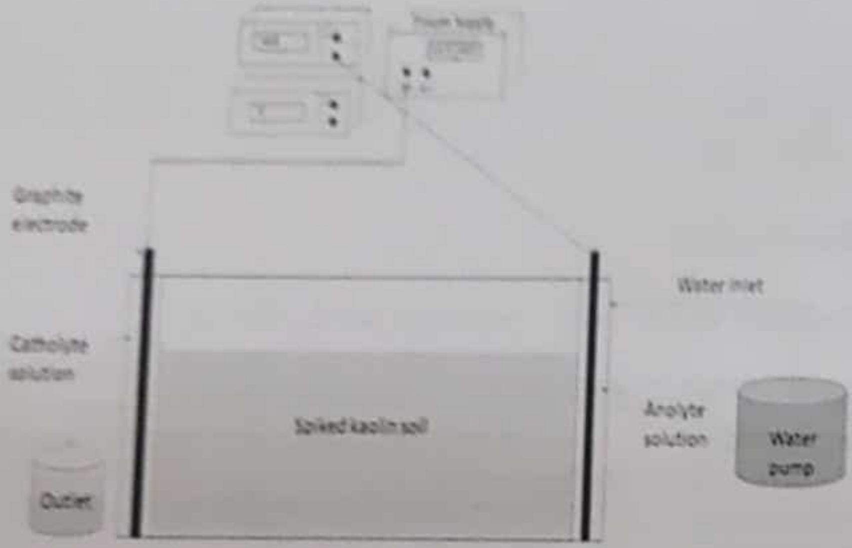

The soil washing technique to remove organic contaminants is a common method of remediation and different chelating agents and inorganic and organic surfactants have been used with diverse effects and mechanisms, because their efficiency depends on the washing conditions: type of agent, concentration, pH, contact time, and the solidliquid relationship (Liu et al., 2022). In the case of PHs, PAHs and PCBs or chlorinated agents, researchers have insisted not only on eliminating the contaminants but also recovering the extraction agents for reuse and for this reason, technical combinations such as advanced oxidation processes (AOP) in situ for the formation of OH radicals are being applied, which constitute a good option; in addition, anodic oxidation processes have been highlighted to selectively degrade target contaminants (Trellu et al., 2021). If the contaminant is more toxic or risky, then the intermediate volatile components that result from the process are of special concern and cause for future research (Tran et al., 2022), together with the development of washing agents that respect the environment, optimization of washing conditions, cost reduction avoiding the destruction of soil function and groundwater contaminatetion (Liu et al., 2022). It is also observed that electrochemical techniques are used to eliminate synthetic herbicides from agricultural soils, such as triazine, chlorophenoi acetic acid, urea, among others, highly bio recalcitrant and stable. It is also usual to find reports of the combination with other techniques such as simple and combined electrochemical advanced

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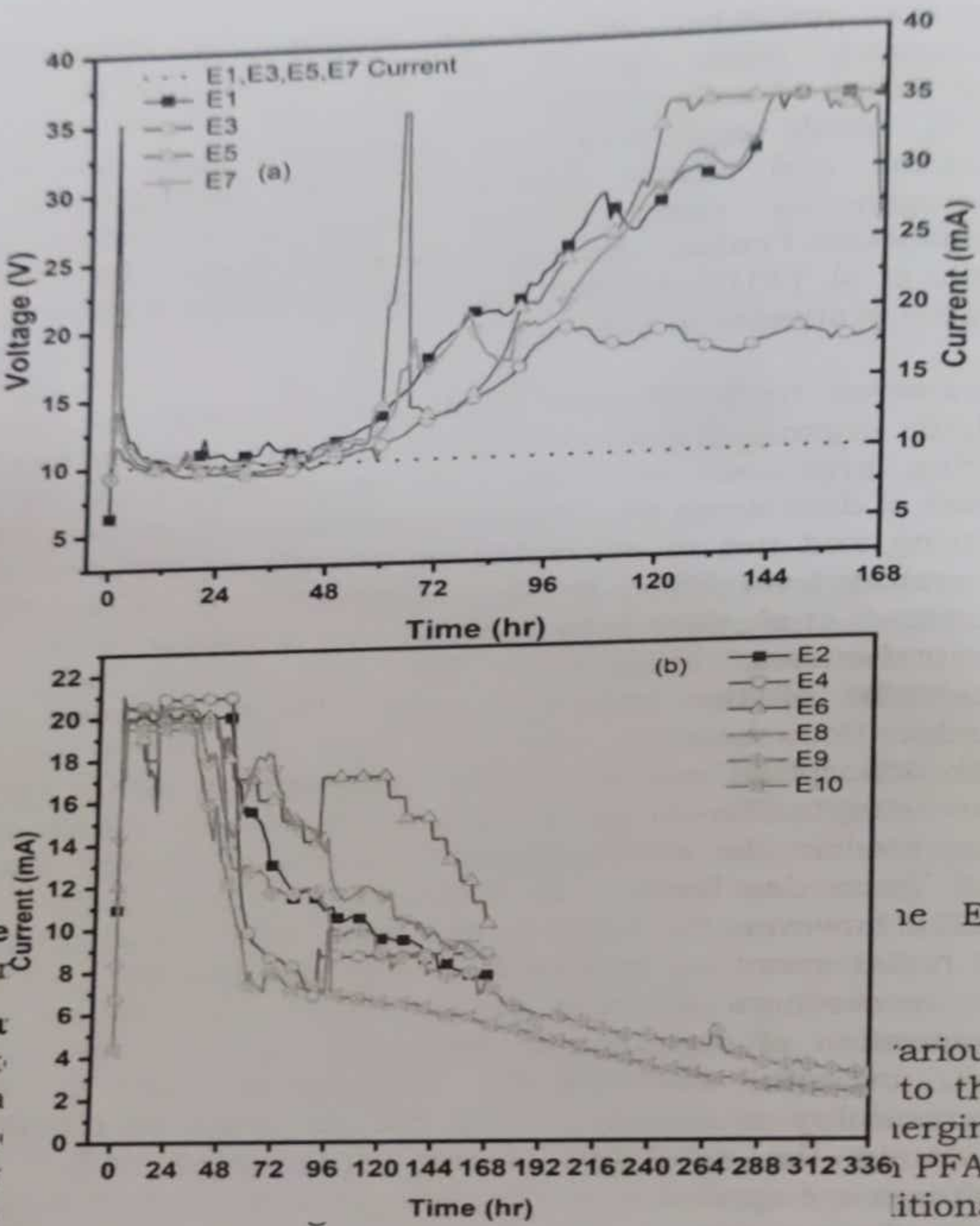
oxidation (published with greater emphasis in 2010). In the bibliometric study carried out by Brillas (2021) on the remediation of soils published in the Scopus database (2010–2020), single and combined treatments such as: anodic oxidation and electro generated H2O2, homogeneous and heterogeneous electro-Fenton, photo-electro-Fenton, solar photoelectro-Fenton and photo-electrocatalysis. for example, Trellu et al. (2019) applied boron-doped diamond electrodes to remove pesticides in soils.

Unresolved trade-offs still exist when it comes to removing volatile organic pollutants (VOCs) and gas streams produced during large-scale treatment. The researchers have not been aware of discussing why the mechanism corresponds to ground heating and not to electrokinetic heating as reported at the laboratory level (Miller de Melo Henrique et al., 2021; Munoz-Morales ˜ et al., 2021); In addition, the technique is not totally comprehensive, because it does not always include the treatment of the produced gases. There are also certain combinations between solid electrolyte cells (direct treatment) with adsorption and absorption processes, whose results are promising to recover gases such as chlorine or volatile species generated in the electrochemical process of the soil (Andrade and Vieira dos Santos, 2020; Miller de Melo Henrique et al., 2021); however, the high consumption of electrical energy and its replacement by renewable energy has become a challenge for researchers (Ganiyu et al., 2020). In relation to the elimination of organic and inorganic contaminants from the soil, in situ electrokinetic on porous matrices of low permeability is beneficial; but the pH must be regulated to maintain the solubility of the contaminant and if higher voltages are applied in the presence of carbonates or gravel, the temperature of the soil increases, thus reducing the efficiency of the process (Virkutyte et al., 2002). Certain emerging in-situ electrokinetic technologies (Lasagna™, Elektro-Klean™, and electro-bioremediation) require further research to improve their large-scale commercial applicability (Wen et al., 2021).



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Conclu...

Due t... 'arious polluta... to the treatm... ıerging contan... ı PFAS stands ... litional methods such as immobilization or washing are not efficient, requiring future research. In addition, it is important to study how to control the emission of secondary gases and avoid the impact on biodiversity, looking for its feasibility and profitability in situ. Raw plastic waste that generates microplastics contains chemical additives such as phthalates, bisphenol A, and polybrominated diphenyl ethers, which are part of the emerging pollutants and can induce toxic effects when ingested by living organisms. In addition, there are still no standardized protocols for their identification and quantification, which in a certain way has limited the investigations for their removal from the soil matrix. Finally, the current trend of combinations of techniques is very attractive because it is aimed at improving soil remediation processes, showing that the application of nanoparticles in bioremediation with microorganisms has been giving excellent results at the laboratory level; however, more research is required to measure the potential risk and adverse effects on the environment due to its final disposal.

Remedial measures

On the other hand, the remediation of emerging contaminants such as microplastics will demand continuous interest from researchers; consequently, research about the identification, physical and chemical characterization, treatment, and their impacts on the soil will be increased. The combination of techniques has been developing successfully in the elimination of contaminants; However, more research is still required on the mechanisms of the processes on toxicity in biodiversity, the routes and their final disposal because the laboratory conditions could present certain biases in relation to their application in the field.

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