Remediation of diesel-polluted soil by the combined thermal desorption and thermal plasma methods

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1. Introduction

Soil pollution has significantly increased due to several factors, including the swift growth of urbanization, development of industrialization, modern agriculture, and unsustainable resource exploitation. Thus, the accumulation of myriad contaminants in the soil usually worsens soil quality and affects its health while simultaneously inducing threats to various ecosystems and living beings, including plants, animals, and humans [1, 2]. Accordingly, in seeking to protect living beings' health and to maintain the environment's ecological balance [3], it is necessary to remediate polluted soil as fast and smoothly as possible. Among the myriads of soil contaminants, petroleum products are recognized as one of the most essential organic-type pollutants. This tendency may be influenced by the fact that petroleum products remain the most used energy source globally. Correspondingly, accidental oil spills during disposal and transportation, the rupture of underground storage tanks or pipelines, or other accidents during crude oil processing cause this pollutant entry into the soil environment [4]. As a result, restoring petroleum-polluted soil has become an important topic. Removing petroleum products from the soil involves physical, biological, chemical, and thermal methods or combinations of these methods. Thus, this experimental research aimed to investigate the ability of the combined thermal desorption and thermal plasma methods to remediate diesel-polluted soil while converting diesel into lower hydrocarbons or gaseous compounds, thereby removing pollutants from the soil.

2. Experimental – Diesel-polluted soil (25 g/kg) remediation was carried out via thermal desorption by applying a tube furnace. The temperature in the tube furnace was 300 °C. The remediation was performed in an Argon (Ar) environment, and the Ar flow rate varied between 1-3 l/min. The remediation took 40 minutes. The extracted diesel was supplied throughout this cleaning period into a thermal air plasma torch, where diesel conversion appeared. The airflow rate used for the plasma formation was equal to 4 l/min. Air also played the role of a gasifying agent. Soil and produced gas analysis were done before and after the remediation using energy-dispersive X-ray spectroscopy (EDX), scanning electron microscopy (SEM), and gas analysers.

3. Results and Discussion – Measurements performed with EDX showed that carbon concentration in the clean and diesel-polluted soil differed slightly and was equal to 25.10 at. % and 24.67 at. %, respectively. After the soil treatment, C concentration increased by 2-3 at. %. The content of the remaining elements, such as oxygen, silicon, calcium, potassium, etc., varied negligibly, implying that the cleaning process did not significantly change the soil composition. SEM images indicated no significant changes in the soil surface morphology. The results gained with a gas analyser showed that diesel was mainly converted to lighter hydrocarbons, such as CH_4 and C_3H_8, as well as to CO_2 and synthesis gas (H_2+CO) during the polluted soil remediation.

4. Conclusions – The experimental results showed that the combined thermal desorption and thermal plasma methods are suitable for cleaning diesel-polluted soil without significantly changing its properties.

5. References

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