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Efficiency of diesel-contaminated soil washing with different tween 80 surfactant concentrations, pH, and bentonite ratios

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ABSTRACT

Soil contaminated with diesel fuel is a hazard to the environment and people; therefore, it needs to be remediated. Soil washing enhanced with Tween 80 (TW80), non-toxic and non-ionic surfactant, can effectively remove diesel from contaminated soils. In this study, the effects of 0.01%, 0.1%, 0.5%, 1%, and 1.5% (v/v) [TW80] concentrations; 0%, 5%, and 15% (w/w) bentonite; and variation in pH on washing efficiency were examined in a batch test. The prepared samples were physiochemically characterized on the basis of particle size, zeta potential, cation exchange capacity (CEC), scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) analysis. When the bentonite content in soil was 5% or 15%, 1.5% [TW80] solution exhibited the highest washing efficiency. The diesel removal efficiencies in soil with 0% bentonite were slightly higher than those in soils with 5% and 15% bentonite because of the increase in adsorption sites by bentonite; consequently, diesel could not be easily washed out. The extracted *n*-alkanes showed that the percentage of carbon number 20 was higher than that of the other even-numbered carbons in the retained washed samples analyzed by gas chromatography-mass spectrometry (GC-MS). In all the washing tests, the diesel removal efficiencies in soil with 15% bentonite and 0.1% [TW80] were lower than those in soil with 15% bentonite and water because of adsorption. The bentonite samples washed with TW80 have different morphologies, with a voluminous structure composed of the fusion of all layered structures, as supported by SEM results. Changes in the diesel content and residual TW80 content in the soil before and after washing were shown by the carbon content in the EDS results. The mechanism of the washing effect was investigated by CEC and zeta potential measurements. This study may aid in selecting appropriate conditions for improving washing efficiencies in future field applications.

1. Introduction

Total petroleum hydrocarbons (TPHs) are found in crude oil, which is the raw material used in the manufacture of petroleum products. Some examples of petroleum products produced by crude oil distillation are gasoline, diesel, kerosene, and lubricating oil. Diesel contains alkanes mainly with 8–28 carbon atoms (Kuppusamy et al., 2020; Wongsa et al., 2004). Diesel contaminates soil during production, transportation, and storage; as a result, it spills into the soil (Han et al., 2009; Wang et al., 2019). In addition to alkanes, polycyclic aromatic hydrocarbons (PAHs) are found in diesel; alkanes and PAHs are cytotoxic, mutagenic, and carcinogenic, but PAHs are more potent than alkanes (Dutta et al., 2017; Li et al., 2008; Rakowska, 2020; Willumsen and Arvin, 1999). Therefore, diesel contamination of soil is an environmental problem that can affect soil biological activities. Diesel in contaminated soils cannot be easily removed with water only because it is insoluble and can accumulate on soil surfaces. It can also easily combine with organic matter in natural soil because of its nonpolarity (Falciglia et al., 2011; Ukalska-Jaruga et al., 2018), thereby exacerbating the difficulty of diesel removal (Kuran et al., 2014). Thus, diesel-contaminated soil must be remediated to improve human health and ecological safety (Alrumman et al., 2015).

Clay, a common component of soil, impairs the washing effect by

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