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Biodegradation Effects onto Source Identification of Diesel Fuel Contaminated Soils

Authors : Colin S. Chen, Chien-Jung Tien, Hsin-Jan Huang

Abstract : For weathering studies, the change of chemical constituents by biodegradation effect in diesel-contaminated soils are important factors to be considered, especially when there is a prolonged period of weathering processes. The objective was to evaluate biodegradation effects onto hydrocarbon fingerprinting and distribution patterns of diesel fuels, fuel source screening and differentiation, source-specific marker compounds, and diagnostic ratios of diesel fuel constituents by laboratory and field studies. Biodegradation processes of diesel contaminated soils were evaluated by experiments lasting for 15 and 12 months, respectively. The degradation of diesel fuel in top soils was affected by organic carbon content and biomass of microorganisms in soils. Higher depletion of total petroleum hydrocarbon (TPH), n-alkanes, and polynuclear aromatic hydrocarbons (PAHs) and their alkyl homologues was observed in soils containing higher organic carbon content and biomass. Decreased ratio of selected isoprenoids (i.e., pristane (Pr) and phytane (Ph)) including n-C17/pristane and n-C18/phytane was observed. The ratio of pristane/phytane was remained consistent for a longer period of time. At the end of the experimental period, a decrease of pristane/phytane was observed. Biomarker compounds of bicyclic sesquiterpanes (BS) were less susceptible to the effects of biodegradation. The ratios of characteristic factors such as C15 sesquiterpane/ 8β(H)-drimane (BS3/BS5), C15 sesquiterpane/ 8β(H)-drimane (BS4/BS5), 8β(H)-drimane/8β(H)-homodrimane (BS5/BS10), and C15 sesquiterpane/8β(H)-homodrimane (BS3/BS10) could be adopted for source identification of diesel fuels in top soil. However, for biodegradation processes lasted for six months but shorter than nine months, only BS3/BS5 and BS3/BS10 could be distinguished in two diesel fuels. In subsoil experiments (contaminated soil located 50 cm below), the ratios of characteristic factors including BS3/BS5, BS4/BS5, and BS5/BS10 were valid for source identification of two diesel fuels for nine month biodegradation. At the early stage of contamination, biomass of soil decreased significantly. However, 6 and 7 dominant species were found in soils in top soil experiments, respectively. With less oxygen and nutrients in subsoil, less biomass of microorganisms was observed in subsoils. Only 2 and 4 diesel-degrading species of microorganisms were identified in two soils, respectively. Parameters of double ratio such as fluorene/C1-fluorene: C2-phenanthrene/C3-phenanthrene (C0F/C1F:C2P/C3P) in both top and subsoil, C2-naphthalene/C2-phenanthrene: C1-phenanthrene/C3-phenanthrene (C2N/C2P:C1P/C3P), and C1-phenanthrene/C1-fluorene: C3-naphthalene/C3-phenanthrene (C1P/C1F:C3N/C3P) in subsoil could serve as forensic indicators in diesel contaminated sites. BS3/BS10:BS4/BS5 could be used in 6 to 9 months of biodegradation processes. Results of principal component analysis (PCA) indicated that source identification of diesel fuels in top soil could only be perofrmed for weathering process less than 6 months. For subsoil, identification can be conducted for weathering process less than 9 months. Ratio of isoprenoids (pristane and phytane) and PAHs might be affected by biodegradation in spilled sites. The ratios of bicyclic sesquiterpanes could serve as forensic indicators in diesel-contaminated soils. Finally, source identification was attemped for samples collected from different fuel contaminated sites by using the unique pattern of sesquiterpanes. It was anticipated that the information generated from this study would be adopted by decision makers to evaluate the liability of cleanup in diesel contaminated sites.

Keywords : biodegradation, diagnostic ratio, diesel fuel, environmental forensics
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