Biogeosciences 2015 vol.12 N12, pages 3681-3693

Response of soil microorganisms to radioactive oil waste: Results from a leaching experiment

Galitskaya P., Biktasheva L., Saveliev A., Ratering S., Schnell S., Selivanovskaya S.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© Author(s) 2015. CC Attribution 3.0 License. Oil wastes produced in large amounts in the processes of oil extraction, refining, and transportation are of great environmental concern because of their mutagenicity, toxicity, high fire hazardousness, and hydrophobicity. About 40% of these wastes contain radionuclides; however, the effects of oil products and radionuclides on soil microorganisms are frequently studied separately. The effects on various microbial parameters of raw waste containing 575 g of total petroleum hydrocarbons (TPH) kg^{-1} waste, 4.4 of ^{226}Ra, 2.8 of ^{232}Th, and 1.3 kBq kg^{-1} of 40K and its treated variant (1.6 g kg^{-1} of TPH, 7.9 of ^{226}Ra, 3.9 of ^{232}Th, and 183 kBq kg^{-1} of 40K) were examined in a leaching column experiment to separate the effects of hydrocarbons from those of radioactive elements. The raw waste sample (H) was collected from tanks during cleaning and maintenance, and a treated waste sample (R) was obtained from equipment for oil waste treatment. Thermal steam treatment is used in the production yard to reduce the oil content. The disposal of H waste samples on the soil surface led to an increase in the TPH content in soil: it became 3.5, 2.8, and 2.2 times higher in the upper (0-20 cm), middle (20-40 cm), and lower (40-60cm) layers, respectively. Activity concentrations of ^{226}Ra and ^{232}Th increased in soil sampled from both H- and R-columns in comparison to their concentrations in control soil. The activity concentrations of these two elements in samples taken from the upper and middle layers were much higher for the R-column compared to the H-column, despite the fact that the amount of waste added to the columns was equalized with respect to the activity concentrations of radionuclides. The H waste containing both TPH and radionuclides affected the functioning of the soil microbial community, and the effect was more pronounced in the upper layer of the column. Metabolic quotient and cellulase activity were the most sensitive microbial parameters as their levels were changed 5-1.4 times in comparison to control ones. Changes in soil functional characteristics caused by the treated waste containing mainly radionuclides were not observed. PCR-SSCP (polymerase chain reaction - single strand conformation polymorphism) analysis followed by MDS (metric multidimensional scaling) and clustering analysis revealed that the shifts in microbial community structure were affected by both hydrocarbons and radioactivity. Thus, molecular methods permitted to reveal the effects on soil microbial community not only from hydrocarbons, which significantly altered functional characteristics of soil microbiome, but also from radioactive elements.

http://dx.doi.org/10.5194/bg-12-3681-2015