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Acetate stimulated microbial iron and sulfate reduction and methanogenesis in saturated soil columns affected by dissolution of cement debris

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Construction and Demolition Wastes (CDWs) have become a significant environmental concern due to urbanization and population growth. CDWs are commonly disposed to landfill sites and can generate high pH leachate with various organic and inorganic constituents such as acetate and sulfate, which may affect biogeochemical properties in surrounding environments. Previous studies have mainly focused on changes in geochemical properties and contaminant concentrations. However, the impact of CDW leachate on microbial reactions and communities in subsurface environments remains poorly understood. Here we investigated the continuous impact of CDW leachate on subsurface environments using columns composed of two soil layers: the top layer with cement debris and the bottom layer without cement debris. The columns were fed with artificial groundwater with or without acetate and/or sulfate. The pH of the bottom layer in all columns rapidly increased to 8–10 within 28 days. Fe(III)- and sulfate-reduction did not occur in the columns without acetate. However, in the column with acetate alone, Fe(II) was produced with increase in relative abundance of Fe(III)-reducing bacteria followed by increase in methanogenic archaea, *Methanosarcina*, indicating potential methanogenesis. In the column with both acetate and sulfate, Fe(III) and sulfate were reduced simultaneously along with increase in both Fe(III)- and sulfate-reducing bacteria, and then *Methanosarcina* appeared at the later time. The results demonstrate that microbial Fe(III)- and sulfate-reduction as well as acetoclastic methanogenesis can occur even in soils with high alkaline pH resulting from the dissolution of cement debris. These results provide insights into the relationship between CDW leachate and subsurface microorganisms and emphasize the need for further research to thoroughly understand the impact of various types of CDW leachates on subsurface biogeochemistry.