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Geochemical characteristics and microbial community compositions in groundwater from underground waste storage sites

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The leaking groundwater from underground waste storage sites can pose a complex biogeochemical problem involving redox changes, sorption and precipitation of solutes. This study investigated how microorganisms distributed in groundwaters from the underground waste storage site located in a coastal region and which microorganisms are dominant in each specific geochemical condition. We collected several water samples leaked through the wall at the site and investigated physicochemical characteristics and microbial community compositions via 16S rRNA gene sequencing analysis. Bacterial phyla with high relative abundances in all samples included Proteobacteria (61.3%), Bacteroidetes (10.5%), Firmicutes (6.1%), Chlorobi (3.8%), Actinobacteria (2.5%), and Spirochaetes (2.3%). Site-1 showed the highest electric conductivity ($\sim$9000 μS/cm) with high ion concentrations (Na^{+}: 830 mg/L, Ca^{2+}: 739 mg/L, Cl^{-}: 2803 mg/L, SO_4^{2-}: 460 mg/L) likely due to the seawater intrusion and also indicated relatively high abundance ($>$14.7%) of sulfate-reducing bacteria (SRB)(i.e., *Desulfobacteraceae*, *Desulfuromonas*). Site-3 contained high dissolved Fe (27.5 mg/L) and relatively low pH 6.8. The relatively low pH and high iron level might be linked to the presence of iron-oxidizing bacteria (*Gallionellaceae* 13.8%, *Nitrosomonadaceae* 6.4%) and acidophilic bacteria (*Holophagaceae* 5.1%, *Coxiella* 1.6%) as well as *Magnetospirillum* (1.7%). Rarefaction analysis showed that the diversity of observed species in Site-3 was highest. Site-5 and Site-6 indicated extremely high pH (10.1 and 12.0, respectively) and dissolved alkali metals and contained the genus closely related to *Variovorax* (50.8% and 81%, respectively) which has been discovered in alkaline caves in the previous study. Site-4 and Site-5, both with approximately pH 10, showed several alkaliphilic bacteria such as *Silanimonas* (4.2% and 5.8%, respectively), *Erysipelothrix* (3% and 2.2%, respectively). Interestingly, these alkaliphilic bacteria were not observed in Site-6 in spite of highest pH suggesting that the geochemical conditions in Site-6 are too extreme for those bacteria to survive. Rarefaction analysis also showed that the diversity of observed species in Site-6 was lowest. Our study suggests that microbial communities in the underground waste storage site located in a coastal region are diverse and the community compositions change dramatically depending upon surrounding geochemical conditions, particularly pH and salinity. Long-term monitoring of the site is required to understand how such community development further influences subsurface geochemical properties in and around the site.

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