Geophysical Research Abstracts
Vol. 14, EGU2012-9788, 2012
EGU General Assembly 2012

Geochemical and microbiological assessment of groundwater status: a case study

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The qualitative status of the groundwater resources is drawing increasingly attention in relation to the requirements of the European legislative framework. The monitoring strategies are developed by considering the chemical processes affecting groundwater quality. However, despite the use of biological indicators is a common practice for the qualitative assessment of surface waters, a similar approach is hardly being taken into account by policy makers for ground waters. Aquifers are key environments due to the ecosystem capability to ameliorate water quality, e.g. through the natural biodegradation of chemical contaminants.
The objective of this research was to characterize a porous water table aquifer from a geochemical and microbiological point of view, aiming to link the hydrogeochemical properties to distribution patterns of the free-living microbial communities. The broader perspective is to integrate the role of microorganisms in the groundwater evolution processes, with new insights in the knowledge of the different microbial communities inhabiting different aquifer typologies. Moreover, microbiological parameters that could be used as a valuable indicator of groundwater quality are sought.
A field-scale analysis was performed along the southern Sabatini Mounts aquifer (Central Italy, 50 sampling sites), in an area of about 340 square km, where Pleistocene volcanic products overlay Pleistocene gravel and silt-clay layers, the latter being much more widespread in the downgradient part of the study area. The selected aquifer is contaminated by natural origin elements such as arsenic and fluoride, as well as by human activities, both diffuse (agriculture) and localized, especially in the downgradient part of the aquifer (e.g. landfills, quarries, oil deposits). The main physicochemical parameters of ground waters were determined in situ (redox status, pH, conductivity, T, DO, alkalinity) and in laboratory by ionic chromatography and mass spectrometry (major and trace elements, including arsenic). Total bacterial abundance and vitality (live/dead cell ratio) was determined by combining Flow Cytometry with a double staining fluorescence assay, while the microbial community composition was analyzed through hybridization techniques (CARD-FISH).
The hydrogeochemical characterization defined an arsenic rich, mainly alkaline-earth bicarbonate type, which evolves downgradiently towards a more calcium rich water. The variability of bacterial abundance was nonetheless high and the percentage of dead bacterial cells shows a significant correlation with the arsenic concentration. In addition, differences of the taxa along the flow path were detected with an increasing abundance of Delta-Proteobacteria in the more anoxic sites. Overall, our results highlighted that a multidisciplinary approach, which combines geochemical and microbiological surveys, can describe more appropriately ground water status and the evolution processes in the aquifer.