Geophysical Research Abstracts
Vol. 20, EGU2018-15148-4, 2018
EGU General Assembly 2018

Arsenic, iron, manganese mobilisation in groundwater and microbial communities properties at a landfill facility

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Maximum contaminant levels in groundwater are set in Italy by national acts as threshold values (TV), the exceedance of which in a landfill facility obliges to perform a risk analysis, unless it is proved that the observed levels are of natural origin. At an urban landfill facility located in central Italy, arsenic, iron and manganese concentrations were reported largely above their national TVs. The landfill lies above a Pleistocene thick lacustrine sequence with clay, silt and sandy levels rich in peats and organic matter, with a local groundwater circulation N to S. Reducing conditions enhance the mobilisation of these compounds from the hosting rocks. Our research entailed to address fundamental research questions that remained largely unexplored: is this a natural process or partly enhanced by the landfill activity? To which extent do the redox conditions and geochemistry influence the characteristics of the autochthonous microbial community in groundwater? Can the microbial community properties tell us something on the ongoing processes? How can a multidisciplinary approach allow for a deeper understanding of the active processes?

Four groundwater monitoring campaigns were conducted in 2016-2017 at the site. Field parameters (T, EC, pH, DO, ORP) were measured with probes in a flow through cell, ammonia was measured in the field (UV-VIS). Due to strongly anoxic conditions, groundwater sampling was performed with an in-line device in order to minimize sample disturbance. Lab analysis were performed for major and trace elements, environmental isotopes (d18O, d2H, Tritium, d13C), DOC, IPA, PCB, VOC. Microbial cell counting (flow cytometry), microbial functional diversity (BIOLOG EcoPlates^{TM}) and total coliforms/E.coli were assessed.

Groundwater mostly has an anoxic facies and reducing conditions, less pronounced in the NW side. As, Fe and Mn largely exceed the TVs, broadly following the Eh-DO patterns. IPA were below the detection limits in all monitoring wells while traces of VOCs were found in all the points, with a small exceedance for benzene at one downstream well. Cell abundance ranges between 8E+04 and 2E+07 cells/ml, with the lowest values in the northern wells and the highest one in one well where rain water was supposed to infiltrate during storms. High EC and SO4 also characterize this well. Microbial functional properties follow a spatial distribution, implying a diverse structure of the communities inhabiting different parts of this area. The presence of total coliforms in most of the sites let infer a communication of the aquifer with the surface environment. Moreover, E.coli detection in three of the wells suggested a preferential pathway for contaminants. Environmental isotopes suggest that groundwater is fed by rainfall infiltration processes with long residence time (for the low 3H values), except for the well with benzene above the national bound, where d13C has a less negative value (indicating a different carbon source) and tritium has a slightly higher value (indicating younger waters). As a general remark, the integration of geochemical methods and biomonitoring resulted in a greater depth of interpretation of the data, and seems a very promising tool for the detection of human impacts on groundwater.