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Evaluating the impact of landfill morphology on the groundwater contamination potential – Implications from direct measurements of leachates migration in the waste and unsaturated zone

Imri Aharoni, Hagar Siebner, and Ofer Dahan

Ben Gurion University of the Negev, Blaustein Institutes for Desert Research, hydrology and water, Midreshet Ben-Gurion, Israel (imri.aharoni@gmail.com)

Evaluating the contamination potential of old inactive municipal landfills and the selection of adequate restoration strategy requires proper characterization of leachates generation and migration of the contaminants. In this study we monitor the pollution potential of various landfills with respect to their morphology and climatic conditions. The study also characterize the major biochemical processes that affect the chemical composition of leachates percolating in the vadose zone towards the ground water.

The research setup includes application of advanced vadose zone monitoring systems (VMS) that enables continuous water content measurement, and collection of leachates samples, from the entire waste body and underlying unsaturated zone. Leachates samples and groundwater samples from boreholes located at the edge of the landfills were analyzed for detailed characterization of its chemical composition.

Throughout the study we compare the hydraulic and chemical characteristics of leachates migration in two typical landfills morphologies - “heap” type, in which the waste was piled on the flat land surface and creates a topographic mount rising above the ground, and “quarry” type landfill, where the waste was dumped and filled open mining pits without significant change in the topographic elevation.

Wetting front propagation analysis shows that in the quarry type landfill, wetting fronts cross the waste body and reaches the deepest sections of the vadose zone fast and constantly as result of winter precipitation. In the “heap” type landfill, no significant wetting front was observed inside the waste body, while stronger fluxes were recorded below the edge of the landfill; possibly because the rainwater is diverted as runoff to the edge on the heap, instead of infiltrating to the waste body.

The chemical analysis shows that contaminated leachates with high organic and nitrogen load were created and accumulated in the waste body, in both types of landfills. In accordance with water propagation, high contaminants concentration were measured in the deepest section of the vadose zone in the quarry type landfill; indicating active fluxes of leachates reaching all the way to groundwater. Evidence for such pollution potential was not recorded in the heap type landfill, where most of the percolation takes place on the edges.

As the leachates reach the underlying ground water they undergo a significant transformation. Contaminants concentration reduced by order of magnitude, possibly as a result of mixing and dilution. However, anaerobic conditions below the waste body, persist, so dissolved organic matter (DOC), ammonium and heavy metals concentrations, remain high. At the edge of the landfill, oxidizing conditions of the surrounding ground water lead to the decomposition of organic matter, oxidation of ammonium to nitrate as well as significant attenuation of metals.

In order to characterize the risk, implied by high levels of nitrogen in the leachates; we are studying now the changes in nitrogen speciation and isotopic composition throughout the profile.