Geophysical Research Abstracts
Vol. 18, EGU2016-4875, 2016
EGU General Assembly 2016

Application of Vadose Zone Monitoring Technology for Characterization of Leachate Generation in Landfills

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Ground water contamination due to landfill leachate percolation is considered the most severe environmental threat related to municipal solid waste landfills. Natural waste degradation processes in landfills normally produce contaminated leachates up to decades after the waste has been buried. Studies have shown that understanding the mechanisms which govern attenuation processes and the fate of pollutants in the waste and in the underlying unsaturated zone is crucial for evaluation of environmental risks and selection of a restoration strategy.
This work focuses on a closed landfill in the coastal plain of Israel that was active until 2002 without any lining infrastructure. A vadose zone monitoring system (VMS) that was implemented at the site enables continuous measurements across the waste body (15 m thick) and underlying sandy vadose zone (16 m thick). Data collected by the VMS included continuous measurements of water content as well as chemical composition of the leachates across the entire waste and vadose zone cross section. Results indicated that winter rain percolated through the waste, generating wetting waves which were observed across the waste and unsaturated sediment from land surface until groundwater at 31 m bls. Quick percolation and high fluxes were observed in spite of the clay cover that was implemented at the site as part of the rehabilitation scheme. The results show that the flow pattern is controlled by a preferential mechanism within the waste body. Specific sections showed rapid fluxes in response to rain events, while other sections remained unaffected. In the underlying sandy vadose zone the flow pattern exhibited characteristics of matrix flow. Yet, some sections received higher fluxes due to the uneven discharge of leachates from the overlying waste body.
Water samples collected from the waste layer indicate production of highly polluted leachates over 14 years after the landfill was closed. The chemical composition within the waste body shows extreme variability between sampling ports with respect to DOC (407-31,464 mg/L), BOD/COD ratios (0.07-0.55), Fe2+ (6.8-1154 mg/L), NH4+ (68-2924 mg/L) and heavy metal concentrations. The results show for the first time the magnitude of heterogeneity inside a single landfill unit. Waste degradation hot-spots creating concentrated aggressive ‘acid phase’ leachates exist only 2m away from a ‘stable methanogenic’ environment which create basic and less polluted leachates. In the underlying vadose zone, contaminant concentrations decrease significantly especially with respect to organic matter and metals. The results suggest that biogeochemical attenuation processes are taking place in the deep unsaturated zone, changing the chemical characteristics of the solute before reaching the groundwater. On the other hand, the chemical composition is highly affected by the distribution of fluxes coming from the above waste layer.