Geophysical Research Abstracts
Vol. 18, EGU2016-7095, 2016
EGU General Assembly 2016

Flow and transport within a coastal aquifer adjacent to a stratified water body

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The existence of a freshwater-saltwater interface and the circulation flow of saltwater beneath the interface is a well-known phenomenon found at coastal aquifers. This flow is a natural phenomenon that occurs due to density differences between fresh groundwater and the saltwater body. The goals of this research are to use analytical, numerical, and physical models in order to examine the configuration of the freshwater-saltwater interface and the density-driven flow patterns within a coastal aquifer adjacent to long-term stratified saltwater bodies (e.g. meromictic lake). Such hydrological systems are unique, as they consist of three different water types: the regional fresh groundwater, and low and high salinity brines forming the upper and lower water layers of the stratified water body, respectively. This research also aims to examine the influence of such stratification on hydrogeological processes within the coastal aquifer. The coastal aquifer adjacent to the Dead Sea, under its possible future meromictic conditions, serves as an ideal example to examine these processes.

The results show that adjacent to a stratified saltwater body three interfaces between three different water bodies are formed, and that a complex flow system, controlled by the density differences, is created, where three circulation cells are developed. These results are significantly different from the classic circulation cell that is found adjacent to non-stratified water bodies (lakes or oceans). In order to obtain a more generalized insight into the groundwater behavior adjacent to a stratified water body, we used the numerical model to perform sensitivity analysis. The hydrological system was found be sensitive to three dimensionless parameters: dimensionless density (i.e. the relative density of the three water bodies'); dimensionless thickness (i.e. the ratio between the relative thickness of the upper layer and the whole thickness of the lake); and dimensionless flux. The results also show that this configuration of three interfaces and three circulation cells, which is expected to develop adjacent to the stratified Dead Sea, is expected to decrease the dissolution rates of salt layer that is located within the adjacent aquifer, by one order of magnitude in comparison to the dissolution rates today. Therefore, the processes of salt dissolution and sinkhole formation adjacent to the Dead Sea will be relatively restrained.