Geophysical Research Abstracts
Vol. 14, EGU2012-11369-2, 2012
EGU General Assembly 2012

Groundwater investigations in the Okavango Delta, Botswana, using electric and electromagnetic techniques

P. Meier (1), J. E. Podgorski (1), A. Green (1), T. Kalscheuer (1), S. Greenhalgh (1), L. Rabenstein (1), G. Tshoso (2), B. C. Jaba (2), W. Kinzelbach (3), and N. Foged (4)

(1) Institute of Geophysics, ETH Zurich, Zurich, Switzerland (meierphi@ethz.ch), (2) Botswana Department of Geological Survey, Lobatse, Botswana, (3) Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland, (4) Hydrogeophysics Group, Aarhus University, Aarhus, Denmark

The Okavango Delta, one of the world's largest inland deltas, lies in the semi-arid Kalahari Desert of northwestern Botswana. Most of the surface water inflow and local rain is evaporated, with only a small percentage being discharged downstream. About 1/3 of the evaporation is due to transpiration of groundwater by trees on islands. This leads to salt accumulation in the shallow groundwater. Eventually, the denser water sinks to the deeper saline aquifer by fingering. Mapping the subsurface salinity distribution is important to understand the fate of dissolved salts imported into the delta. This can be effectively done using electrical resistivity tomography (ERT) and electromagnetic (EM) measurements. Airborne transient EM (TEM) surveys have delineated a resistive fresh water layer overlying a broad conductive salt water and/or clay layer, which sits on another resistive layer. The basal resistive layer was interpreted as bedrock or a fresh water aquifer, covered by clay which prevents the salt water from further downward movement. To improve model resolution, 2-D ERT and TEM surveys were conducted at two selected locations: HR2 on the western border and Jedibe Island in the heart of the delta. ERT was performed using 96 electrodes at 5 m spacing, with additional current electrodes at either end of the line for increased depth penetration. The TEM soundings used square transmitter loops of size 40 m or 100 m, responses were recorded on two in-loop receiver channels.

At HR2, two TEM lines and one ERT line were recorded. Inversions of the TEM data were performed individually (single site 1-D models) and laterally constrained (LCI) to form quasi 2-D models. The layering sequence is resistive (>50 Ωm) - conductive (<15 Ωm) - resistive (>20 Ωm). Depth to the conductive and the bottom resistive layer is ∼20 m and ∼140 m, respectively. ERT smooth inversion yields greater lateral heterogeneity in the shallow subsurface. The same layering pattern as for the TEM is observed, but with better resolution at shallow depth. The quasi 2-D joint ERT/TEM inversion approach of laterally and mutually constrained inversion (LCI/MCI) was applied to the coincident datasets. Careful data editing was required. The final models combine the benefits of both methods.

At Jedibe, two TEM and two ERT lines were recorded, but one ERT line was discarded due to poor coupling. Individual TEM inversions indicate strong lateral heterogeneity. Some soundings could not be interpreted with a 1-D model. However, the TEM LCI models show a predominantly "layercake" structure: resistive (>15 Ωm) - conductive (<15 Ωm) - resistive (>20 Ωm), with the top layer only 2 m thick. Depth to the bottom layer is well resolved at ∼50 m, whereas its resistivity is not resolved. ERT smooth inversion cannot resolve the top resistive layer. LCI/MCI results are considered more reliable than those obtained at HR2. The conductive layer may be an example of density driven flow removing salt from the surface fresh water regime.

Resistivities are consistent with the airborne EM results but layer boundaries are generally 10 - 20% shallower.