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GEOZENTRUM HANNOVER

Influence of geological heterogeneity on the saltwater freshwater interface position in coastal aquifers – physical experiments and numerical modeling

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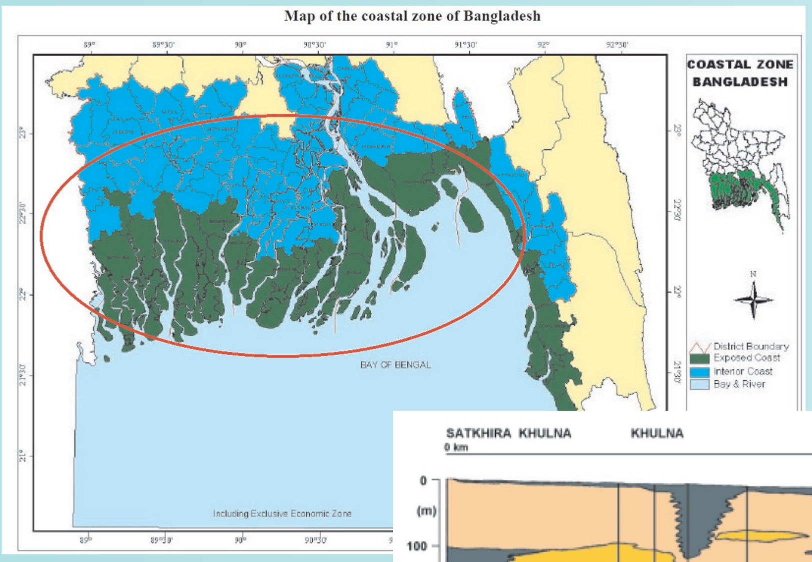
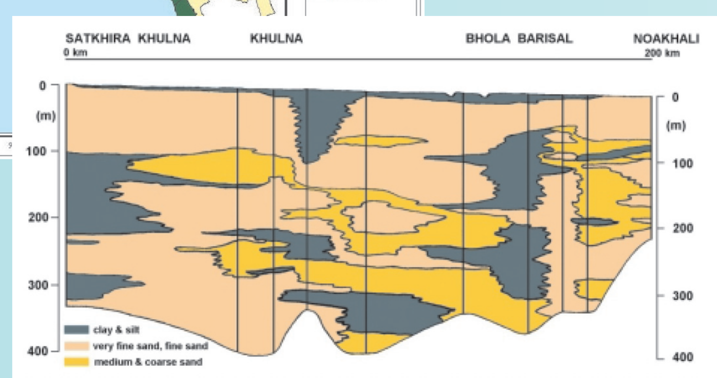
Freshwater Lens Investigations FLIN

Example: Coastal zone of Bangladesh

- Highly heterogeneous geological formation (delta)
- Coastal groundwater is under serious threat of saline water intrusion
- Projected sea level rise of 30-50 cm by the year 2050



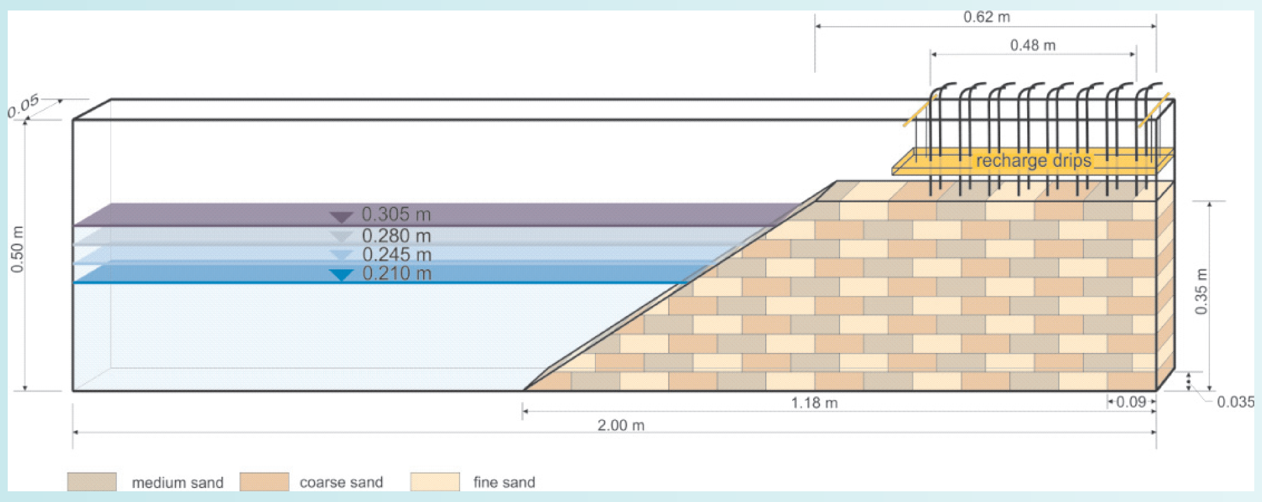
Source: Ahmad, 2003



Lithological cross section of coastal area (Source: Aggarwall et. al. 2000)

Objectives

- Influence of different length scales in geological heterogeneity on the saltwater - freshwater interface position
- Effects of sea level rise on saltwater intrusion in heterogeneous porous aquifers

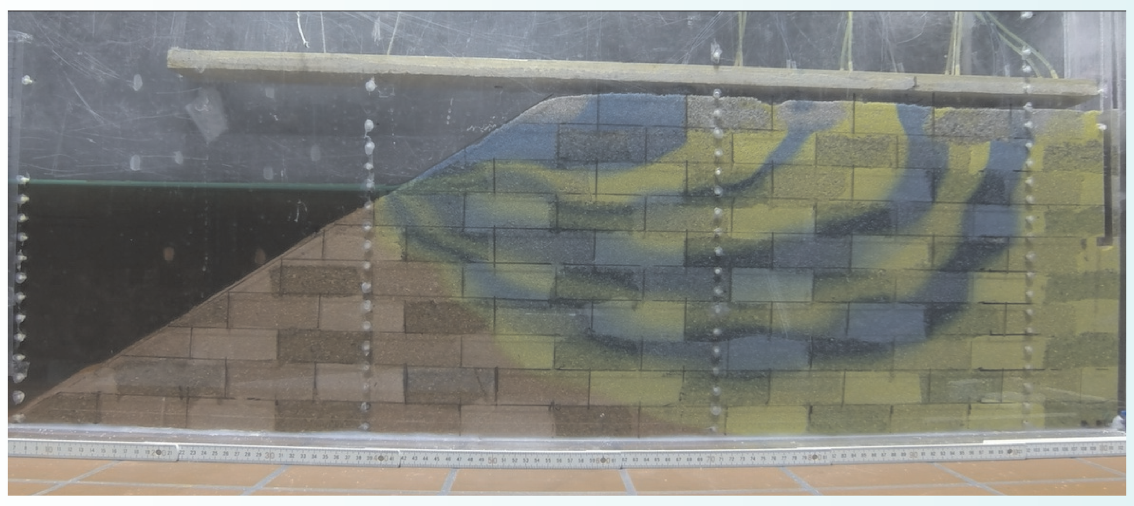


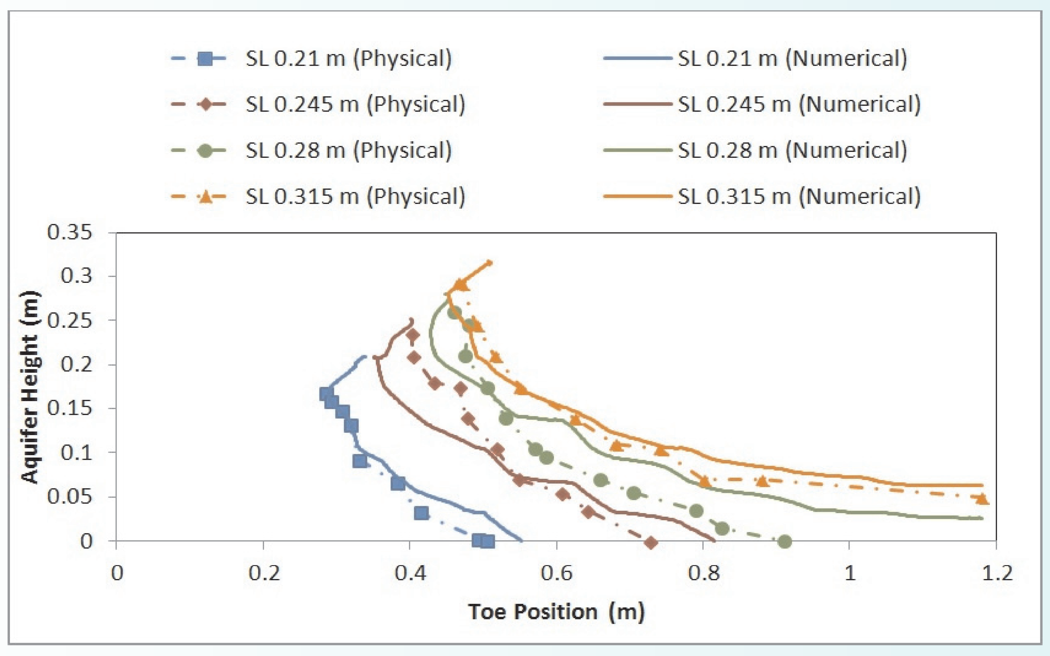
Schematic diagram of the model setup

Experimental Set-up

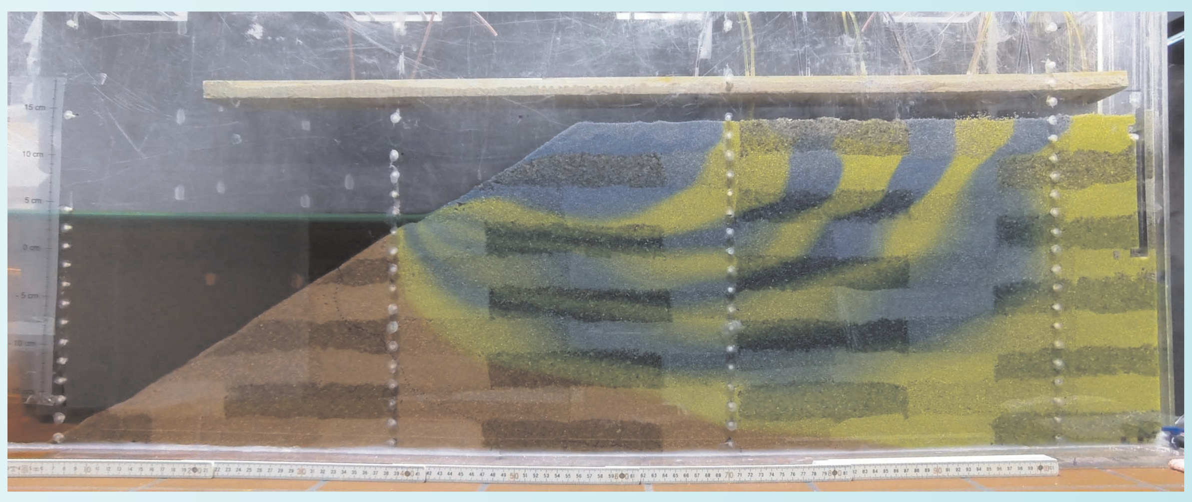
- Trapezoidal shaped aquifer: bottom length 1.18 m, top length 0.62 m, height 0.35 m
- Freshwater recharge rate of 1.8 $l \cdot h^{-1}$
- Different tracer dyes (Indigotine-blue, Uranine-yellow and Eosine-red) for visualization (concentration 0.3 $g \cdot l^{-1}$)
- Three different sands with different hydraulic conductivities: fine (165 $m \cdot d^{-1}$), medium (355 $m \cdot d^{-1}$) and coarse (1229 $m \cdot d^{-1}$)
- Identical compartment height (3.5 cm) but variable compartment lenght (9 cm, 18 cm, 27 cm)
- Four seawater levels of 0.210 m, 0.245 m and 0.280 m and 0.315 m

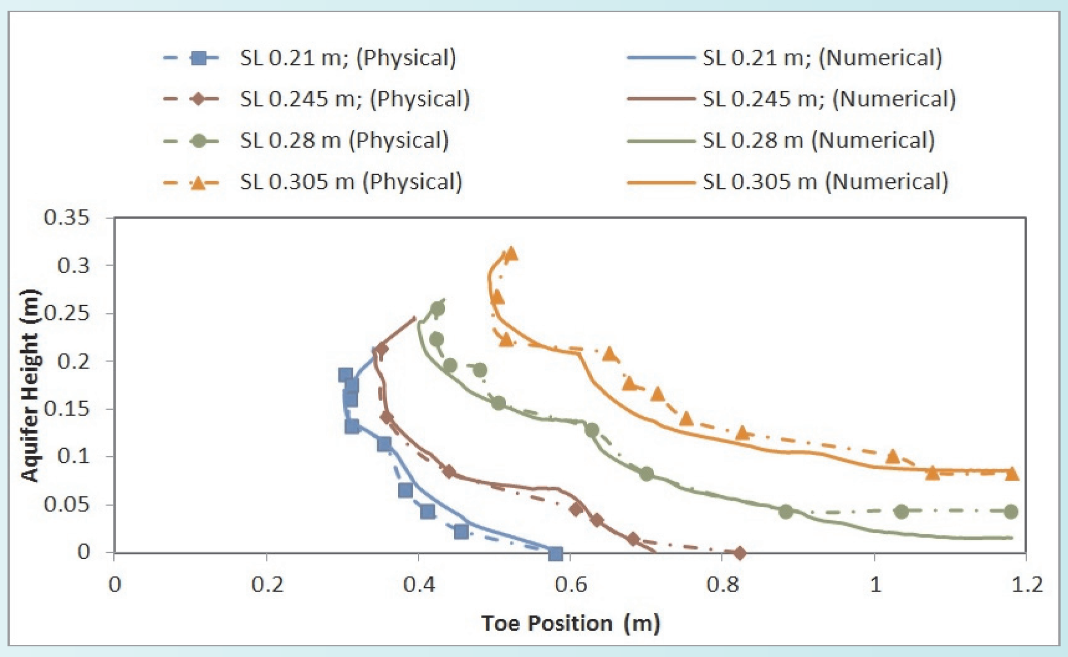
Compartment length 9 cm



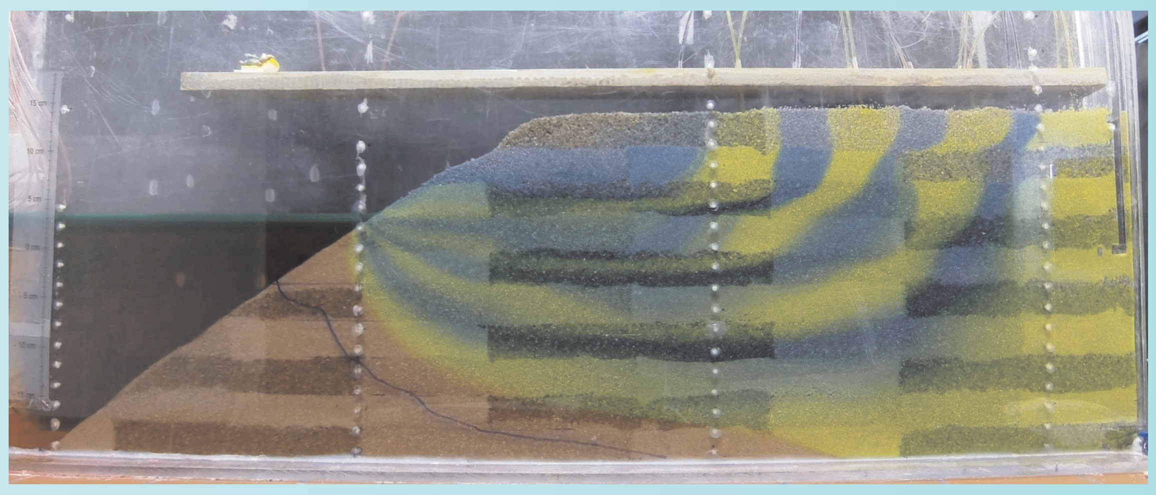


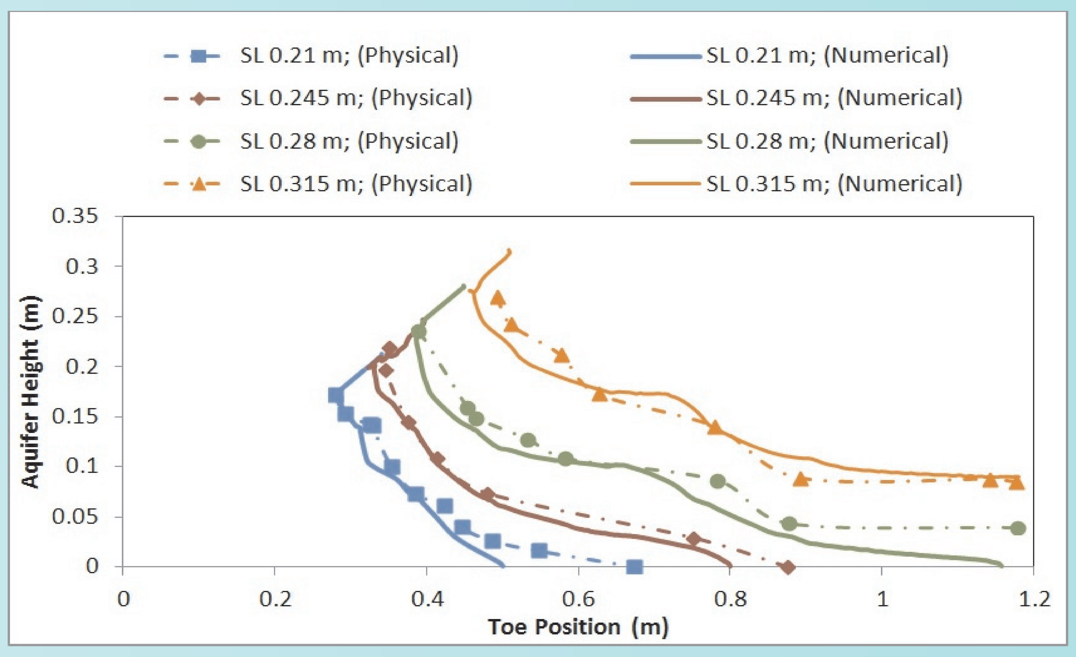
Compartment length 18 cm





Compartment length 27 cm



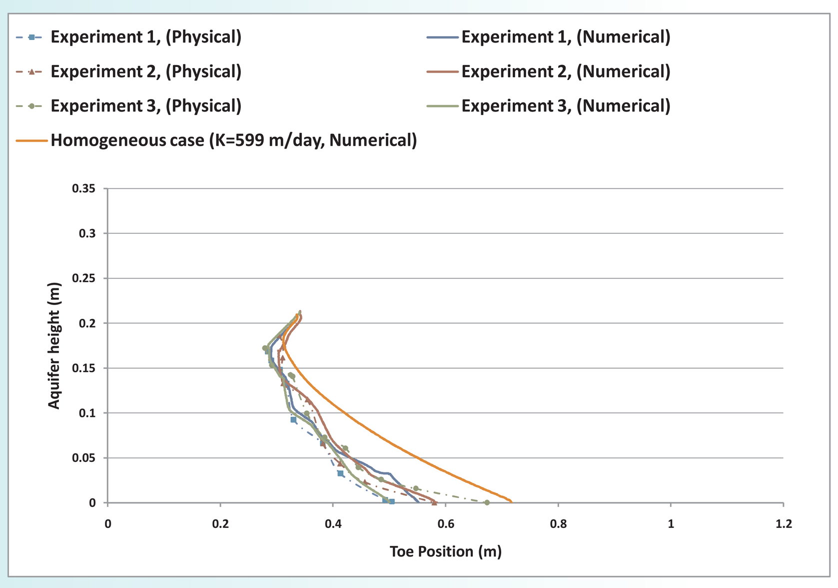


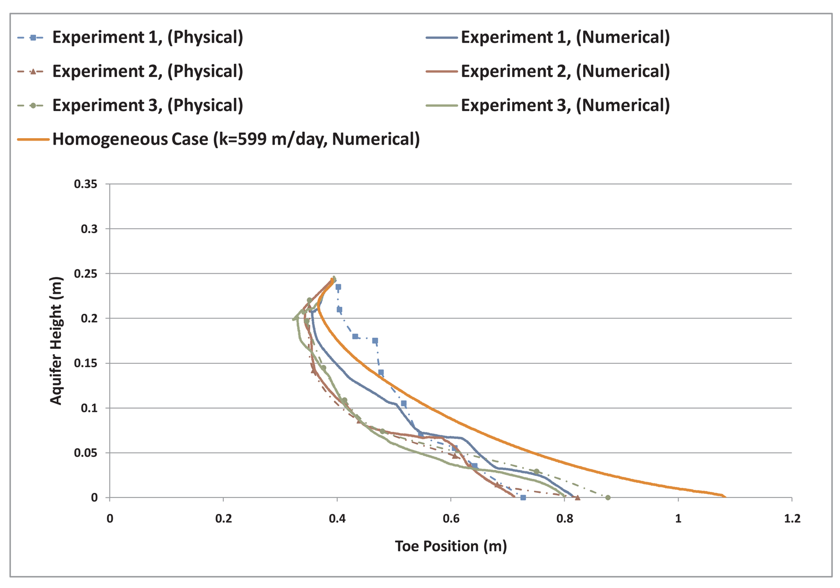
Numerical modeling

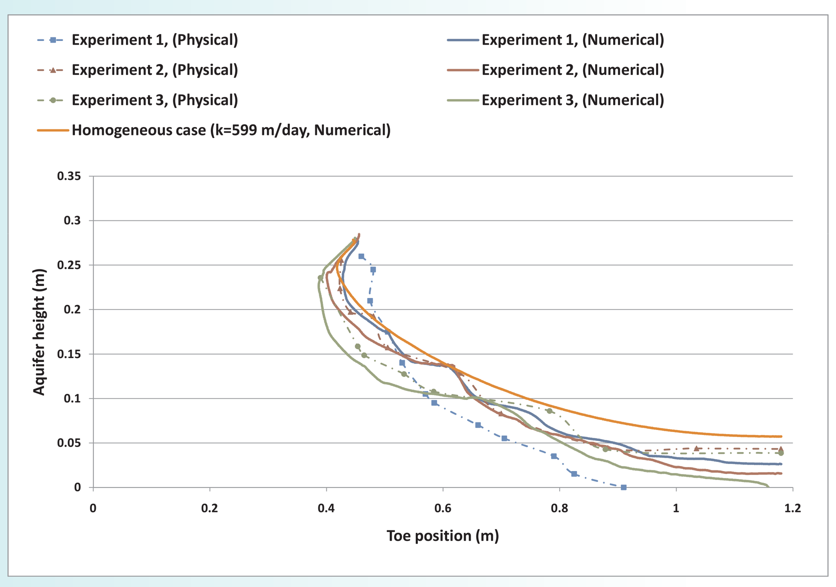
- FEFLOW 6.1 used for numerical simulations
- Variable density (and unsaturated) flow and mass transport model
- Homogeneous equivalent modeled for comparison

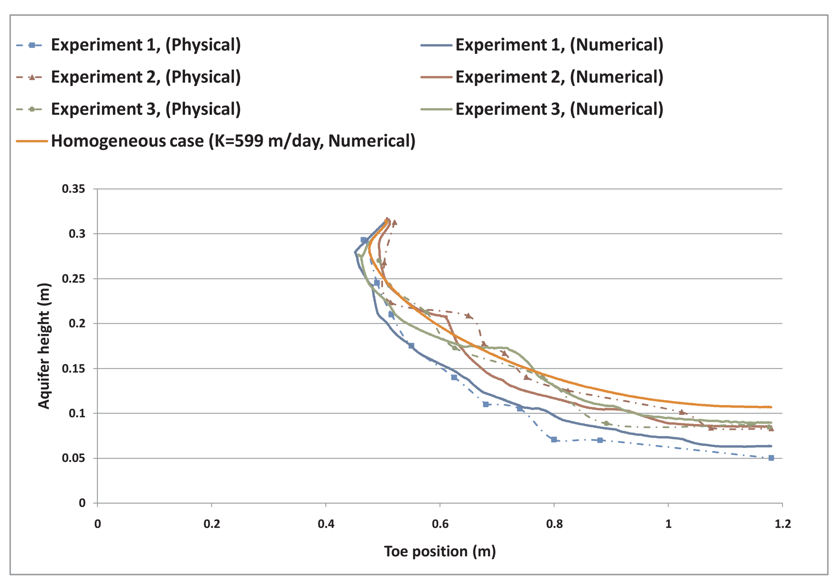
Sand Type	Hydraulic Conductivity (m/day)	Porosity	Longitudinal dispersivity (m)	Transverse dispersivity (m)	Van Genuchten Parameter	
					α	n
Coarse	1229	0.41	0.01	0.001	30	3
Medium	355	0.45	0.005	0.0005	25	2.5
Fine	165	0.47	0.001	0.0001	20	2

Sea level variation









Conclusions

- Physical models and numerical simulations of interface geometry show good fit for all sea level studied
- With greater compartment lenght, salt water intrusion reaches further inland
- Homogeneos equivalent generally shows further sea water intrusion and might therefore be used as first estimation (when pumping is not included)

References

Aggarwal, P.K., Basu, A.R., Poreda, R.J., Kulkarni, K.M., Froehlich, K., Tarafdar, S.A., Ali, M., Ahmed,N., Hussain, A., Rahman, M., Ahmed, S.R., 2000. Isotope Hydrology of Groundwater in Bangladesh: Implications for Characterization and Mitigation of Arsenic in Groundwater. IAEA-TC Project: BGD/8/016.
Ahmad, M., 2003. Coastal Livelihoods an introductory analysis. Program Development Office for Integrated Coastal Zone Management Plan (PDO-ICZMP): WP015.

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