EGU2020-4073, updated on 15 Jun 2020
https://doi.org/10.5194/egusphere-egu2020-4073
EGU General Assembly 2020


# Prediction of seawater intrusion to coastal aquifers based on non-dimensional diagrams

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A numerical analysis of the groundwater flow and contaminant transport equations, based on the variable density flow approach, is used for the construction of non-dimensional diagrams to predict seawater intrusion to confined coastal aquifers. The classical Henry's seawater intrusion problem is analysed by using a finite element model. The model's equations are written in non-dimensional form and the numerical solutions depend solely on three non-dimensional parameters:

$\alpha=q'/K^0$, $\beta=(bK^0)/(nD_m)$, $\alpha'=bS^0/n$ (eq. 1 a,b,c)

where q' is the freshwater recharge rate (m/d), $K^0$ the freshwater hydraulic conductivity (m/d), b the aquifer thickness, n the porosity (-), $D_m$ the molecular diffusion coefficient ($m^2$/d) and $S^0$ the freshwater specific storage (1/m). Please note that hydraulic conductivity appears in two of the non-dimensional parameters, α and β.

The non-dimensional formulation has led to the construction of non-dimensional diagrams of salt distribution for a homogeneous and isotropic confined aquifer with horizontal base and constant thickness that is uniformly recharged with freshwater. These diagrams illustrate the influence of the key hydrological and hydraulic parameters, and furthermore, can be used to predict the evolution of seawater intrusion in real case studies.

The numerical simulations were carried out up to the equilibrium state for different values of the non-dimensional parameters of equation 1. By decreasing the value of parameter $\alpha=q'/K^0$, seawater intrusion is advancing inland and the width of dispersion zone is increasing. By increasing the parameter $\beta=(bK^0)/(nD_m)$, the seawater-freshwater transition zone is narrowing and shifted to the seaside at the upper part of the aquifer, while the intrusion of saltwater is advancing inland at the lower part of the aquifer. The distribution of the salts in the aquifer was found essentially identical for different values of the parameter $\alpha'=bS^0/n$; hence this parameter exhibits very low sensitivity, which makes it of low importance, especially for real case studies.

Overall, the non-dimensional diagrams – constructed by following the variable density flow approach and under specific assumptions – can be used for a quick and direct prediction of

seawater intrusion in real aquifers. These diagrams would be useful for an initial prediction at the case studies of the PRIMA MEDSAL project (www.medsal.net), namely the coastal aquifers in Rhodope (Greece), Samos island (Greece), Bouficha (Tunisia), Bouteldja (Algeria), Tarsus (Turkey) and under specific assumptions to the karstic aquifer in Salento (Italy).