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Modeling of Physical and Geochemical Behaviors of Saltwater in a Coastal Aquifer

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Saltwater intrusion into a coastal aquifer is a traditional but still important subject for the hydro-geologists and civil engineers even at present time. Contamination of salt is a trouble for various freshwater uses. Therefore, much attention has been put on the movement and potential contamination of saltwater in pumped water. In general, saltwater intrusion is a complicated process. If the geochemical or geophysical study is solely carried out, the consistent and accurate conclusion will be hardly obtained due to the complicated and limited information on the aquifer properties. In order to get a confident conclusion that can be agreed by the researchers in various fields, an interdisciplinary approach anticipating both hydrological and geochemical processes is indispensable. The present paper develops the numerical model to predict the change in the saltwater quality as shown in Table 1. The numerical simulation includes the transport of multi-chemical species, and the processes such as bacteria growth, oxygen consumption, denitrification, reduction of manganese and iron, when saltwater is infiltrated into the column packed with alluvial soil. The change in the major cation and dissolved oxygen in a steady state are measured. The entity species are Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, S-Mn^{2+}, S-Fe^{2+}, DO, Cl^{-}, NO_3^{-}, TOC, and etc. Besides, the set of the equations describing the growth of aerobic and anaerobic bacteria that consumes both DO and nitrate is simulated. The growth of anaerobic bacteria groups which reduce oxidized manganese and iron hydroxide are also simultaneously calculated. The numerical simulation shows a reasonable agreement with the column experiment. It is expected that the present model is applicable for the two- or three-dimensional simulations for the change in the saltwater geochemistry as well as saltwater intrusion in a coastal aquifer.

Table 1 Measured and calculated concentration for the infiltrated seawater

Measured species	Analyzed values (after 60 days of infiltration)		Calculated effluent saltwater concentration[3]
	Infiltrated saltwater concentration[1]	Effluent saltwater concentration[2]	
DO[mg/l]*	0.200	0.016	0.121
Ca^{2+}[meq/l]*	21.059	20.260	20.257
Mg^{2+}[meq/l]*	98.745	106.970	106.956
Na^{+}[meq/l]*	487.170	482.820	482.811
K^{+}[meq/l]*	12.328	11.586	11.586
S-Mn[meq/l]*	0.000	0.011	0.196
T-Mn[meq/l]	0.000	0.013	
S-Fe[meq/l]*	0.005	0.027	0.651
T-Fe[meq/l]	0.426	0.423	
Cl[meq/l]*	552.850	507.720	507.720
NO_3-N[meq/l]*	0.004	0.001	0.001
S-TOC[meq/l]*4	0.056	0.333	0.008

1. Saltwater is taken from the sea and is infiltrated from the top of the column.
2. Outflow from the column with 30cm length. Concentration is measured after 60 days of infiltration in a steady state condition where cation exchange is already over.
3. Numerical solution for entity species denoted by the asterisks of the left row.
4. S-TOC denotes total organic carbon as CH2O.

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