Geophysical Research Abstracts
Vol. 15, EGU2013-6901, 2013
EGU General Assembly 2013
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The effect of seawater intrusion and freshening of coastal aquifers on trace elements and nutrient characteristics as deduced from column experiments and field sampling

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The purpose of this study was to understand the geochemical effects of seawater intrusion and freshening events on the fresh-saline water interface (FSI) on trace elements and nutrient characteristics. In addition to field sampling, column experiments were conducted to simulate salinization and freshening under aerobic and anaerobic conditions. Wide range of geochemical parameters of the water were analyzed as major ions, trace elements (including Mn^{2+}, Ba^{2+}, Li^{+}), the nutrients as NO_3^-, NO_2^- and NH_4^+ (dissolved inorganic nitrogen (DIN)) andstable nitrogen isotopes ratio of DIN species ($\delta^{15}N$).

The results of the column experiments indicate that cation exchange is the main process affecting Mn^{2+}, Ba^{2+} and Li^{+}. Mn^{2+} and Ba^{2+} behavior is similar to that of $Ca^{2+}$and Sr^{2+}, whereas Li^{+} behaves as K^{+}. In addition, during salinization under anaerobic conditions, NH_4^+concentration increased by more than order of magnitude due to cation exchange. $NO_3^-$and NO_2^-seem conservative during aerobic experiments, while during anaerobic experiments, $NO_3^-$was depleted and $NO_2^-$was enriched due to denitrification. This was indicated by the $\delta^{15}N$, as well. During the aerobic experiments, $\delta^{15}N$ values are similar to that expected from mixing between the fresh water and seawater, whereas during the anaerobic experiments, the $\delta^{15}N$ values are enriched.

The field results show that the $Mn^{2+}$and Ba^{2+} were high in the FSI, higher than by mixing between fresh water and seawater only. On the other hand, Li^{+} was depleted in the FSI, with decreasing concentrations further inland. These results indicate that the Mn^{2+}, Ba^{2+} and Li^{+} could be used as indicator for seawater intrusions events.

The FSI acts as a redoxcline. The oxidized fresh groundwater zone is characterized by relatively high NO_3^- and low NH_4^+ and NO_2^- concentrations, while the saline groundwater is almost anoxic with high NH_4^+ and low NO_3^- and NO_2^-. Within the FSI NO_2^- was enriched, which indicated that biogeochemical process occurred. However, the $NO_2^-$and NH_4^+concentration did not reached high concentration as was found during the experiments. Moreover, the depleted $\delta^{15}N$ in the FSI indicates that nitrification was occurred. Nitrification is a biogeochemical process occurring under aerobic condition and therefore indicating that the FSI is controlled mostly by aerobic conditions, even though anaerobic conditions exist in the FSI and affect the DIN species.