

The Variations of Hydrogeochemistry of the Shallow Aquifer in Karhinkangas Esker, Finland

Background

Water quality of the shallow permeable aquifers in Finland is vulnerable to change due to the effects of the natural factor such as groundwater recharge and human activities such as pumping rate or the existing of contamination in the aquifer areas. There is an urgent need to understand the geochemical evolution processes and the movement of the solutes in the groundwater flow system under the different factors and processes from both natural and anthropogenic sources that control groundwater quality.

Aims of the study

The study aimed to investigate and to gain a better understanding of the factor controlling the chemical composition of groundwater and groundwater evolution under the different recharge and pumping rates in the case study area of the shallow sand and gravel aquifer in the Karhinkangas esker, southern part of central Finland. This will provide the basis information for the future geochemical modelling studies in the study area.

Methods

The methods used consist of the integration of the conventional geochemical analysis, the multivariate statistical analysis (hierarchical cluster analysis (HCA) and principal component analysis (PCA)) and the 1D geochemical PHREEQC model, based on the hydrogeochemistry, stable isotopes $\delta^2\text{H}$ and $\delta^{18}\text{O}$ of water samples, the pumping rates and field monitoring data during 2011-2013.

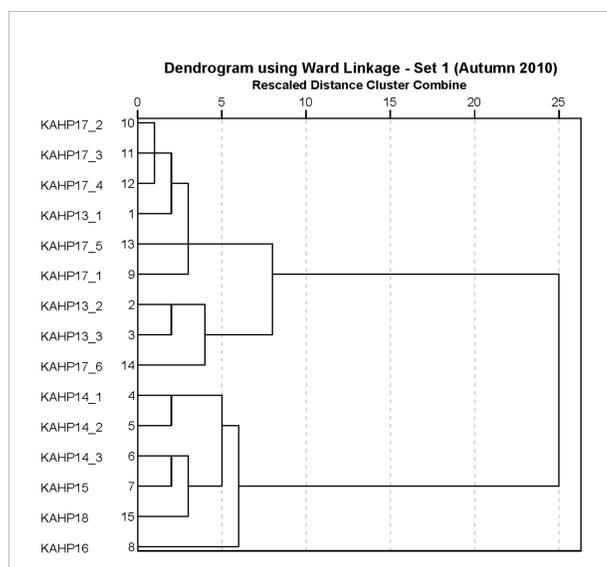


Figure 4. Hierarchical clustering results (dendrogram) of water samples ($n = 15$) taken during autumn 2010.

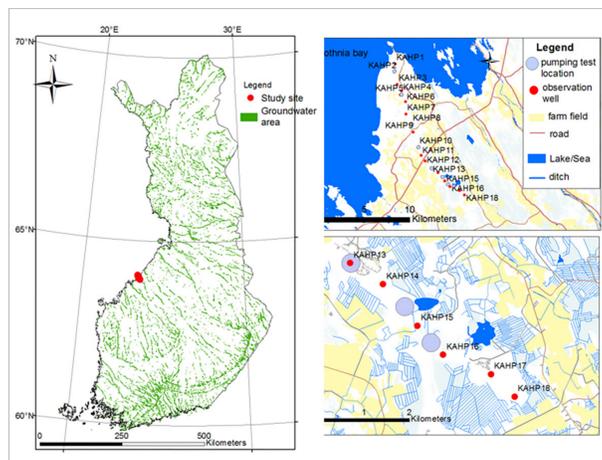


Figure 1. Location map of the study area.

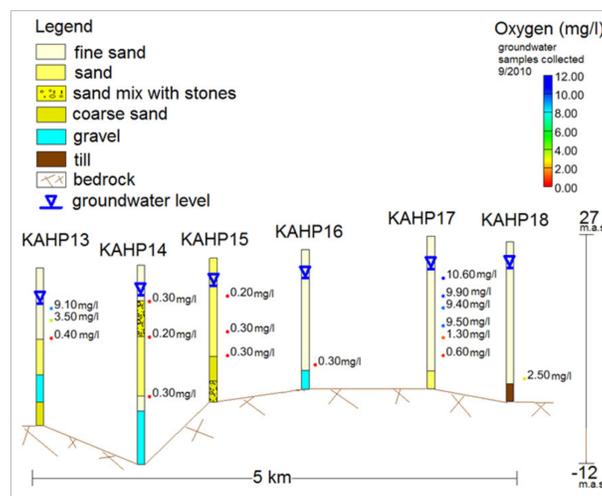


Figure 2. Depth profile of dissolved oxygen (O_2) in the well screen section of observation wells in the study area during autumn 2010.

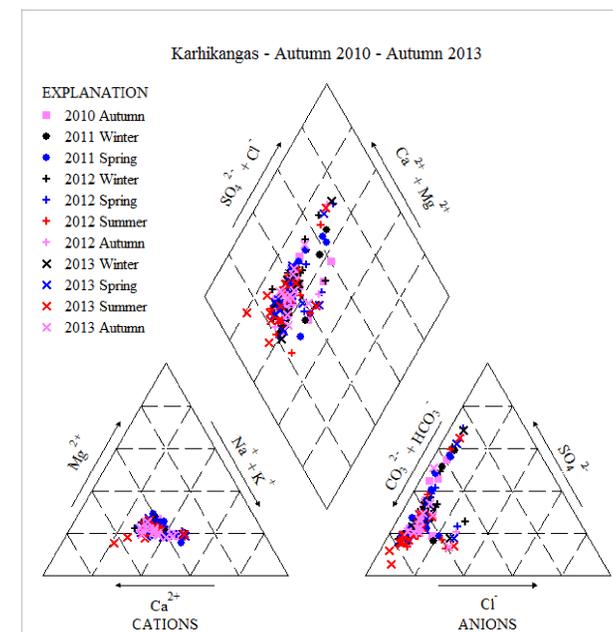


Figure 3. Piper diagrams showing proportional concentrations of major ions of groundwater samples in the study area. The composition of groundwater in Karhinkangas is mainly of the Ca-HCO_3 type.

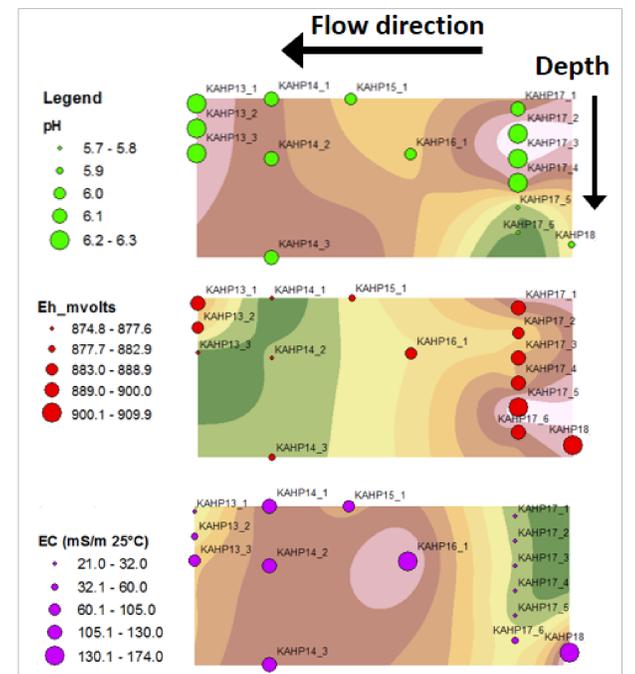


Figure 5. Depth profile of parameters: pH, redox potential (E_h) and electrical conductivity (EC) in the well screen section of the observation wells during autumn 2010.

The main findings

The major aqueous species is the free ions and varies spatially both in horizontal and vertical directions. The Iron (II) hydroxide ($\text{Fe}(\text{OH})_2$) and sulphate (SO_4^{2-}) species are the most abundant for samples and those are sensitive to change in pH and oxidation-reduction potential. The saturation index of the iron and sulphide species are in supersaturated phase ($\text{SI} > 0$), which suggested that those species may precipitate and co-precipitate with the other species. The effects of different redox states from the mixed groundwater as the results of pumping on hydrogeochemistry processes such as dissolution and sorption/desorption are of interest for further study.

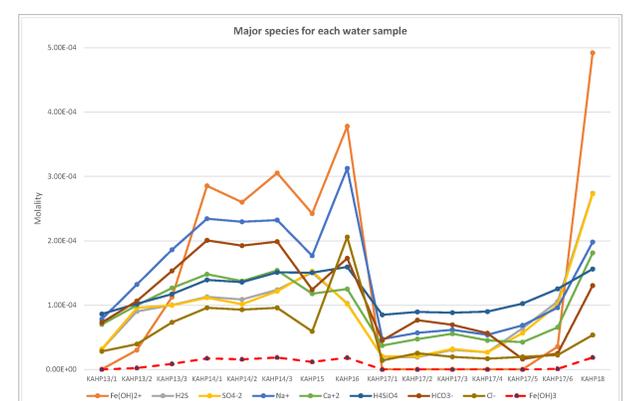


Figure 6. The molarity of major species (greater than $1.0\text{E}-06$) for each water sample during autumn 2010.

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