Trace element concentrations of groundwater from public supply well fields, and their relation with marine sedimentary environments of the aquifer and postdepositional salinity changes

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ABSTRACT

Various public supply well fields (PSWFs) in the Netherlands pump groundwater with elevated concentrations of trace elements, notably Al, As, B, Ba, Be, Br, Cd, Co, Cu, F, I, Li, Mo, Ni, Rb, Sn, Sr, U, V, W, Zn and lanthanides, some of which are close to or exceeding drinking water standards.

In this contribution a protocol is presented how to diagnose the causes of these elevated trace element concentrations, by recognizing element associations (including trace elements, main constituents and selected isotopes) that indicate specific inputs or processes. The causes are subdivided into (a) anthropogenic exogenic (resulting from atmospheric inputs or from activities at land surface); (b) anthropogenic endogenic (resulting from anthropogenic activities that trigger specific water – sediment interactions (like pyrite oxidation by declining groundwater tables); (c) related to corrosion of well materials; and (d) natural.

Our main focus is, however, on identifying unusual natural backgrounds in groundwater from PSWFs associated with particular palaeohydrological settings (like a marine depositional environment of the pumped aquifer and postdepositional marine transgressions and regressions), or with (sub)recent fresh or salt water intrusion due to pumping.

To that purpose, all active PSWFs (241; including separate well groups pumping from deeper aquifers) were sampled during a national sampling campaign in the first trimester of 2008. The samples were analyzed on main constituents, 55 trace elements and 2-5 isotopes. All PSWFs were hydrologically classified into 5 hydrological groups (phreatic sand and gravel, (semi)confined sand and gravel, limestone, phreatic sand with artificial recharge, phreatic or (semi)confined sand with river bank filtration), and into 14 hydrochemical facies (young, intermediate, old; (sub)oxic, anoxic, deep anoxic, mixed; very low, low, intermediate and high alkalinity; positive, negative or zero base exchange). In addition, well fields were classified on the basis of Cl trends in the period 1898-2008, as salinizing, freshening or stable. And finally, the pumped aquifers were geologically classified into the following groups: continental Pleistocene, continental Tertiary, marine Pleistocene, marine Tertiary and marine Cretaceous.

This way, anomalous natural backgrounds of trace elements, in association with marine conditions, were clearly observed and explained for As, B, Br, F, I, Li, Rb and Sr.

This study illustrates the importance of identifying natural marine sources of trace elements in groundwater, in order to exclude potential pollution sources and expensive site investigations. This is considered of general interest to inventories required by the European Water Framework Directive. It also shows that many other trace elements normally are not associated with marine sedimentary environments or postdepositional salinity changes, and thus may necessitate further research on potential anthropogenic sources.