Characterization of selenium behaviour in groundwater of the Chalk aquifer in Northern France: origin and fate

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Groundwater in a small area of 60 km2 located south of Lille, Northern part of France, is under quantitative and qualitative pressure from industrial, urban and agriculture origins. Four wellfields are exploited the Chalk aquifer water. Groundwater quality is quite poor regarding nitrate, nickel and selenium elements. Selenium concentrations are often higher than French and European standards (10 $\mu g.l^{-1}$) for potable drinking water. In some cases, Se concentrations are as high as 30 $\mu g.l^{-1}$.

The great variability of selenium concentrations observed for studied groups of wells located within a small area and exploiting the same aquifer suggested two possible origins; i) an anthropic origin of the contamination or ii) a geogenic origin in a complex and heterogeneous system driven by redox processes and perhaps microbiological effects. Indeed, mobility of Se depends on aqueous speciation and therefore pH, temperature and oxidoreduction potential (ORP). Thermodynamic diagnostic of equilibrium conditions is necessary in order to examine the transfer conditions of Se in groundwater and contribute in the adequate management scenarios of water exploitation.

For that purpose, a field sampling campaign was undertaken in June 2011 including 20 wells from the 4 well fields. Major and trace elements, Total organic carbon, Dissolved organic carbon, stable water isotopes ($\delta^{18}O$, $\delta^{2}H$), $\delta 34S$ and $\delta^{18}O$ of SO_4, $^{87}Sr/^{86}Sr$ and CFC-11, CFC-12, CFC-113, SF_6 analyses were undertaken in addition to the redox-sensitive chemical elements (SeIV, SeVI, NO_3, NH_4, NO_2, SO_4, $S2O_3$, SO_3, FeII and FeIII). Potential redox conditions of relevant minerals, degasing potential of sampled waters were calculated using PHREEQC (Parkhurst and Appelo, 1999) associated to the THERMODDEM database (http://thermoddem.brgm.fr/).

At the same time a geological study was undertaken in order to highlight the geological formation that may have high selenium contents. Considering previous analyses carried out in various rocks from Paris basin the geological formations enriched in organic carbon and/or clays and sulphurous minerals (such as pyrite) and that may potentially have high Se contents are clayey, pit layers of loam horizon and clayey tertiary formation on top of the Chalk aquifer or marly formation constituting basement of the Chalk aquifer.

The results of this integrated study (characterization of geological levels, field and laboratory measurements of fluids and thermodynamic modelling), which main objective is to understand the mechanisms of pollutant transfer (especially Se), is presented. The ultimate goal is to identify the key process controlling the reactive transport involving Se in order to optimize the operating conditions of the (Chalk aquifer) exploiting.

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