Geophysical Research Abstracts,
Vol. 11, EGU2009-9918, 2009
EGU General Assembly 2009

Isotopic characterization of nitrate sources in karstic springs in the basin of Paris

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In many locations in the world, karst springs are used in drinking water supply because of their big productivity. However, rapid transfer of water and then of contaminants in this kind of system, could affect water quality and vulnerability.
Five groups of springs located in two neighbouring watersheds, the Lunain and in the Loing watershed contribute in Paris (France) supply of drinking water. Villemer, Villeron are situated in the Lunain watershed (important agricultural activity) and Bourron, La Joie and Chaintréauville are in the Loing watershed (big part of its surface covered by forests).
Hydrochemical and geochemical characteristics of the springs are very different although they are close geographically. In Villemer spring, a high turbidity sometimes with specific bacterial contamination and phytosanitary products are observed. Nitrate concentrations are between 30 and 50 mg/l. In the Villeron group of springs, the inter-annual and seasonal variability of nitrates is less important than Villemer, but it is much more enriched with nitrate (50 - 55 mg/l). Phytosanitary substances are present. In Bourron site, nitrate concentrations are the lowest and produces the largest daily discharge (phytosanitary products are not present) at the opposite of La Joie and Chaintréauville springs where nitrate concentrations exceed drinking water standard limited value (50 mg/L), daily water production is important.
Artificial tracing have shown rapid and important connection between surface water and groundwater.
The objective of the present study is 1) to understand nitrate origins in the springs of the Lunain watershed, 2) to characterize different end-members of nitrate suitable to supply the springs, using 15N and 18O analyses and 3) to understand the links existing between the springs contamination and seasonal variations.
At first, an isotopic study was carried out during sampling campaigns in the high flow and the low flow periods. It concerned surface water, groundwater and several environmental end-members (samples of different aquifer, domestic effluents, etc...). In the same way, a hydrological study was made. It included water and nitrate flow quantification in the Lunain watershed. Water and nitrate balance calculated in the catchment during 2008, manifested that the most important part of water brought in the system is originating from the chalk aquifer. Moreover, it is sustained by water coming from precipitation. This water is responsible of nitrate contribution since groundwater receives continuously water enriched in nitrate, originating itself from agricultural soils leaching. Because the chalk aquifer contributes with a small part of its water in the Lunain watershed feeding, it concentrates all the remaining water and nitrate. However, the karst pipes have a small contribution but their transfer of contaminants could be temporal and rapid.
The isotopic study allowed a first characterization of aquifers existing in the watersheds of the study. It enabled demonstrating that:
The fluctuation of seasons seems to have an effect on mixing proportions of water aquifers in the springs. In Bourron site, the isotopic signature shows a mixing of the chalk and limestone water in the high flow season and a more important contribution of limestone aquifer during the low flow period. The same trend is observed at La Joie with different nitrate concentrations and different isotopic compositions values involving different end-members n water feeding.
Villemer spring is affected by contrasted seasons, and the environmental end-members contribute differently as well as the chalk aquifer and surface water.
However, there is no evidence on the effect of seasonal variations in Villeron and Chaintréauville sites. Villeron seems to have the chalk signature with a small contribution of surface water a shown by the tracing tests. In

Chaintréauville, water might be resulting from the mixing of limestone and chalk, without variations through the contrasted seasons.