Spatial hydrochemical and isotopic variations within the alluvial aquifer of the Allier River (Massif Central, France)

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INTRODUCTION / METHODOLOGY

This study focus on the alluvial aquifer of the Allier River (the main tributary of the Loire River) that represents 80% of the water supplies, for drinking and industrial purposes, of Clermont-Ferrand city (100,000 inhabitants). Considering its fundamental socio-economic role for the city, the functioning and contamination sources of this aquifer have to be better understood. In this purpose, a follow-up of hydrodynamic, physico-chemical (Temperature, Electrical Conductivity, pH, turbidity, dissolved CO₂ and O₂), hydrochemical (major ions, traces, stable isotopes, pharmaceuticals and pesticides) and biological investigations were conducted since December 2010:

- 90 points (72 boreholes, 13 piezometers, 2 springs, 3 surface waters) were sampled during the 1st field campaign hold from the 9th to the 14th of December, 2010. Samples were analyzed for major ions, traces, stable isotopes, dissolved gases and bacteria;
- 22 points have been selected among the dataset and have been biweekly sampled since February 2011 for all parameters during two years in order to draw parameter variations over time. Samples were analyzed for major ions, traces, stable isotopes, dissolved gases and bacteria;
- 4 points (Allier River, P13, B29 and B33) have been monthly sampled since February 2011 for analyzing pharmaceuticals, pesticides and biological parameters;

The poster presents preliminary results and focus on the first field campaign hold from the 9th to the 14th December 2010.

RESULTS

A principal component analysis (PCA) was carried out on physico-chemical and chemical variables. The two principal axis of PCA explain 87% of the sampling variance. Graph observations allow dividing the dataset in two groups: first group represents the points which are close to the Allier River and primarily recharged by the surface water, while the second group consists of points which are far from the Allier River.

Springs of Cognet and Jallat, sampled in the surrounding hills of the alluvial plain present the same chemical characteristics of the second group.

According to Schoeller diagram, ionic concentrations increase from the Allier River to the hills. This could highlight either a main supply by the surface water and then an increase of the residence time within the aquifer for the most remote locations from the river or a feeding by groundwater coming from surrounding hills aquifers.

According to Piper diagram, we observe that all the water samples present the same facies Ca-HCO₃ except Mezel pond which has Mg-Ca-HCO₃ type. An enrichment in Mg can be quoted for waters sampled far from the Allier River.

Electrical Conductivity ranges from 136 (in Allier River) to 1090 µS/cm (in P13) with an average value of 339 µS/cm. EC increases toward eastern part, by going away from the Allier River. Out of 90 sampling points, only 14 had values above 500 µS/cm. These points are far from the Allier River and close to the surrounding hills, Jallat and Cognet springs present also high EC.

Local rainfall and groundwater isotopes have been plotted on a δD/H versus δ18O diagram. A clear evolution of the isotopic signature could be quoted from points aligned on the GMWL and points aligned on the Local Meteoric Water Line defined by the following equation: δD = 7.7 δ18O + 8.9. 3 groups are distinguished:

- Allier River and boreholes close to the river present values close to the GMWL attesting of a feeding of this boreholes by the Allier River which isotopic composition is due to rainwater precipitate on the whole basin.
- Sampling points far from the Allier River and close to the surrounding hills, represented by Cognet and Jallat, present an isotopic signature close to the GMWL and seem to be recharged by local precipitation (weighted mean value of δD=−6.60 and δ18O=−47.93).
- P12, P14, B65 and Mezel present a particular evolution may be due to evaporation processes and/or mixing with deep groundwater from geothermal origin. Further analysis in carbon 13 should allow to solve this ambiguity.

CONCLUSIONS

- Thanks to the results, three recharge mode could be suspected for the groundwater circulating in the Allier alluvial aquifer - infiltration of local rainwater, feeding by the infiltration of surface water i.e. Allier River or supply from the connected hillside aquifers.
- Isotopic results highlight both the local recharge by precipitation which imposes in the main supply of the Allier River. Jallat and Cognet that represent the surrounding hills aquifers are clearly recharged by local rainfall.
- The alluvial aquifer present generally a (Ca-HCO₃) facies with a clear enrichment in Magnesium and increase of EC when going far from the Allier River. This fact is more in agreement with an increase of the residence time in the aquifer than a supply from the connected hillside aquifers.

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