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Occurrence of arsenic and selenium in aquifers used to produce drinking water near Orleans, France: indices of active biogeochemical processes

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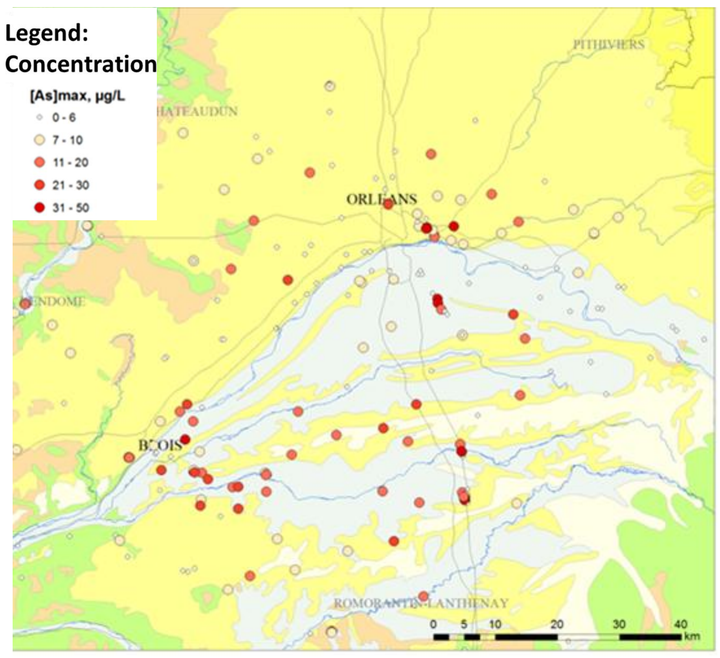
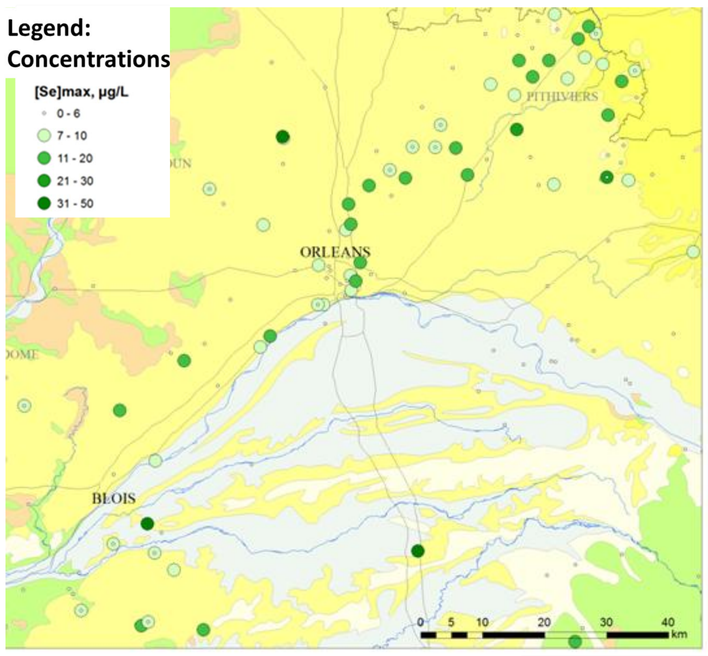
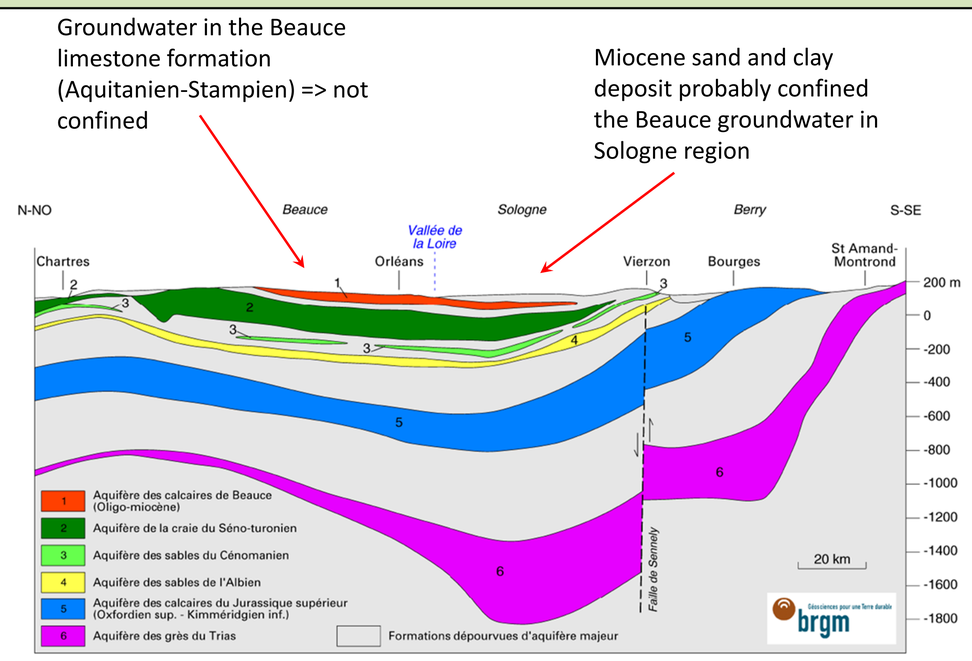
Arsenic and selenium are both toxic elements whose concentration should not exceed 10 µg/L in drinking water. Their mobility and toxicity, depending on their speciation, is often driven by microbial reactions. In an area of approximately 5000 km² around Orleans (Val de Loire, France), occurrence of arsenic and/or selenium above the drinking water standards imposes application of treatment strategies in several localities.



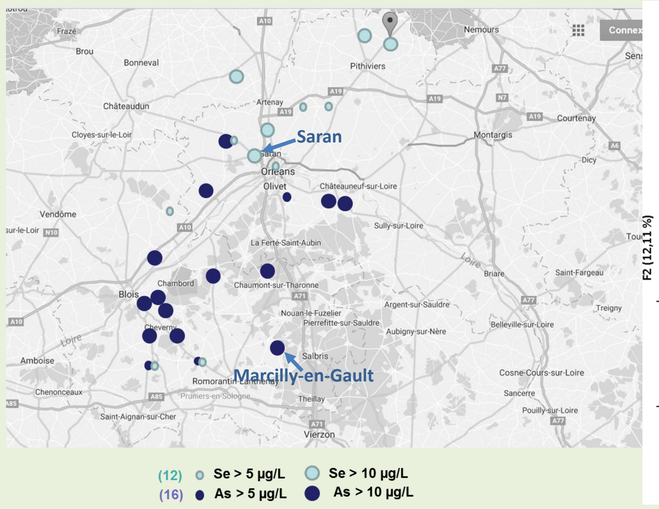


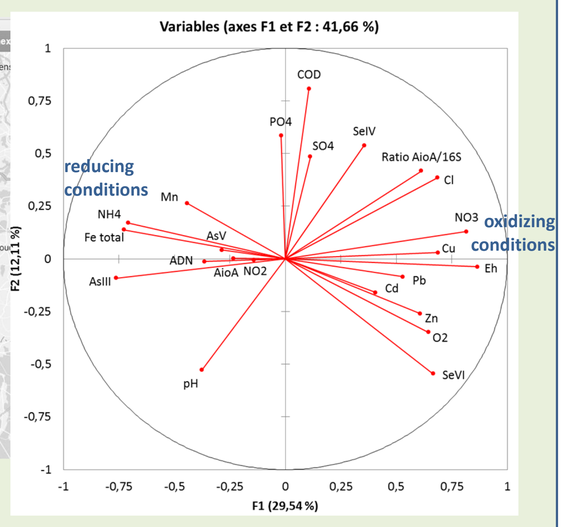


Correlations between groundwater parameters

Survey of 26 drinking water wells selected in the whole region

In order to understand the origin of these elements, 26 wells were characterized in terms of physical-chemical, geochemical and biological parameters in water. This survey revealed contrasted features of Se and As-containing waters.



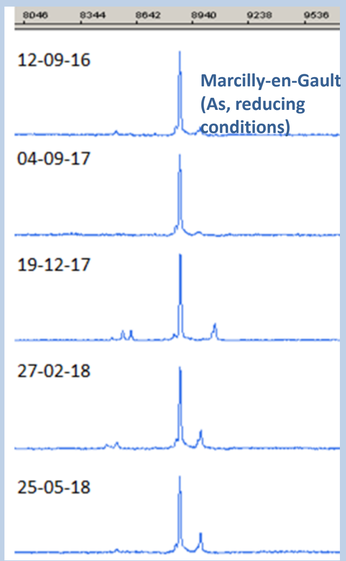


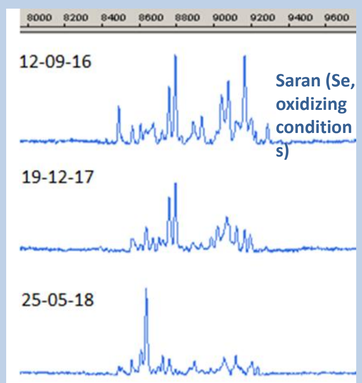
The wells presenting high Se concentrations were mainly located in the northern part of the region (Beauce), and were characterized by high redox conditions and high concentrations of nitrate. In contrast, the wells producing As-containing water were mainly located in the southern part of the region (Sologne) and exhibited low redox conditions, together with presence of iron and manganese.

Temporal evolution, microbial parameters

Monitoring of two drinking water wells, one containg As and one containing Se, for 2 years

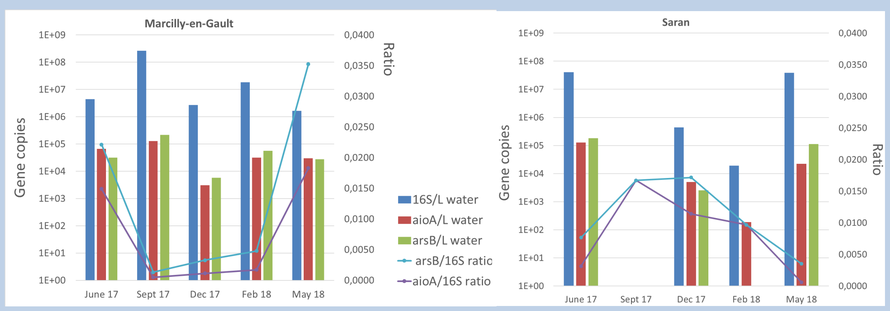
The bacterial diversity in groundwater was monitored by Capillary Electrophoresis fingerprints using the Single Strand Conformation Polymorphism (SSCP) technique.





The bacterial diversity was lower and more stable in the groundwater of Marcilly-en-Gault, confined, than in the groundwater of Saran, not confined.

The functional genes linked to bacterial As transformation, *aio*A (arsenite oxidase) and *ars*B (arsenic reduction for resistance) were quantified.

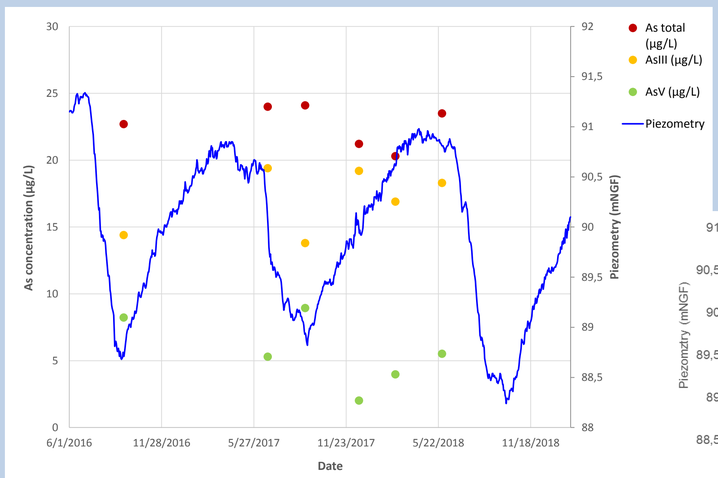


The ratio of genes involved in As biotransformation (*aio*A and *ars*B) to total 16S ribosomal genes varied during the monitoring in an opposite trend for the two sites.

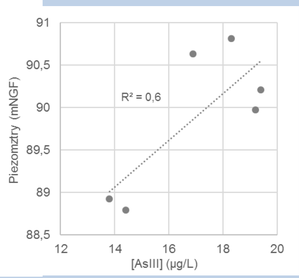
Temporal evolution, geochemical parameters

Monitoring of two drinking water wells, one containg As and one containing Se, for 2 years

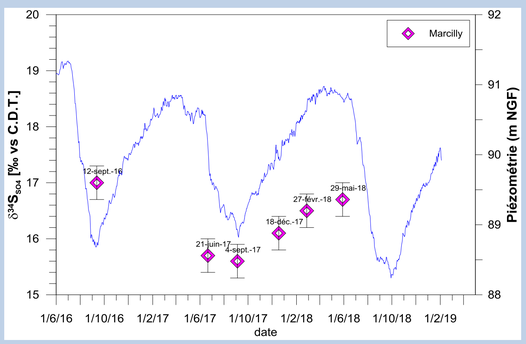
Monitoring of the drinking water of **Marcilly-en-Gault,** Sologne, reducing conditions, arsenic concentration > 10 µg/L:

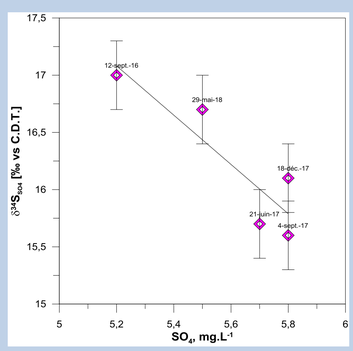


The As speciation seems to be influenced by the groundwater level, with higher As(III) proportion when the level is high.

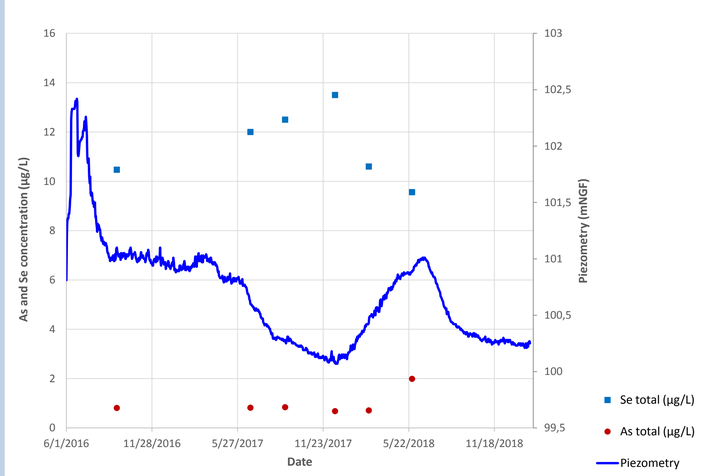


Correlation between variation of piezometric level and $\delta^{34}S$ / SO_4 fractionation and $\delta^{34}S$ anti-correlated with SO_4 concentration => Indices of active sulfate-reduction.

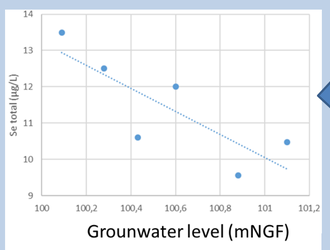




Monitoring of the drinking water of **Saran,** Beauce, oxidizing conditions, selenium concentration > 10 µg/L:



The Se concentration seems to be influenced by the groundwater level, with higher Se when the level is low.



Conclusion

The concentration of arsenic and selenium in the groundwater seem to be linked to redox conditions: arsenic is mobilized in reducing context, and selenium in oxidizing conditions. Biogeochemical processes probably contribute to the behavior of these two elements. The temporal evolution of biological and geochemical water parameters suggest that these biogeochemical reactions are not ancient events but currently active processes. As a consequence, the variations of groundwater levels linked to climate change might induce evolution of arsenic and selenium in groundwater.

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