

## **A multi-isotopic approach as a tool for assessing nitrate pollution in the province of Girona (NE Spain)**

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Surface and groundwater nitrate contamination is a problem that affects a large part of Europe. According to the European Directive 80/778/CEE, waters with concentrations higher than 50 mg/L can not be used for human consumption. Nitrate concentration can be decreased by natural denitrification, mediated by autochthonous bacteria under reducing conditions. This reaction can partially or completely reduce dissolved nitrate to harmless nitrogen gas (N<sub>2</sub>). This study describes the application of isotope tools -  $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$  of dissolved nitrate, and  $\delta^{11}\text{B}$  of dissolved boron - to understand the origin and fate of dissolved nitrate in the area of Girona, in order to potential environmental impacts on the province of Girona's water resources [1, 2]. The combination of chemical and multi-isotopic data allowed us identifying NO<sub>3</sub><sup>-</sup> sources and verifying if natural denitrification processes were taking place. 38 groundwater and 6 surface water samples were collected from different hydrographic basins of the Girona province. The combination of chemical data, the  $\delta^{15}\text{N}$  (+2.6 ‰ to +23.2 ‰) and  $\delta^{18}\text{O}$  (+0.2 ‰ to +16.4 ‰) of NO<sub>3</sub><sup>-</sup>, and the  $\delta^{11}\text{B}$  (+1.7 ‰ to +42 ‰) of boron, allowed us to determine the main nitrate sources in the area. For 33 % of the samples NO<sub>3</sub><sup>-</sup> is exclusively derived from animal manure (20 %), waste water (9 %) or inorganic fertilizers (4 %), whereas for 41 % of the samples NO<sub>3</sub><sup>-</sup> can be explained as a mixture of different sources. For the remaining samples (26 %) it has not been possible to accurately determine NO<sub>3</sub><sup>-</sup> origin. The isotopic results also indicated that for more than 40 % of the studied samples a certain degree of denitrification was taking place. Isotope geochemistry, combined with a correct hydrochemical characterization, has proven to be a useful tool to determine the origin of nitrate contamination and to assess the occurrence of natural nitrate attenuation.

[1] Aravena *et al.* (2010) In: *Environmental Isotopes in Biodegradation and Bioremediation*, CRC Press, 203-246.

[2] Widory *et al.* (2005) *Environ. Sci. Technol.* **39**, 539-548.