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Evaluating the sources of nitrate contamination in groundwater using stable isotopes of oxygen and nitrogen: a comparison of two case studies in Italy

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Diffuse nitrate pollution in groundwater is currently considered one of the major causes of water quality degradation. The use of stable isotope of nitrate can be a very useful tool in the investigation of diffuse contamination sources. Many nitrate sources can introduce nitrate in groundwater system, and among them sewage, animal manure, chemical fertilizer and natural soil mineralization. To discriminate between them is not simple but extremely useful, especially to implement management actions for groundwater protection.
In this research the isotopic composition of nitrate was used to evaluate nitrate contamination sources and to identify geochemical processes occurring in two different hydrogeological environment: an alluvial aquifer in the western Piedmont Plain (NW Italy) and an alluvial-pyroclastic aquifer of the Campanian plain (S Italy).
The analysed Piedmont plain is essentially an agricultural zone with cereals and forages cultivations, in which livestock farming (especially cows and pigs) are highly developed. Moreover, in the small towns domestic waste water is locally not connected to sewerage.
In the studied Campanian plain, the land use shows a strong agricultural development, mostly in association to the numerous livestock activities (predominantly buffalo farming companies). The urbanized environment represents a relevant percentage of the area (about 8%) and extends mainly along the coast. Moreover, in some areas illegal building developments are present with illicit sewage connections or on-site sewage disposal.
In both study areas, different sampling campaigns were performed to identify the nitrate distribution in groundwater. Groundwater samples were also collected for isotopic analysis (δ15N and δ18O) of dissolved nitrates.
Both areas are characterized by high nitrate levels in groundwater, up to 180 mg/L. Isotope data of nitrate indicate that nitrate contamination in the Piedmont Plain originates from mixtures of synthetic fertilizers, manure and septic tank effluents. A further discrimination, made using boron isotopes, confirms that both domestic sewage and animal manure contributes to the nitrate contamination. At last, a significant denitrification process was highlighted especially in the shallow aquifer of Poirino Plateau, that is the most contaminated part of the study area.
The source of nitrate in Campanian plain seems prevalently due to the spreading manure application to crops and to the urban sewage leakage. Indeed, this hypothesis seems confirmed by the changes in land use showing an increase of peri-urban areas, often not connected to the sewer systems.
Determining the sources, distribution and persistence of nitrate in groundwater is a significant first step for a better management of water quality. Especially, we would propose the application of isotope techniques in both areas as an important support to face the attenuation in nitrate content.