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PROIECT APUSENI

Groundwater pollution within the Gârda Seacă–Gheţari–Poiana Călineasa karst area (Bihor Mountains, Romania)

The contamination of natural water in karst regions is a very critical problem, because of the particular nature of the topography that develops on carbonate rocks, namely on limestone and dolomite. Features that are specific to the karst landscape, such as potholes, caves, swallets, etc., to which there should also be added the relatively thin soil cover, are all responsible for the poor organization of the surface streams network. Rainfall water reaches in the underground much faster, and as a result there is not enough time anymore for self-purification processes to be completed.

As drinking water sources, local people in the investigated area use mainly low flow rate springs that discharge from aquifers of small extent located in Early Jurassic deposits (Ocoale Depression) or in shallow karst aquifers. Some of these springs were turned into "fountains". Less frequently, there are used to this purpose karst springs (The "Fountain" in Valea Iepei), but never the outlet caves.

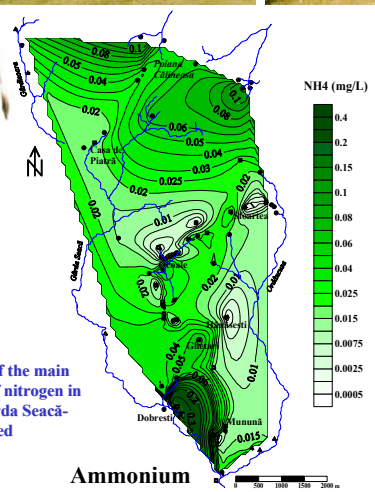
Work procedure

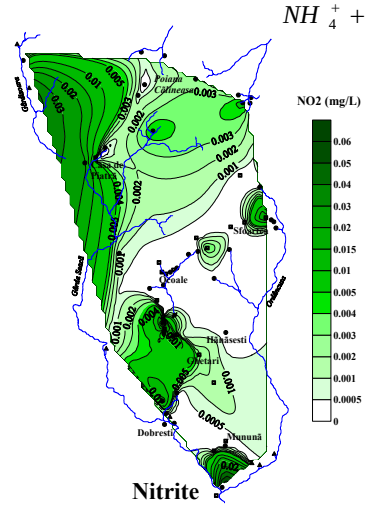
The investigation program included collection of groundwater samples during field trips performed within the time interval May-December 2001, totaling four series of sampling. The chemical analytical works consisted of *in situ* measurements of the basic physical and physical-chemical parameters, and laboratory measurements of the chemical structure of the water, including the major components and the chemical nutrients, measurements of trace-elements concentrations, mainly for those with elevated toxicological potential, microbiological characterization, as well as testing the presence of pesticides.

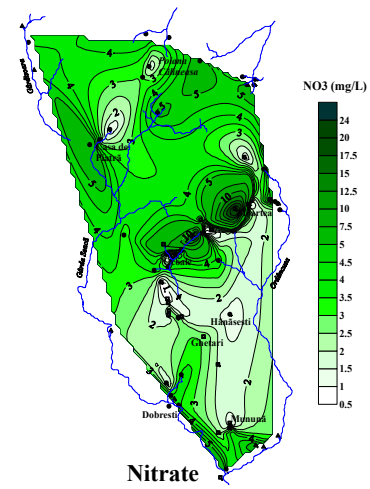
Pollution sources

The main cause of groundwater pollution in the investigated area is cattle grazing that occurs over extended areas. Additional causes are manure used as a fertilizer, domestic waste, and dejections from toilets that exist next to the local people households.

Frequently, there occur situations like those in the adjoining photographs, in which the pasture, used as a place for grazing (when cattle is brought back from Poiana Călineasa), the crops of potatoes of and of other various vegetables (fertilized with manure), as well as households with all their outbuildings, are all placed within the drinking water sources recharge areas.







Areal distribution of the main anorganic species of nitrogen in groundwater in Gârda Seacă-Ordâncuşa watershed

$$NH_4^+ + 3/2O_2 \rightarrow NO_2^- + H_2O + 2H^+$$

$$NO_2^- + 1/2O_2 \rightarrow NO_3^-$$

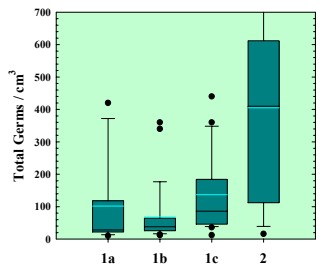
The occurrence of NH_4^+ in groundwater is mainly due to animal dejections, hence this is not a punctiform pollution but a diffuse one, extended over large surfaces. Intense grazing in Poiana Călineasa results in the highest NH_4^+ concentrations being recorded here. In this area ammonium may be viewed as an actual natural tracer, the displayed diagram clearly outlining an underground flow path directed from the central-south-eastern area of Poiana Călineasa toward Izbucul Vulturului, in the catchment area of Gârda Seacă stream. On the other hand, the central-north-western section of Poiana Călineasa discharges toward the catchment area of Someşul Cald. Nevertheless, the two distinct sections of Poiana Călineasa, outlined by the distribution of NH_4^+ concentrations in groundwater, are in fact separated by the water divide between the two indicated catchment areas.

In the southern part of the watershed, high NH_4^+ concentrations occur in Dobreşti area. The situation recorded in this specific case is a very good illustration of the karst flow function that consists in collecting and concentrating pollutants toward the points of discharge. The groundwater sources located in the plateau have small, strictly local recharge areas, which results in a low level of ammonium concentrations. Alternatively, infiltration water carries ammonium, that originates in the households groups and in the grazing areas, toward the spring of Coteţul Dobreştilor. In this case there occurs a fast flow, and as a consequence the nitrification process chemical reactions, whose scheme is indicated above, do not benefit of the entire time interval required for completion. It is also quite probable that this underground flow occurs as a closed system (in entirely flooded passages), without inflows from permanent sources of oxygen or of other oxidizing agents.

The origin of NO_3^- in the groundwater of the considered area is to be ascribed to two major causes. On one hand, nitrate is the final product of the nitrification process and this must be the main cause of the elevated concentrations recorded at the sources located within the shallow karst, as for instance the spring at Casa de Piatră, but also in the case of certain outlet caves like for instance Poarta lui Ioanele cave. On the other hand there exist punctiform contamination sources, able of being identified, due to the inappropriate use of manure as a fertilizer, as for instance in the close proximity of Debii spring and of the "Fountain" in Stânisoara.

The bacteriological analysis provide remarkable confirmations of the trends recorded in the case of nutrients distribution in groundwater. As outstandingly vulnerable appear to be the sources that discharge from a substratum that it is only slightly concerned by karst processes, whose supply is strictly local, most probably through runoff on the adjoining terrains. In this respect outlet caves and typical karst springs range behind, yet with a much stronger variability of pollutants concentration.

Less exposed to pollution result to be the springs associated to a substratum that is moderately concerned by karst processes. This situation may be explained on one hand through the effects resulting from a recharge that occurs on an area that is slightly larger than that of the shallow karst sources, to which there should be associated a certain filtration stage of the water, and on the other hand through the underdeveloped character of the karst flow network, that it is not able to concentrate the pollutant substances, as it happens in the case of the typical karst outlets.



Distribution of the total number of bacteria that develop at 37°C in one cm^3 of water for: **1** – groundwater, where (**a**) represents karst outlets, (**b**) sources originating in a substratum that is moderately concerned by karst processes, (**c**) substratum slightly concerned by karst processes; **2** – rainfall water collected by local people.

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