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Development and deployment of a passive sampling system in groundwater to characterize the critical zone through isotope tracing

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The Critical Zone (CZ) is the evolving boundary layer where rock, soil, water, air, and living organisms interact, zone controlling the transfer and storage of water and chemical elements. For investigating the CZ, we have developed an integrative sampling system to concentrate the chemical elements in groundwater (CRITEX project). Aims are to measure concentrations and isotopic ratios in groundwater through integrative sampling. In the frame of the groundwater analysis, particularly those located in the critical zone (0-100 m depth), this system makes it possible to create a water flow in a support of passive samplers using Diffusive Gradient in Thin type (DGT) and thus to pre-concentrate the chemical species on a chelating resin by diffusion through a membrane and over a given period in order to facilitate subsequent laboratory measurements.
Because DGTs are generally used in surface waters with a high flow rate, the current objective is to create a sufficient flow of water in the sampler to optimize the trapping of elements. Different options and geometries have been modelled by simulation of the flow (agitation of water supplied by a motor and a propeller, pumping ...). The economic model of the device is based on an assembly of commercially available equipment, the novation is based on the support, fully designed in house (patent pending). The device aims to recreate sufficient water flow to avoid the creation of a too large Diffusion Boundary Layer (DBL) on the DGT surface and then to mimic the uptake conditions that prevail in surface waters. The simulations made it possible to optimize the position of the DGT and the velocity of the fluid in order to obtain the maximum flow at its surface and avoid the creation of the DBL. Conditions equivalent to those of a circulation of weakly agitated surface water are thus recreated.
The first tests were carried out at lab, in a column simulating a piezometer, including pump, DGT holder and flow meter. Initial functional tests were carried out with tap water to observe the flow of water in the device, to determine the technical characteristics of the system (current, voltage, flow...) and to perform blank measurements to ensure that the device brings no contamination. We then carried out 6 days of immersion of the system on a piezometer of the BRGM site. In parallel, daily sampling was performed using conventional pumping method. Finally, we carried out tests on drillings in the Coët Dan experimental basin (Naizin, Morbihan, France). We established a screening of chemical elements on which isotopic measurements can be done by comparing the accumulated mass in the DGT with respect to the concentration of the elements in water. This suggests that the isotopic determination is possible for U, Sr, Nd and Ni with the exception of Cu and Zn at the moment. Possible contamination of DGTs themselves and/or during field investigations should be further studied in order to rule if Cu or Zn isotope analyses can be foreseen in the future.