SQUARING THE CYCLE: THE INTEGRATION OF GROUNDWATER PROCESSES IN NUTRIENT BUDGETS FOR A BASIN-ORIENTED REMEDIATION STRATEGY

Arianna MUSACCHIO [1], Viviana RE [1], Carlo Andrea DELCONTE [2], Erica RACCHETTI [3], Elisa SOANA [3,4], Raffaella BALESTRINI [2], Marco BARTOLI [3,5], Pierluigi VIAROLI [3], Elisa SACCHI [1]

[1] Department of Earth and Environmental Sciences, University of Pavia, Via Ferrata 1-27100 Pavia, Italy, arianna.musacchio01@universitadipavia.it
[2] Water Research Institute, National Research Council (IRSA-CNR), Via del Mulino 19-20861 Brugherio, MB, Italy, delconte@irsa.cnr.it
[3] Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Parco Area delle Scienze 11/A-43124 Parma, Italy, erica.racchetti@unipr.it
[4] Department of Life Sciences and Biotechnology, University of Ferrara, Via L. Borsari 46-44121 Ferrara, Italy, elisa.soana@unife.it
5 Coastal Research and Planning Institute, Marine Science and Technology, Center of Klaipeda University, H. Manto g. 84-LT-92294, Klaipeda, Lithuania, marco.bartoli@unipr.it

Diffuse contamination of surface and ground waters resulting from the green revolution since 1950's represents a major threat to the long-term sustainability of water resources worldwide. Nutrients budgets, calculated in a wide array of river basins, have shown that a high amount of nutrients can be retained or lost within the watershed, where site-specific characteristics contribute to define their fate. In the Lombardy plain (North Italy) the uneven distribution of nitrates in groundwater, not fully matched to any of the civil, industrial and agricultural sources, suggests that local features and processes (e.g. depth of water table, land use, denitrification etc.) play a key role in preserving or removing nutrients.

In this framework, the INTEGRON project, funded by the CARIPLO Foundation (Grant number: 2015-0263), aims at evaluating the role of groundwater as a temporary or permanent sink or as a source in nutrient mass balances at the catchment scale in two key sub-basins of Po River, the Adda and the Ticino.

An innovative and integrated approach is proposed, considering both surface and groundwater, combining hydrogeology and biogeochemistry and targeting both N and P species. This includes: (i) the calculation of the nutrient surplus and the load exported by rivers at the closing section to quantify the amount retained within the basin; (ii) the groundwater dating to infer the residence time of nutrients; (iii) the estimate of the amount of nutrients exchanged between surface and ground waters and the identification of processes occurring at the interface; (iv) the investigation of the factors promoting the retention or removal of nutrients (e.g. denitrification, P adsorption); (v) a socio- hydrogeological analysis to identify key-actors in the implementation of new management practices.

Preliminary outcomes, referred to the previously described topics, show that:

(i) the Adda basin has higher percentage of agricultural surfaces, livestock density and fertilizer application than the Ticino basin, resulting in higher N and P surplus;

(ii) both increasing and decreasing NO3- concentration trends in groundwater with time are present in the higher plain;

(iii) NO3- in both rivers increases in correspondence of the transition between the higher and lower plain, in particular during the irrigation period. Groundwater feds springs located in the Adda basin and shows higher NO3- concentrations compared to Ticino basin;
(iv) elevated P contents may be found in shallow groundwater below rice paddies;
(v) a complex network of stakeholders, with conflicting interests and goals, is present.

In conclusion, groundwater has a complex role in nutrient mass balances, acting both as sink and source in each basin. Considering the temporal scale is essential to properly relate the nutrient surplus with the amount upwelling through the springs. The integration of hydrogeochemical and social results is a crucial step to understand the poor efficacy of mitigation actions and to propose new management practices where limitations imposed by EC Directives do not seem to be effective.