

Evaluating the vulnerability to emerging pollutants at the Sant'Alessio Induced RiverBank Filtration Managed Aquifer Recharge facility (Lucca, Italy)

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Sant'Alessio Induced RiverBank Filtration (IRBF) scheme is recharged by the River Serchio surface water and it provides drinking water for about 300,000 people of the Tuscany coastal area (town of Lucca, Pisa and Livorno). At Sant'Alessio IRBF, ground -water storage is increased by means of one weir crossing the riverbed to raise the river head and therefore increasing the saturated part of the aquifer along the river reach. Groundwater is then pumped by means of ten vertical wells in high transmissivity gravel and sandy aquifer. The required drinkable water quality standard is naturally obtained through several processes throughout the path (50 to 100 m) from the river water to the pumping wells, and largely occurring in the first meters of filtration.

Emerging pollutants (Eps; Personal Care Products, PCPs, Pharmaceutical Active Compounds, PhACs, and transformation products) enter in surface water bodies primarily through discharged effluents from wastewater treatment plants, causing river water contamination. Many of these compounds are only slightly transformed/degraded, or may pass, even unchanged, in standard wastewater treatment processes. Only a few are eliminated.

To evaluate the vulnerability of the Sant'Alessio IRBF scheme to potential EPs, seven sampling campaigns to detect emerging contaminants were carried out between 2014 and 2016 in different hydrological conditions. We monitored one surface river water point, six groundwater observation and drinking wells, and a nearby drainage channel collecting untreated wastewater in the area. The first two sampling campaigns (October 2014 and July 2015) were oriented to analyze a wide spectrum of PhACs and PCPs (about 100 different compounds combining the two campaigns were searched) in surface- and ground-water.

The third campaign (March 2016) was performed in order to focus only on PhACs; in particular on 9 compounds (atenolol, carbamazepine, clarithromycin, ibuprofen, diclofenac, naproxen, erythromycin, estrone, estradiol) and three of their major metabolites. Combining the results of the first three exploratory campaigns with data on the quantity of specific PhACs sold in the IRBF related area, and in compliance with the European Community watch list of EPs, 8 compounds were selected for a short-time multi-temporal analysis (four campaigns within 30 days). The highest levels of EP were detected in the superficial water of the drainage channel and the Serchio river. In the drainage water, the detected compound concentration values were usually more than ten times higher than the level detected in the Serchio River.

The PhACs detected ranged in concentration, from 0.8 ng/L (i.e. sulfamethoxazole) up to 150 ng/L (i.e. metformin). The average values in the Serchio River are: clarithromycin 8.68 ng/L, atenolol 1.53 ng/L, diclofenac 2.70 ng/L, ibuprofen 2.48 ng/L, naproxen 1.22 ng/L, carbamazepine 4.05 ng/L, metformin 137.74 ng/L, sulfamethoxazole 1.35 ng/L.

Carbamazepine, diclofenac and sulfamethoxazole show a similar degradation pattern, resulting in a constant decrease (10-100 times reduction) from the river to the Sant'Alessio abstraction wells. As exception to this general trend, Ibuprofen shows a more persistent behavior and other source of contamination in the inner part of the Sant'Alessio plain.