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Chemical speciation and microbial growth of natural spring waters associated with diverse hydrogeological settings in the area of Lecco (Italy)

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Understanding speciation of metals (such as, e.g., Iron, Zinc, Arsenic, Copper, Lead or Aluminium) in natural waters is critical to assess their mobility, bioavailability, and potential impact on human health, as well as for developing appropriate mitigation strategies.

The present study is conducted in the mountain range adjacent to Lake Como (Province of Lecco, Italy). The study area encompasses two adjacent areas separated by the well-known Orobic line. We perform a comprehensive analysis (chemical and microbial) of more than 400 water samples collected at springs within the study areas during the years 2018-2022. Our results document a significant variation in the water chemistry in both target areas. Consistent with the geological makeup of the southern area, spring waters sampled therein are characterized by high calcium and bicarbonates concentration levels. Otherwise, water samples from springs in the northern region display significantly high concentrations of metals such as Fe, Zn, As, Al, Cu, and Pb.

We quantify speciation of these metals and saturation indices upon relying on the well-known and tested PHREEQC [1] and The Geochemist's Workbench [2] modeling suites. We document a significant impact of bicarbonate and calcium concentrations on chemical speciation of metals. Moreover, the higher concentrations of heavy metals appears to be associated with a negative effect on microbial (Coliform bacteria) growth. We conclude that the geological setting associated with the springs affects water chemistry and, in turn, heavy metal speciation, and microbial diversity. A detailed multivariate statistical analysis suggests that seasonal changes are associated with a non negligible correlation to microbial growth in the spring waters, even as they do not have a marked impact on chemical speciation and saturation indices.

Our study also highlights the importance of water quality monitoring and management to protect public health and the environment and provides the basic elements required for future quantification of the impact of speciation and saturation on the fate and transport of emerging pollutants across the subsurface water bodies in the area.

[1] Bethke, C. M. (1995). Geochemist's Workbench.

[2] Parkhurst et al. (2013) US geological survey techniques and methods, 6(A43), 497.