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An integrated approach to asses origin and mobilization of As, Fe and Mn in groundwater: the case study of Cremona (northern Italy)

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The present work concerns the analysis of the hydrogeology and the hydrogeochemistry of the As, Fe, Mn rich groundwater of the alluvial multi-layer aquifer in the lower Po Plain of Cremona (northern Italy). In this analysis, an integrated approach is applied in order to understand the origins (natural or anthropic) and chemical mechanisms of high groundwater As, Fe and Mn concentrations found in the study area.
The study area covers a 50 km2 wide area around the urban territory of Cremona. It is located near the confluence between Adda and Po rivers. The multi-aquifer system which interests the first 200-250 m of depth is investigated. The integrated approach involves the (a) collection of historical data related to water quality, water levels and well logs; (b) storage of collected data in specific databases and geographical information systems; (c) design and execution of two field surveys of water levels and water quality, realized in July 2010 and July 2012, concerning also groundwater sampling for isotope and microbiological analysis; (d) construction of a 3D model of aquifer hydrogeological properties (deposits texture, hydraulic conductivity and effective porosity), built by means of ordinary kriging interpolation of numerical values derived from the coding of well logs; (e) analysis of the hydrodynamic properties of the system on the basis of the field measurements; (f) analysis of water quality data (both field and historical data) considering the hydrogeological and hydrodynamic properties of the aquifer system; (g) analysis of isotope and microbiological measurements; (h) implementation of a 1D reactive transport model in order to better understand the hydrogeochemical mechanisms in the system; (i) elaboration of a general hydrogeochemical conceptual model concerning possible origins and chemical mechanisms for the high groundwater As, Fe, Mn and NH4 concentrations, considering also possible anthropogenic influences; (j) development of management tools, as natural background levels (NBL) derivation, supporting groundwater resources protection by public authorities.
This approach allows to assume the process of natural organic matter degradation (i.e. peat) as primary control factor on high As, Fe, Mn and NH4 concentrations. Degradation of peat is associated with the consecutive reduction of O_2, NO_3-, Mn(IV), Fe(III), SO42-, CO_2. The reductive dissolution of Mn and Fe oxides (contained in the aquifer sediments) leads to high concentrations of dissolved Fe and Mn, but also to high concentrations of dissolved As, which is generally sorbed on Mn and Fe oxides. Dissolved As concentration can be also lowered by different processes (co-precipitation of As in iron sulfides, precipitation of arsenic sulfides, sorption of As on the remaining Fe-oxides and Mn-oxides, etc.). NH4 is released from the degradation of organic nitrogen of peat. Therefore, a natural origin of As, Fe, Mn and NH4 can be assumed. In addiction, anthropogenic influences on groundwater As, Fe, Mn and NH4 concentrations are locally identified in two sites located in the study area, that are affected by hydrocarbons and organic leachate pollution.