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Assessing Natural Background Levels of aquifers in the Metropolitan Area of Milan (Lombardy)

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The European Water Framework Directive (WFD 2000/60/CE) requires Member States to evaluate the status of groundwater bodies in order to reach a good water quality for human consumption. One of the preliminary steps for defining the status of groundwater bodies consists in the definition and evaluation of the so-called Natural Background Levels (NBL). The NBL or Baseline level can be defined as "the range of concentration of a given element, isotope or chemical compound in solution, derived entirely from natural, geological, biological or atmospheric sources, under conditions not perturbed by anthropogenic activity" (Edmund and Shand, 2009). The qualitative analysis for a large area (ca 4500 Km2) of the Po Plain around the Milan Metropolitan area (Lombardy, Italy) is presented in this study. Despite the aquifers in the Milan metropolitan area are an incredible groundwater resource for a very large population (3.195.629 inhabitants in the metropolitan area, data at November 2014) and a highly industrialized area, a groundwater baseline characterization is still missing.
In order to attain the hydro-geochemical characterization a complete geodatabase was built (120.655 chemical samples from 1980 to 2014). This database has been explored by classical and multivariate statistical analyses to provide relationships among the more influential lithological, hydrogeological and hydro-chemical variables. Finally, the NBLs of different chemical species which may be anthropogenic sensitive (Na, Cl, K, NO_3, SO4, NH4, As, Fe, Cr, Fe, Mn, Zn) and for multiple aquifer bodies (phreatic, semi-confined and confined aquifer) are evaluated. Two different approaches are applied: the Pre-Selection method (BRIDGE, 2006) and the Component-Separation method. The first one (PS) consists in the exclusion of samples from the available dataset that could indicate human activities then deriving the NBL as the 90th percentile of the remaining data. The second one (CS) consists in the fitting of the frequency distribution function of the concentration of a given chemical species under the assumption that the total concentration is composed by a natural distribution (lognormal) and an anthropogenic distribution (normal) then deriving the NBL as the 90th percentile of lognormal distribution. The NBL values are compared with the standard reference values (REF) for drinkable waters in order to assess threshold values. The results are similar for the two different method. The NBLs of major ions (Na, Cl, SO4 and NH4) never exceed REF values; on the other hand the NBLs of As, Fe and Mn exceed REF values in the southern sector of study area and in general tends to increase moving from superficial to deepest aquifers.The Fe-Mn-As distribution indicates important changes in redox conditions (from oxidising to reducing environment). The spatial-temporal analysis of the values exceeding NBL values from PS-approach indicates an increasing trend through time and close to area with high percentage of land urban cover. The CS-approach allows to compare anthropogenic inputs (normal distribution peaks) of chemical species such as Cl, Na, NO_3 and SO4 with land cover use finding main relation with the percentage of urban areas, the percentage agricultural areas, the population density and the type of cultivation within a defined zone. The results are useful to define a series of chemical facies in order to solve groundwater management problems from the single public supply well to regional scale.