The use of geochemical ratios in groundwater quality assessment: the case of the Thriassion Plain Attica, Greece

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Hydrochemical diagrams aim at interpreting any evolution occurring in the groundwater systems. This paper is an effort to assess the groundwater quality and the geochemical processes using a diagram based on Chadha's work (Chadha, 1999), who classifies natural waters, documenting Piper's and extended Durov's diagrams. The example of hydrochemical analyses were given from groundwater samples of Thriassion Plain. The study area (Figure 1) is located 25 km west of Athens and has undergone uncontrolled urban and industrial development. Geologically, it is dominated by alpine sediments represented by Palaeozoic volcano-sedimentary complex, Triassic phyllites and sandstone, limestones, dolomitic limestones and dolomites, and Cretaceous limestones. Post-alpine sediments of Neogene-Quaternary marls, clay and marly limestones conglomerates as well as Holocene clay, sands and gravels have filled in the basin (Katsikatsos et al., 1986). The post alpine tectonic activities (Papanikolaou et al., 1999) combined with the Pleistocene sea level fluctuations (Lambeck, 1996) is responsible for the current landscape: firstly a sequel of Pliocene to Lower Pleistocene movements gave born to the main neotectonic fault of Mt. Parnes (Lekkas, 2001; Mariolakos et al., 2001) at the northern edge of the study area. Later, in M. Pleistocene the extension fault of Aspropyrgos defined the basin of Eleusis; this activity goes on to date. As a result, a complex hydrogeological regime has been established in which a multi-layered confined aquifer system has been formed (Hermides, 2018).

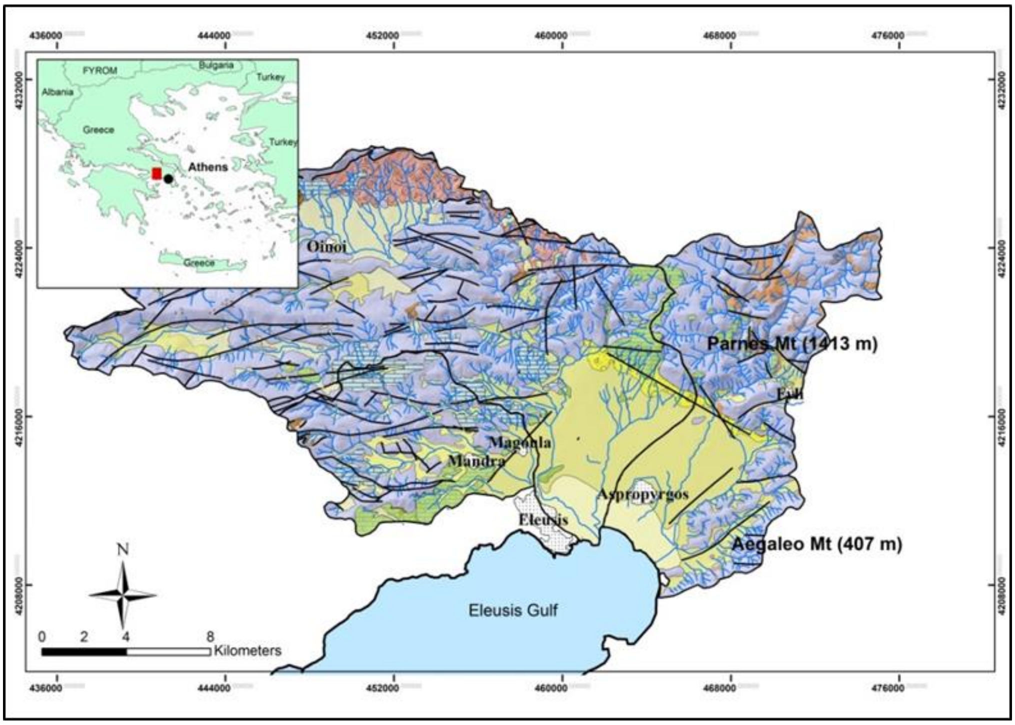

Figure 1.The study area

To attend our objective, sampling of 45 wells and boreholes along with measurement of basic physico-chemical parameters took place. The target anions Cl^- , SO_4^{-2} and cations Ca^{+2}, Mg^{+2}, Na^+, K^+, were identified with Ion Chromatography, while the HCO_3^- anion was characterized with titration. Then, hydrochemical sections, XY diagrams, distribution maps of ionic ratios as well as Gibbs diagrams (Gibbs, 1971) were used to identify origin of salinity and geochemical processes. Based on the relationship between TDS (meq/l) and Na/Na+Ca, Cl/Cl+HCO_3 meq/l ratios these diagrams have shown that evapotranspiration (ET) and rock-water interaction that dominate the study area play an important role to the increase of groundwater salinity. All data were illustrated on a Chadha diagram (Figure 2) to interpret groundwater geochemical processes: this diagram uses simple spreadsheets excel file. Concentration meq/l % of (Ca+Mg)-(N+K) and HCO_3^- (Cl+SO_4) are displayed onto X and Y axes respectively. The diagram is divided into 8 fields. The geochemical processes that occur in groundwater such as mix of fresh water with modern seawater (red dashed line and arrow 3 in Figure 2), refreshening (arrow1), mix of fresh water with aged water and possible ancient seawater influence (arrow 2), reverse cation exchange (double arrow 4) and base ion exchange are mainly presented in the fields 5, 6, 7, 8. The interpretation of the produced diagram highlights the stratigraphic factors and especially the clay strata occurrence that have isolated fresh groundwater from seawater. The abundant occurrence of clay deposits to the depth of the plain work as barriers to sea intrusion. Good quality groundwater has been identified which confirms the role of clay strata, showing evolution of saline to fresh water.

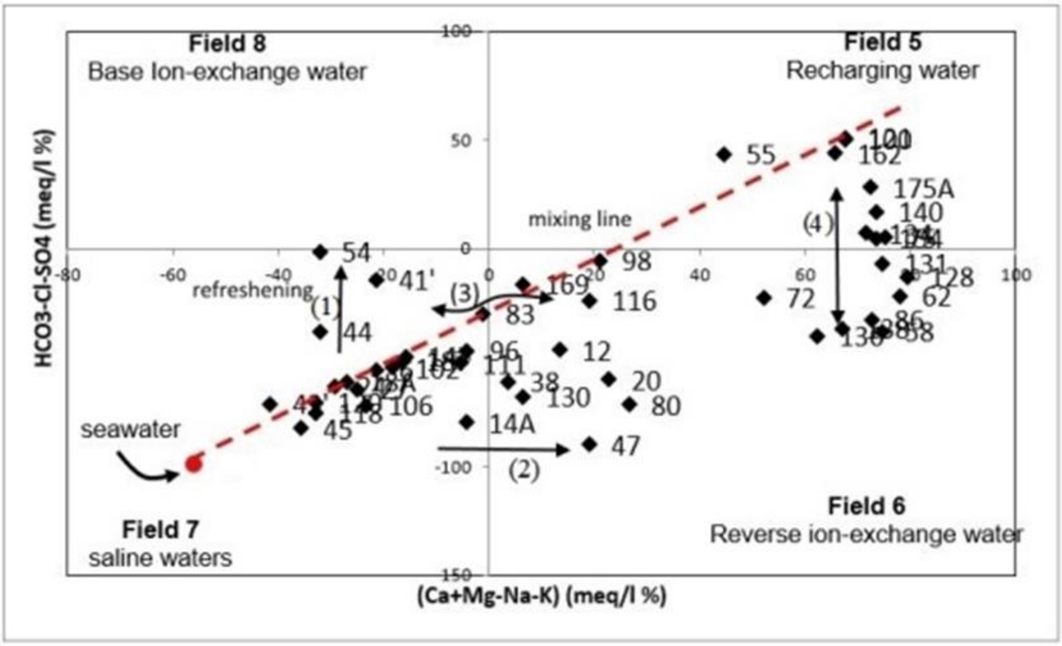

Figure 2: The geochemical processes in the groundwater illustrated on a Chadha diagram. Dashed line represents the mix of modern seawater with modern fresh water. Arrows represent hydrogeochemical processes as follows: (1) refreshening, (2) reverse cation exchange of aged seawater, (3) reverse cation exchange of modern seawater, (4) reverse cation exchange of aged fresh water. Double direction of the arrows means that the position of the sample shifts depending on the season time.

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