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Hydrochemical characteristics of the Oropos coastal aquifers, Attica, Greece

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This article deals with the hydrochemistry of coastal aquifers of the Oropos plain, Attica, Greece (Fig. 1). The geological structure of the study area is complex consisted of: (i) alpine sediments of Permo-Triassic volcanosedimentary and carbonate rocks, ophiolites and Cretaceous limestone and flysch (Katsikatsos, 2000); and (ii) post-alpine lacustrine, lagoon and torrential Miocene sediments, Pleistocene conglomerate/breccia and clay and Holocene clay, sand and conglomerate (Parginos et al., 1989, Perissoratis, 1989; Mettos, 1992). The Oropos plain is a NE-SW oriented neotectonic depression affected by W-E, NE-SW and NW-SE striking tectonic and neotectonic faults (Papanikolaou et al., 1986; Perissoratis, 1989; Papanikolaou *et al.*, 1989) as well as by the Pleistocene sea level fluctuations (Lambeck 1996). The interaction of tectonic and stratigraphic factors combined with eustatic changes established a complex hydrogeological regime where successive unconfined and confined aquifers have been formed. In total, four aquifers occur in the study area (Dounas et al., 1980; Pagounis 1994). The upper aquifer occurs in the Holocene sediments which is unconfined and locally confined. The second aquifer, which is confined, occurs in the Pleistocene sediments. The third aquifer occurs in the Miocene conglomerate and the last one in the Mesozoic carbonate.

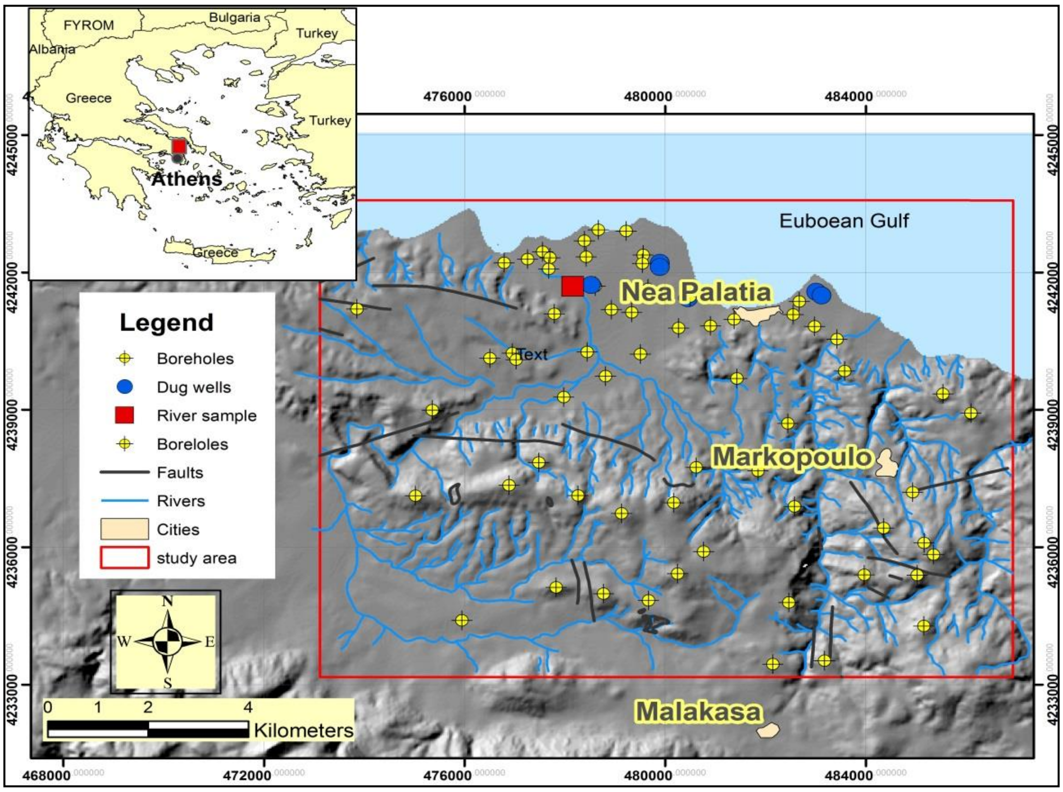

Figure 1. Study area.

The objective of this article was to highlight the occurrence of good quality groundwater which is hosted in the confined aquifer of the Pleistocene sediments located adjacent to the coastline of the Oropos plain.

The hydrochemistry of Oropos groundwaters has been investigated using major and heavy metal constituents. Groundwater samples from 36 wells and one sample from Asopos River surface water were collected. Physico-chemical characteristics of Temperature T (oC), pH and Electrical Conductivity EC (μS/cm) were measured in situ. The method of titration was used for Ca^{2+}, Mg^{2+}, HCO_3^-, and Cl^- determination and Hack Dr 3000 Spectrophotometer was used for NO_3^-, PO_4^{3-}, NH_4^+ and SiO_2 determination. The concentration of Na^+ and K^+ was determined using the CORNING Flame Photometer 410. Heavy metals Sr, Cd, Cu, Fe, Mn, Ni, Pb, Cr VI και Zn were determined using AAS GBS 908 Atomic Absorption Spectrophotometer. Ion balance error was better than 5%.

Hydrochemistry of groundwaters in the Holocene, Miocene and Mesozoic sediments indicated seawater influence. Electrical conductivity (EC) values ranged between 526 and 3770 μS/cm with a median at 2098 μS/cm. Chlorides ranged between 31 and 993 mg/l with a median at 260 mg/l. On the contrary, groundwater quality of the Pleistocene conglomerate was very good. The EC values which ranged between 766 and 971μS/cm with a median at 854 μS/cm and chlorides which ranged between 95 and 163 mg/l with a median 121 mg/l led to the conclusion that this coastal aquifer is protected from seawater intrusion, despite the fact that it is located adjacent to the coastline. The NO_3^- and PO_4^{3-} concentrations were increased in the agricultural area which is attributed to fertilizers. Most of the heavy metal concentration such as Cd, Fe, Pb and Ni exceeded the EU limits which they have been determined at 82, 2500, 817, 217 μg/lit respectively. Groundwaters were categorized into 2 main water types based on the expanded Durov diagram (Fig. 2) (Lambrakis, 1991): (i) the first group was mainly depicted on the field 2 indicating fresh groundwater of Ca-Mg-HCO3 type; and (ii) the second group was depicted on the field 8 that is Ca-Mg-Cl type indicating reverse cation exchange of old Na-Cl waters (Lloyd, *et al.* 1985). The Asopos River surface sample was projected on the field 9 indicating Na-Cl type contaminated by seawater. Based on the Piper diagram most of the samples showed Ca-Mg-Na-HCO3 type and some samples showed no dominant type which means mixing processes are in progress.

It is worth mentioned that the Pleistocene aquifer resources represent a reserve of good quality water which needs to be properly managed.

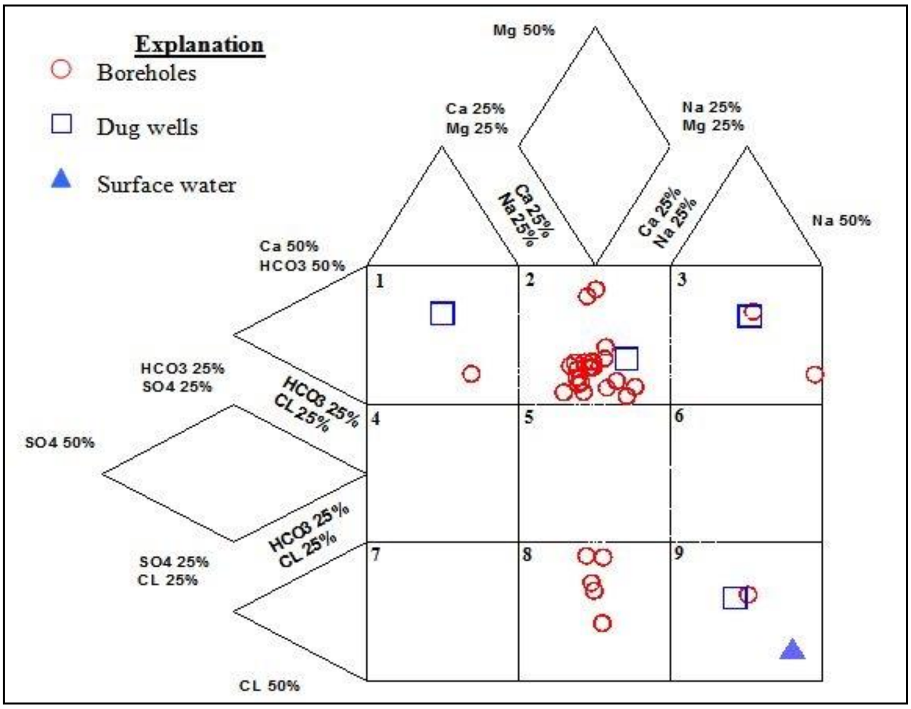

Figure 2. Expanded Durov diagram showing the classification of the Oropos groundwaters

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