Assessment of water quality in the Messolonghi–Etoliko and Neochorio region (West Greece) using hydrochemical and statistical analysis methods

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Abstract Assessment of the water quality can enhance understanding of the hydrochemical system and effective management of water resources. To this end, an assessment of water quality was conducted in the Messolonghi–Etoliko and Neochorio region. Surface water and groundwater samples have been collected, treated, and subjected to chemical analysis for the following parameters: Br$^-$, Cl$^-$, F$^-$, NO$_2^-$, NO$_3^-$, PO$_4^{3-}$, SO$_4^{2-}$, Li$^+$, Na$^+$, NH$_4^+$, K$^+$, Mg$^{2+}$, Ca$^{2+}$, HCO$_3^-$, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, and Zn. A characterization has been carried out using the Piper trilinear diagram, the United States Salinity Laboratory diagram, and the Wilcox diagram. Assessment of water samples by comparing the recorded values of the water quality parameters with the parametric values established by European Community indicated that the 50% of the surface water samples and 67% of the groundwater samples in the study area are chemically suitable for drinking use. Assessment of water samples from calculation of chemical indexes like sodium adsorption ratio, sodium percentage, residual sodium carbonate, and by comparing the values of the water quality parameters with the water quality limits established by Canadian Council of Minister of the Environment indicated that 75% of the surface water and that all the groundwater samples are chemically suitable for irrigation use.

Keywords Water quality · Hydrochemistry · Geochemical modeling · Messolonghi · Greece

Introduction

The increased demand for water due to agriculture expansion, growing population and urbanization, as well as the frequent and intense drought episodes due to anticipated climatic change will cause water shortages in many Mediterranean coastal areas (Alexakis and Tsakiris 2010). Furthermore, since water resources management has become increasingly important for sustainable development of these regions it is necessary to assess the suitability of water for agricultural use or human consumption. The quality of water is controlled by natural and anthropogenic factors that include geological structure and mineralogy.
of the watersheds and aquifers, the residence time, the reactions that take place within the aquifer as well as the type of land uses (Alexakis 2008; Appelo and Postma 2005; Bathrellos et al. 2007; Hajizadeh Namaghi et al. 2011; Kelepertsis et al. 2001; Lambrakis 2006; Palma et al. 2010; Saeedi et al. 2010; Stamatis and Gartzos 1999; Stamatis et al. 2006; Suthar et al. 2010). The interaction of natural and anthropogenic factors leads to various water types. According to Hamzaoui-Azaza et al. (2011), the increased knowledge of geochemical evolution of water quality could lead to effective management of water resources. Thus, the quality of water is equally important to that of quantity. By “proper management of water resources” is meant how the quality and quantity of water can be maintained in a sustainable manner.

In the present study, the aim is: (a) to record the present quality status of the surface and groundwater in the Messolonghi–Etoliko and Neochorio region, (b) to compare element contents in the water of the study area with standards for water recorded in the literature/legislation, and (c) to aid the management and future development of water resources in the region.

Study area

The studied area is situated in the western part of central Greece (Fig. 1). The Messolonghi–Etoliko and Neochorio region is located about 250 km northwest from Athens, the capital of the Greek Republic (Fig. 1). It includes the cities of Neochorio, Etoliko, and Messolonghi and the villages of Pentalofo, Katochi, Ellinika, and Agios Thomas. Messolonghi–Etoliko and Neochorio region is bordered in the west by the Messolonghi lagoon, respectively (Fig. 1). The area studied extends from the Pentalofo village in the north to the Evinos cape in the south, from the Neochorio village in the west to the Arakynthos Mountain in the east (Fig. 1). The study area is lying between the latitudes 38°16′ and 38°29′ and longitudes 21°13′ and 21°31′. Morphologically, the study area can be separated into two sections, namely flat and hilly. The Messolonghi plain with an altitude ranging from 0 to 20 m is situated in the eastern part of the area and Neochorio plain with an altitude ranging from 0 to 20 m is situated in the western part of the area. The hills of Pentalofo with an altitude ranging from 30 to 200 m, are located in the western part of the area (Fig. 1). The Arakynthos Mountain with an altitude varying between 100 and 800 m is situated in the eastern part of the area (Fig. 1).

The geological structure of Messolonghi–Etoliko and Neochorio region comprises limestones, flysch, breccias, evaporites (mainly microcrystalline Gypsum: CaSO₄ 2 H₂O) and sedimentary deposits (IGME 1989, 1991, 1998) (Fig. 1). The Alluvial deposits cover the central part of the study area, which include alluvial deposits, recent delta deposits, lagoonal deposits, red clays, and sandy materials. The thickness of the alluvial deposits ranges up to a few meters. The fluvial lacustrine deposits of the Pliocene age, consisting of coarse-grained sandstones, marly sandstones, and conglomerates, occur in the central part of the study area. The thickness of the sediments is estimated as about 80–100 m. The eastern part of the study area is controlled by a fault system with predominate northeast–southwest direction as well by smaller faults of northwest–southeast direction. Generally, the study area can be divided into two main aquifers: a hard-rock aquifer (aquifer developed on limestones and breccias) and an alluvial aquifer. The limestones and breccias constitute the most important aquifer of the western section of the study area; while alluvial deposits constitute a phreatic aquifer which is the most important aquifer of the eastern section of the study area. The phreatic aquifer feeds wells with depths ranging from 5 to 15 m and discharges up to 10 m³ h⁻¹. The hard rock aquifer feeds boreholes with depths ranging from 30 to 40 m and discharges up to 100 m³ h⁻¹.

A major form of land use in the areas for centuries has been agriculture. Messolonghi la- goon, which is under the protection of the Ramsar convention, is an extremely sensitive and valuable ecosystem that constitutes an important regional resource for fisheries, salt extraction, aquaculture, and tourism. Artificial channels were originally constructed to drain the cultivated areas of Messolonghi–Etoliko and Neochorio region. Small breeding farms of cattle and pig are