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Investigation of Seawater Intrusion Zone in the Coastal Area Stavros-Vrasna Using Hydrogeological and Geophysical Methods

D.G. Zerva[1], K. Voudouris[1], G. Vargemezis[2], P.Tsourlos[2]

(1) Aristotle University of Thessaloniki, Department of Geology, Lab. of Engineering Geology & Hydrogeology, 54124 Thessaloniki, Greece, d.zerva2009@gmail.com
(2) Aristotle University of Thessaloniki, Department of Geology, Lab. of Applied Geophysics, 54124 Thessaloniki, Greece

Abstract

The survey was conducted in Stavros-Vrasna area which is located in northern Greece at the eastern part of the prefecture of Thessaloniki and covers 11.27 km^2. Groundwater sampling took place during the dry season, and the samples were analyzed. Moreover, geophysical survey by the application of geoelectrical tomography method has been conducted. Six (6) geoelectrical tomographies were measured in order to determine the electrical resistivity of underground. The results show 3 different lithological types of aquifers: a) Sedimentary, b) Karstic and c) Fractured. The dominant groundwater aquifer is porous, and most part of it, is confined. In the area of Vrasna, a salinity zone has been detected by geoelectrical survey at a quite large distance from drinking wells, enough to not allow any affection. In opposition with the results of hydrochemical analysis, in the area of Stavros an early stage of seawater intrusion has been detected at the W_St1 well by the geophysical survey.

Since the needs of the entire area especially during summer period are limitedly satisfied, mapping of possible salinity zones is very crucial to avoid the quality degradation of the groundwater caused by new drillings in these zones.

Introduction

Salinization (or seawater intrusion) is a widespread phenomenon that concerns coastal aquifers. The reasons of salinization are many and can be related to each other. The climatic change (Ferguson et al., 2012) which results in the rise of the sea-level, the over extraction caused by the increased irrigation needs, the urbanization increase of coastal areas (Neumann et al., 2015), the touristic development (Garcia et al., 2003), even the impact of topography and the aquifer recharge have led to a numerous of studies and approaches.

The objective of this study is to determine the extent of seawater intrusion in the coastal area of Stavros-Vrasna by the use of Electrical Resistivity Tomography (ERT), as a 2D resistivity method, in conjunction with hydrochemical data.

Methodology

Groundwater samples were collected from 17 waterwells and physicochemical parameters of Electrical Conductivity (E.C.), Total Dissolved Solids (T.D.S), active acidity (pH) and temperature (T) have been measured. Moreover, the samples from 11 hydrowells were analyzed by hydrochemical methods and the main ions were measured (Mg^{2+}, Ca^{2+}, Na^+, K^+, HCO_3^-, NO_3^-, SO_4^{2-} and Cl^-) and ionic ratios Mg/Ca, Cl/HCO_3, Na/Cl, (Ca+Mg)/(Na+K), Na/K, SO_4/Cl and Na/Ca have been calculated (Fig. 1).

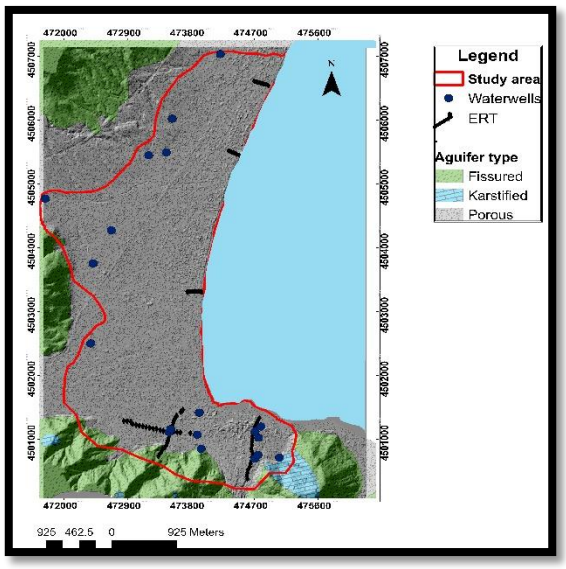

Figure 1. Map of study area.

Six Electrical Resistivities Tomographies (ERT) were measured. Three ERT of 1000 m each were conducted in Stavros and three of 230 m each in Vrasna. Two types of arrays were used, Dipole-dipole and Multiple Gradient.

Results

Throughout the coastal aquifer, the temperature, pH and electrical conductivity with the total dissolved solids are within the normal range. According to the ionic ratio of Na^+/Cl^-, seawater intrusion does not occur, while the high concentrations of Na^+ indicate either the weathering of alkaline formation nor possible sewages. Nevertheless, the geophysical survey reveals, in Stavros area, the potential hazard for seawater intrusion at W_St1 well (Fig. 2).

Moreover, the geophysical survey revealed 5 potential waterwell locations for the avoidance of the W_St1 well further charge and defined that the salinization zone of Vrasna is far from drinking well's locations. Additionally, the lithostratigraphy of the coastal aquifer in the area of Vrasna has been determined (Fig. 3).

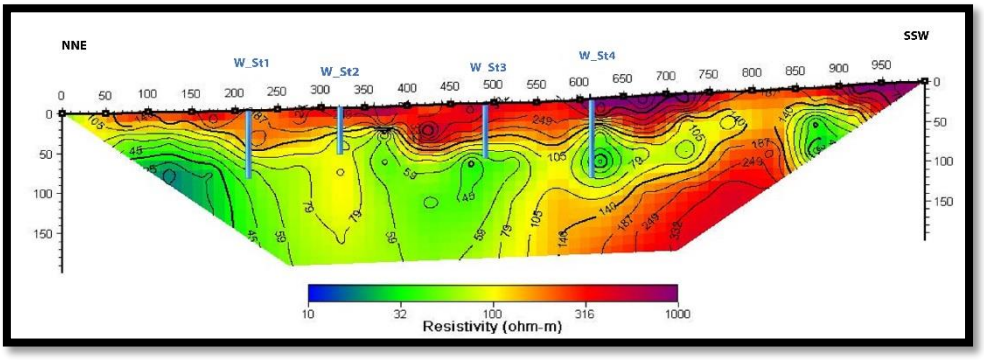

Figure 2. Electrical Resistivity Tomography (ERT) St1.

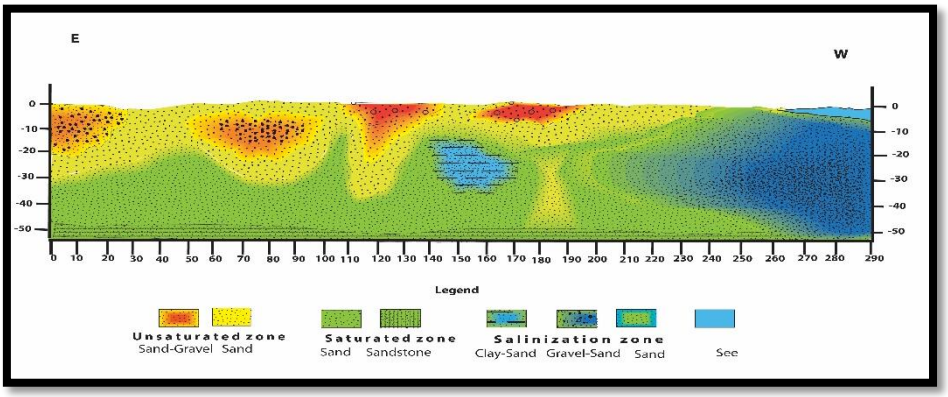

Figure 3. Hydrolithogeophysical section Vr3 (Vrasna).

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