Correlation between chemo-physical parameters NH_3, NO_2, NO_3, SO_4, pH and aquifer and impervious layer electrical resistance in groundwater

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Abstract

Groundwater resources polluted by different compounds limits the possibility of using this important resource. In this research, with the intention of improving the controls for water quality, geo electric methods and determination of the relation between the chemo-physical properties in groundwater and the aquifer and impervious layer of electrical resistances were investigated. The wells in the Yaftabad area in Tehran were investigated in this research. The results show that the true resistance of the aquifer is about 90–134 ohm.m, and for the impervious layer it is 19–78 ohm.m. According to the aquifer and impervious layer resistance and the results of laboratory study diagrams, equations and correlations between the chemo-physical properties of groundwater and true specific electrical resistance were obtained. There is a relation between the true specific electrical resistance of the aquifer and the impervious layer with the most numerous of chemo-physical properties. The extent of the correlation constant variation for NO_2, NO_3, NH_3, and pH is medium and for SO_4 is strong with true specific electrical resistance of the aquifer. The extent of the correlation constant variation for NO_2 is medium, for NH_3 and SO_4 is strong and for NO_3 and pH is too strong with true specific electrical resistance of the impervious layer. The average extent value of the correlation constant variation between chemo-physical properties in groundwater and the true specific electrical resistance of the aquifer is equal to 0.698 and for the impervious layer is equal to 0.539.
Keywords: groundwater quality, aquifer, impervious layer, geo electrics.

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1 Introduction

Groundwater is a highly useful and often abundant resource. It is also ecologically important. About half the population in the city of Tehran relies to some extent on groundwater as a source of drinking water, and still more use it to supply their factories with process water or their farms with irrigation water. Certain problems have beset the use of groundwater around the city and the province of Tehran.

Some of the most important parameters in water are nitrogen compounds. It contains Nitrite (NO_2^-), Nitrate (NO_3^-) and ammonium (NH_3). Nitrate is the common form of inorganic nitrogen found dissolved in water. Groundwater in this region can be polluted by nitrogen from both the discharge (diffusion) of municipal wastewater and drainage from agricultural lands. The health hazard of ingesting excessive nitrate in water is infant methemoglobinemia [3].

Since sulfate is soluble in water, it is found at high concentrations in many aquifers. Sulfate is an oxidized form of sulfur. There are many potential sources of sulfate. Gypsum is an important source in many aquifers that have high concentrations of sulfate. Reduced forms of sulfur are oxidized to sulfate in the presence of oxygen. This process often occurs when sulfide minerals are mined.

Sulfate does not have a health-based drinking water standard. Sulfate has laxative effects and imparts an unpleasant taste to water. Aquifers with high concentrations of hydrogen sulfide have a bad odor [6].

The pH of water determines the solubility and biological availability of chemical constituents such as nutrients and heavy metals [10].

Total dissolved solids (TDS), is defined as the concentration of all dissolved minerals in the water. TDS are a direct measurement of the interaction between ground water and subsurface minerals. High TDS, greater than 1000 mg/L, is commonly objectionable or offensive to taste. The high TDS may cause corrosion of pipes and plumbing systems [8].

Ground water, especially if the water is acidic, in many places contains excessive amounts of iron. Iron causes reddish stains on plumbing fixtures [9]. Table 1 shows total maximum acceptable concentration of chemo-physical properties based on world standards.

In this research, regarding the importance and danger of groundwater pollutants in urban zones and the need to get improved control of wells quality, we investigated geoelectric methods and determination of some relation between chemo-physical properties in groundwater and aquifer and impervious layer electrical resistances.

Geoelectrical methods are used extensively in groundwater mapping for investigation of the vulnerability of aquifers and shallow aquifers themselves. A geoelectrical measurement is carried out by recording the electrical potential arising from current input into the ground with the purpose of achieving information on the resistivity structure in the ground.

Geoelectrical data are commonly expressed as apparent resistivities

$$\rho a= (\Delta V/l)K$$

Table 1: Total maximum acceptable concentration of chemo-physical parameters, based on world famous standards.

Parameter	USEPA Maximum Contaminant Level(MCL)	Canada Maximum Acceptable Concentration	EEC Maximum Admissible Concentration	Japan Maximum Admissible concentration	WHO Guideline
Ammonium			0.5 mg/L	No standard	1.5 mg/L
Cadmium	0.005 mg/L	0.005 mg/L	0.005 mg/L	0.01 mg/L	0.01 mg/L
Chromium	0.1 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Iron	0.3 mg/L	0.3 mg/L	0.2 mg/L	0.3 mg/L	0.3 mg/L
Manganese	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.01-0.05 mg/L	0.1-0.5 mg/L
Nitrate/Nitrite,total	10 mg/L as N			10 mg/L as N	
Nitrates	10 mg/L as N	10 mg/L as N	50 mg/L	10 mg/L as N	50 mg/L as NO3-
Nitrites	1 mg/L as N	3.2 mg/L	0.1 mg/L	10 mg/L	3 mg/L as NO2-
pH	6.5-8.5	6.5-8.5	6.5-9.5	5.8-8.6	6.5-8.5
Potassium		0.002 mg/L	0.5 µg/L C6H5OH	0.005 mg/L	
Solids,total dissolved	500 mg/L	500 mg/L	No Standard	500 mg/L	1000 mg/L
Sodium			75-150 mg/L	200 mg/L	200 mg/L
Sulfate	250 mg/L	500 mg/L	250 mg/L	No standard	250 mg/L
Zinc	5 mg/L	5 mg/L	No Standard	1.0 mg/L	3.0 mg/L

where ΔV is the measured potential, 1 the transmitted current and K the geometrical factor. One of the most common electrode arrays is Schlumberger.

Vertical electrical sounding (VES) is used to determine the resistivity variation with depth. A VES is typically carried out in Schlumberger array, where the potential electrodes are placed in a fixed position with a short separation and the current electrodes are placed symmetrically on the outer sides of the potential electrodes (Fig. 1). After each resistivity measurement the current electrodes are moved further away from the center of the array. In this way the current is stepwise made to flow through deeper and deeper parts of the ground. The positions of the current electrodes are typically logarithmically distributed with at least 10 positions per decade [4, 5, 7].

The most important parameter investigated in this paper is Correlation constant. Correlation constant is a statistical parameter that shows different degrees and conditions of correlation between 2 variations. General formula for calculating correlation constant between 2 variations X and Y is like below. This constant (R_{XY}) is named Pearson constant [4, 5, 7].

$$R_{XY} = \frac{\Sigma(X - M_x)(Y - M_Y)}{\sqrt{\Sigma(X - M_X)^2 \Sigma(Y - M_Y)^2}}$$

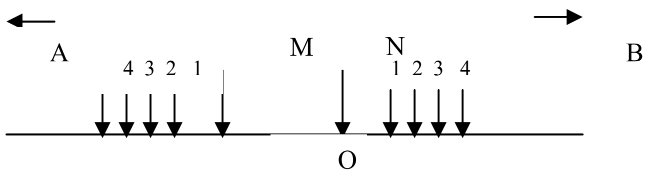


Figure 1: Flow electrodes movements' stages in electrical sounding method (Schlumberger array).

Table 2: Different values of correlation constants and their qualifying classifications.

Constant Value lower than 0.2	Insignificant
Constant Value between 0.2 to 0.4	Weak
Constant Value between 0.4 to 0.6	Medium
Constant Value between 0.6 to 0.8	Strong
Constant Value between 0.8 to 1	Too Strong

If validity of existing statistical relation assured between parameters, qualify assessment will define intensity of this relation. Correlation constants can classify as following (Table 2).

2 Materials and methods

In order to analyze the water quality, laboratory experiments have been carried out using the APHA 1998 [1].

Wells in Yaftabad area in Tehran (Group wells no 300, which include wells no: 301, 302, 303, 304, 305 and 306) were investigated as a case study (Fig. 2).

For studying electrical properties of aquifer, impervious layer and their resistance, we completed six electrical soundings (in Schlumberger method) around 301 to 306 application wells with an average length of AB equal 600 meter. This act accomplished three times for every well except 302, and for well no 302, because of better circumference five times at different time periods [2].

3 Results

Sounding measurements results comment on comparison with standard diagrams. The result of these comments is showing that the true resistance of the aquifer is about 90 to 134 ohm.m and for the impervious layer are 19 to 78 ohm.m. According to aquifer and impervious layer resistance, also laboratory studies we obtained following results (Figures 3, 4).

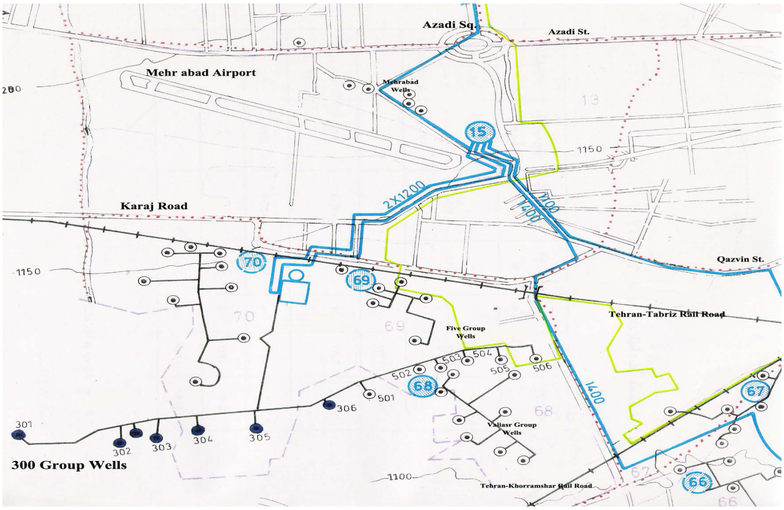


Figure 2: Settlement of 300 group wells [2].

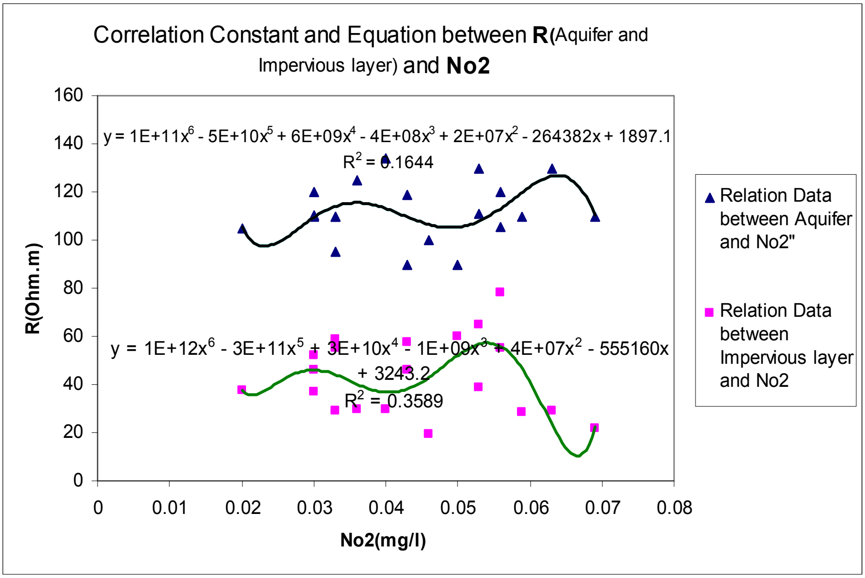
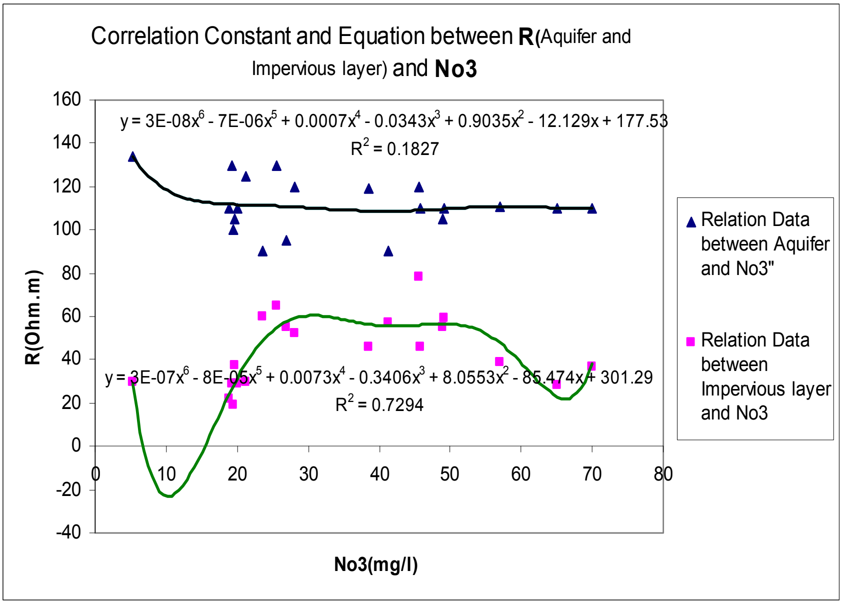
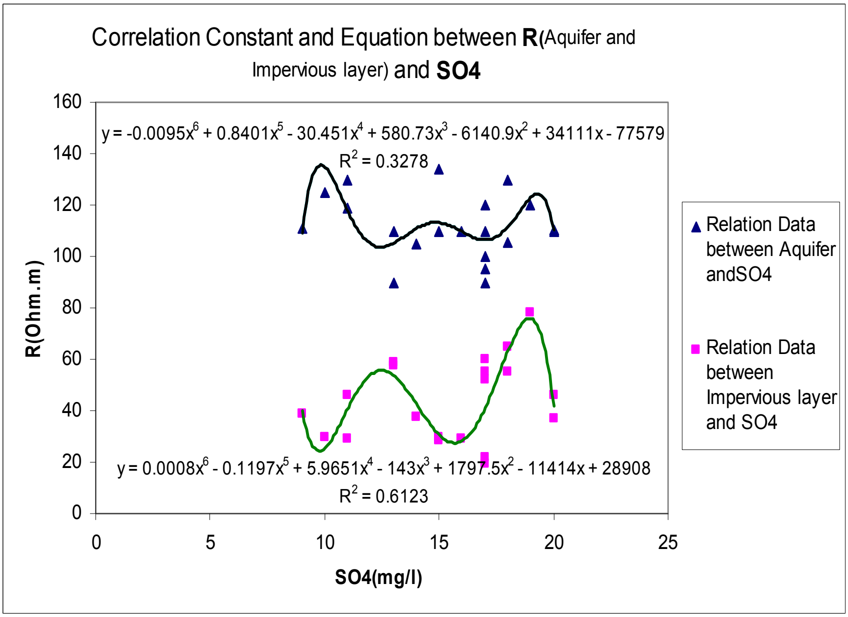


Figure 3: Diagrams, equations and correlations.





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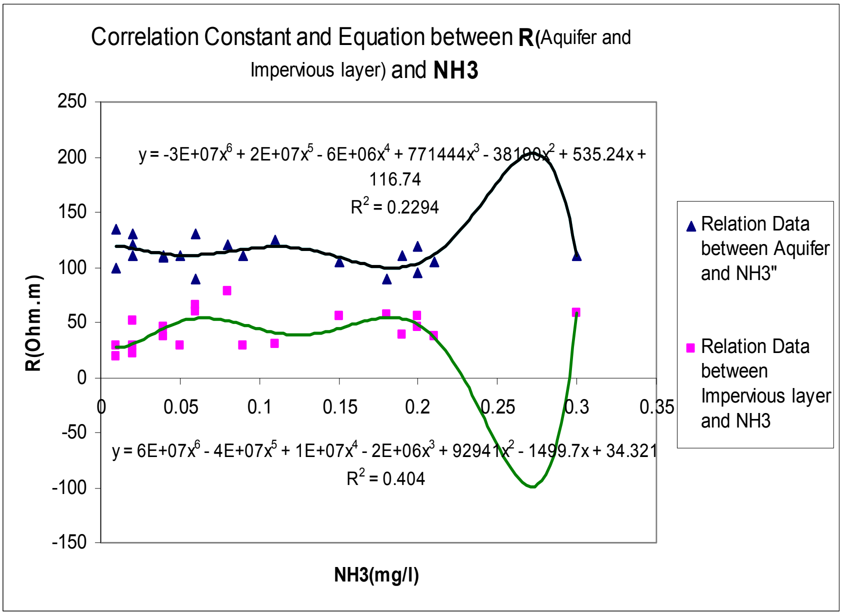

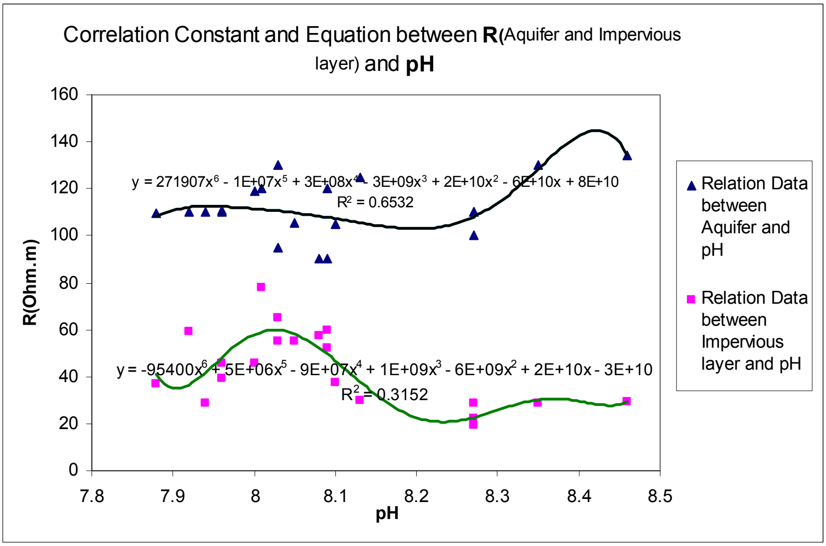

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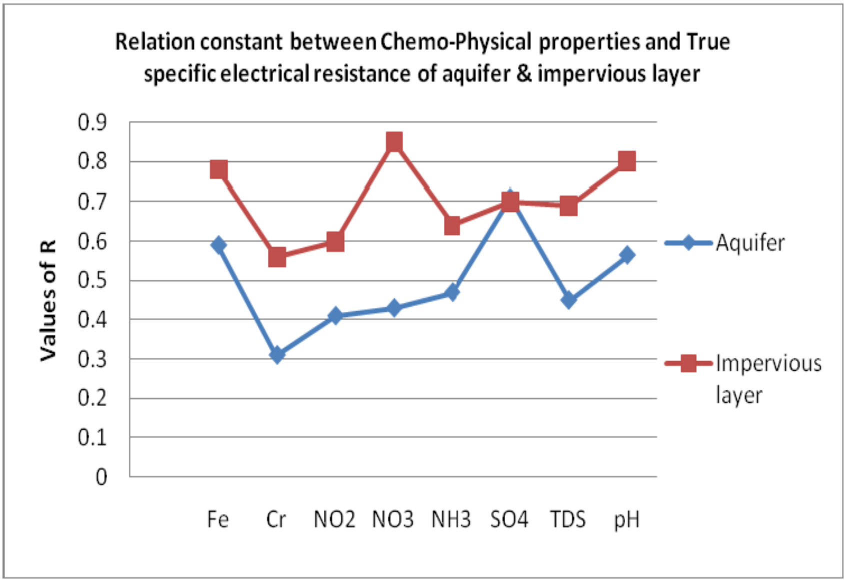

Figure 4: Calculated correlation values between true specific electrical resistance of the aquifer and the impervious layer with the chemo-physical properties of groundwater.

4 Conclusion

After this study and regarding to the results, there is a relation between true specific electrical resistance of aquifer and impervious layer with the most numerous of chemo-physical properties. Except Cr extent of correlation constant variation for Fe, NO_2, NO_3, NH_3, TDS and pH are medium and for SO_4 is strong with true specific electrical resistance of aquifer. Except K, extent of correlation constant variation for NO_2 and Cr are medium and for NH_3, SO_4 and TDS are strong; NO_3 and pH are too strong with true specific electrical resistance of impervious layer. Average extent values of correlation constant variation between chemo-physical properties in groundwater & true specific electrical resistance of aquifer is equal 0.698 and for impervious layer is equal 0.539.

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