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EVALUATION OF GROUNDWATER QUALITY INDEX (GWQI) BY GIS SOFTWARE AROUND MAMLOU DAM (IRAN)

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ABSTRACT

Water has different physical characteristics as turbidity, color, TDS, etc. On the other hand, chemical characteristics of water such as alkalinity, acidity, and hardness can affect its quality. Physicochemical characteristic observation of groundwater resources, based on chemical analysis of the dry and wet period of 2016 and transferred to GIS software and analysis in quality observation has been done in Mamlou dam aquifer in Tehran (Iran). In this study, physicochemical parameters for 16 wells from 16 villages have been experienced. The parameters were: TDS, Cl, SO4, NO3, Ca, Mg, EC, F, HCO3-, pH, total hardness, turbidity, and Na. Finally, groundwater quality index or GWQI was calculated for each village in the dry and wet period of 2016 by just 7 parameters. The results showed that two villages in the research area had a serious problem with drinking water. GWQI for Garmabsard and Viraneh villages were respectively more than 140 and 100 in both dry and wet period of 2016, which shows the water is unsuitable for drinking in these two villages. TDS of the 2 villages are more than 1500 ppm, but they did not have any problem with Calcium and Magnesium. Other parameters such as turbidity follow a different trend and most of the time its problem is related to seasonal rainfall.

Keywords: *Physicochemical Parameters, Quality Index, Fingerprinting, Groundwater, GIS System.*

INTRODUCTION

Groundwater is the most vital natural resource and the main element of the ecological system. In addition to the surface water, groundwater has become the major source of water supply for drinking, domestic, household, agricultural, industrial, recreational, and environmental activities etc. This has led to an increase in water supply which is met mostly to use of groundwater resources. Nowadays, groundwater is a very important concern for mankind since it is directly linked to human safety. Determination of physical, chemical and bacteriological quality of groundwater is important for assessing various usages. Variation in groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by natural processes such as geological formations and anthropogenic activities. (Selvakumar et al., 2017)

Evaluation of groundwater quality is a complex process that undertakes numerous variables capable of causing various stresses on general groundwater quality. (Bodrud-Doza et al., 2016)

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It is essential to supply drinking water for any society and in this research, we just work on the quality of groundwater in some villages near Tehran in Iran, not on the quantity. In this research, the drinking water quality focused on TDS, Cl, SO4, NO3, Ca, Mg and Na.

Turbidity is a phenomenon that shows the amount of water transparency and it is a character related to water appearance. (Shariatpanahi.M, 2012) TDS is total suspended solids in water and the summation of all ions. It is clear that the summation must be based on $CaCO_3$ equivalent. (Chalkesh Amiri, 2005)

Chloride in drinking water originates from natural sources, sewage and industrial effluents, fertilizers, leachate and saline intrusion. High chloride concentration produces hypertension, osteoporosis, and asthma in human beings. (Dhanasekarapandian et al., 2016) The presence of sulfate in drinking water can cause a noticeable taste, and at very high levels. (Dhanasekarapandian et al., 2016). Nitrite, or nitrate converted to nitrite in the body, causes two chemical reactions that can cause adverse health effects: induction of methemoglobinemia, especially in infants below one year of age, and the potential formation of carcinogenic nitrosamides and nitrosamines. (Letterman, 1999). Calcium with bicarbonate can increase temporary hardness. Sulphate, chloride, and nitrate can make permanent hardness. Calcium is one of the most important elements in human food but calcium concentration in water is negligible in comparison to other resources and most of its sediments. (Shariatpanahi, 2012). Magnesium is a common element in water. High concentration of Magnesium in domestic usage can make precipitation in containers. Also, it can cause Diarrhea. Magnesium Hydroxide is a little soluble in pH more than 10. (Shariatpanahi, 2012). Sodium is a naturally occurring constituent of drinking water.

There is strong evidence that there is an at-risk population of persons predisposed to high blood pressure (hypertension) from dietary sodium. (Letterman, 1999).

According to the importance of water supply and its quality and quantity, before well water digging we have to know about the situation of groundwater sources because without this kind of studies, cost and time will be wasted and health of customers will be damaged.

Therefore, study on physicochemical characteristics of actual water sources as wells and rivers, based on chemical analysis results in different periods (wet and dry periods) and modeling in GIS software with the analysis in study phase is very important to choose water sources.

However, this study is very essential to know the actual situation and for future policies in water supply for customers. Any practical phase needs study phase and Theoretical studies can provide GIS maps as a model for changes in physicochemical parameters, and practical studies can help to choose the best policy for water supply, water treatment, fingerprinting of water pollution and try to prevent water pollution in the mentioned area.

The objective of this study is to research on physicochemical characteristics of groundwater and fingerprinting of their changes in GIS software. Practical goal is starting construction phase for water supply based on scientific and precise aspects. Moreover, the special purpose of this research is to find the basis of pollutions to prevent more damages.

METHODOLOGY

Many studies have been conducted in this regard in Iran and other countries. Mir et al. (2017) have worked on spatial monitoring and zoning water quality of Sistan River in the wet and dry years using GIS and geostatistics. This study deals with spatial monitoring of chemical parameters of Sistan River water in the dry and wet years in order to follow the variations in the water chemical quality, determine the most suitable sites to extract potable water and irrigation, and optimize management of water resources in Sistan Plain. Moreover, in the wet year period, river's water quality located in the range of good and acceptable has no limitation in terms of drinking. (Mir et al., 2017)

Nourbakhsh et al. (2015) have proposed an Index to Evaluate the Groundwater Quality Using "Multi-Criteria Decision Making" Approach and Analyzing the Spatial Distribution of it in Tajan Plain, Northern Iran. Finally, the quality index values in each well were calculated by aggregating the sub-index of entire parameters. (Nourbakhsh et al., 2015)

Zheng et al. (2017) have investigated the Hydrochemical characteristics and quality of shallow groundwater in Xincai River Basin, Northern China. In the study area, groundwater flows from northwest to southeast. A total of 45 shallow groundwater samples were taken from Xincai River Basin from August to September, 2013. Electrical conductivity (EC), pH, NO3-N, NO2-N, NH4-N, TH, TDS, K, Na, Ca, Mg and Fe were analyzed. The groundwater quality assessment results show that the shallow groundwater quality in Xincai River Basin is relatively poor and approximately, half of the shallow groundwater is not suitable for drinking, which may be caused by excessive use of chemical fertilizers. (Zheng et al., 2017)

Kourgialas et al. (2017) have assessed the effect of fertilizers on the quality of drinking and irrigation water and wellhead protection zones (Crete, Greece). Groundwater samples collected from 235 different boreholes/wells (10 drinking water wells and 225 irrigation wells) were analyzed to determine the potential concentration of major- and trace elements originating from tree crops fertilizers. This study concerns pollutants related directly to the agricultural fertilizers commonly used in the study area: NO3, PO4 3-, K+, Fe2+, Mn2+, Zn2+, Cu2+, and B3+. The pollutant concentrations were obtained from the groundwater sampling data. From the available data and by using geo-informatic techniques within GIS, the spatial distribution of the major- and trace-element concentrations in the groundwater was estimated. (Kourgialas et al., 2017)

Case study

Geographical coordination of site is between 39° 44' to 39° 68' north latitude and 56 ° to 60° eastern length. Research location included some villages around Mamlou dam which include areas in Damavand and Pardis. Damavand is a city in Tehran province, Iran. Its area is 188000 hectares limited to Firouzkouh, Amol, Varamin, Garmsar, and Tehran and this area is covered by mountains. The average height of the sea is around 2000 meters. 83% of the area belongs to natural sources organization, 16% is farmland and 1 % is urban. Based on the census in 2011, the population of Damavand was 100690 people (30098 families). 52545 of them were men and 48148 capita were women. This city has two parts including central and Boumehen includes 12 towns and 167 villages.

This area has three main rivers: Jajroud river, Damavand and Aah river which Mamlou dam is located on Jajroud river.

Sampling was done in a dry season (August and September) and a wet season (November and December) of 2016.

Well selection

Considering that all wells are near Jajroud River and Mamlou dam and these wells are sources of potable water for the villagers, 16 wells from 16 villages have been selected randomly to study on their physical and chemical qualitative parameters. The names and coordination of villages are as follows: Louman (52.209, 35.629), Masha (52.034, 35.761), Kaldasht-bala (52.052, 35.677), Seyedabad (52.372, 35.63), Moqanak (52.261, 35.561), Hesar-bala (52.04, 35.679), Vadan (52.083, 35.639), Viraneh (52.209, 35.492), Jaban (52.259, 35.629), Chenaran (51.99, 35.706), Eslamabad (52.046, 35.658), Estalak (56.256, 93.51), Zerehdar (51.881, 35.623), Saeedabad (51.696, 35.734), Khosroabad (51.697, 35.757), Garmabsard (52.349, 35.467). Location of wells is seen in figure-1.

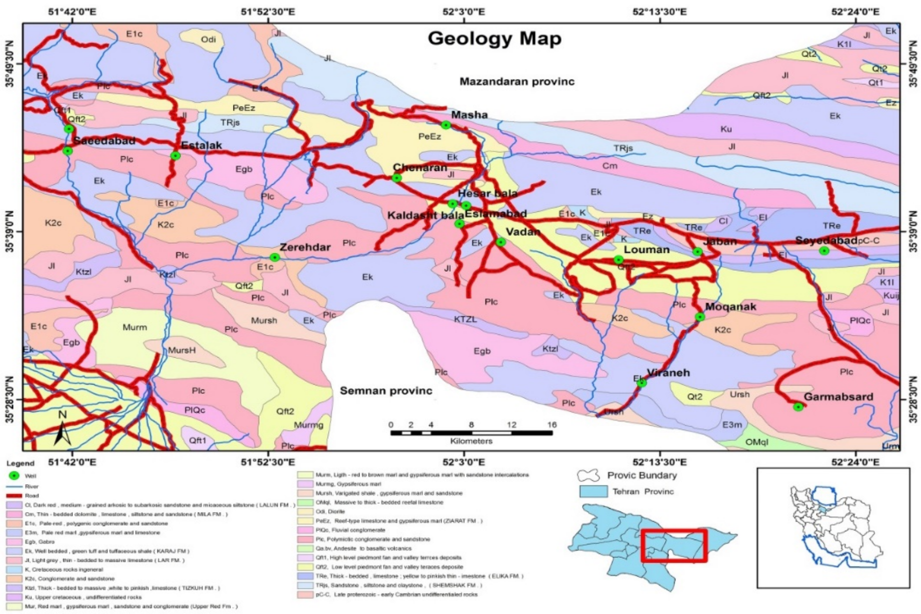

Figure 1: Geographical location of wells

Analytical procedure

For sampling, we used Plastic vessels for chemical sampling and water samples were transferred to water organization laboratory. In this research, all samplings were manual. First, PE vessels were used (1.5 liters at least). Vessels were washed with detergents, raw water, and distilled water. Then vessels were dried and filled with water samples in locations and labeled with the location, time and some in situ parameters as pH and temperature. Samples were conserved in the refrigerator to transfer to the laboratory. In the laboratory, used vessels were washed with nitric acid and distilled water.

All experiments were done based on a standard method for the examination of water and wastewater, 1998. Experiment codes based on mentioned standard, are written as follows:

TDS by 2540, Cl^- by cl^-4500, SO_4^{-2} by SO_4^{2-}4500, NO3 – by NO_3^- 4500, Ca 2+ by Ca^{2+} 3500, Mg $^{2+}$ by Mg^{2+} 3500, Na $^+$ by Na^+-3500, EC by A-2510, F – by F^- 4500, HCO3 – by 2330, PH by A-4500, total hardness by 2340, turbidity by 2130 (Brower et al., 1998).

Calculation of GWQI

First, all data from sampling and experiments were organized in excel files. These data were included wells location and physicochemical parameters of water as TDS, Mg, Ca, Na, NO3, SO4, and Cl. In the next stage, the groundwater quality index or GWQI was calculated based on the following stages.

First stage – index weighting

Wight for each parameter is as following: TDS= 3, Cl = 3, SO4= 4, NO3=5, Ca= 2, Mg= 2, Na=4 (Borud et al. 2016).

Second stage- Ci/Csi calculation for each ion in each village in a dry and wet period of the related year

Third stage – coefficient usage from the first stage should be multiplied to numbers in the second stage (w*Ci/Csi)

The weighting factor (w) by percentage will be: TDS= 13, Cl = 13, SO4= 17, NO3= 22, Ca= 9, Mg= 9, Na=17

Fourth stage – GWQI calculation by summation of previous numbers as the following equation:

$$GWQI = \sum w * \frac{Ci}{Csi} * 100$$

If GWQI is less than 50, the water quality is excellent. GWQI between 51 and 100, shows that the water quality is good. However, when GWQI is more than 101, water is unsuitable for drinking. (Borud et al. 2016)

RESULTS AND DISCUSSION

For Assessment of water quality using GWQI, we prepared charts for GWQI and physicochemical parameters by Excel. Figure-2 shows GWQI for a wet period of 2016.

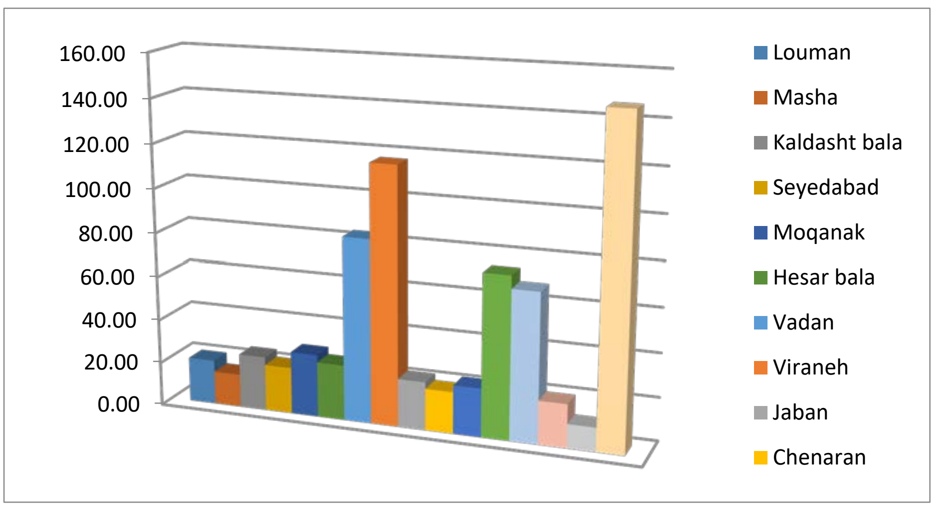

Figure 2: GWQI for the wet period of 2016

It is obvious that GWQI000 for Viraneh and Garmabsard is more than 100. Therefore, the groundwater is unsuitable for drinking. It is due to high concentration of TDS and Sodium, especially for Garmabsard.

The condition of GWQI for mentioned villages is same as the wet period of 2016 and Figure-3 shows GWQI for a wet period of 2016.

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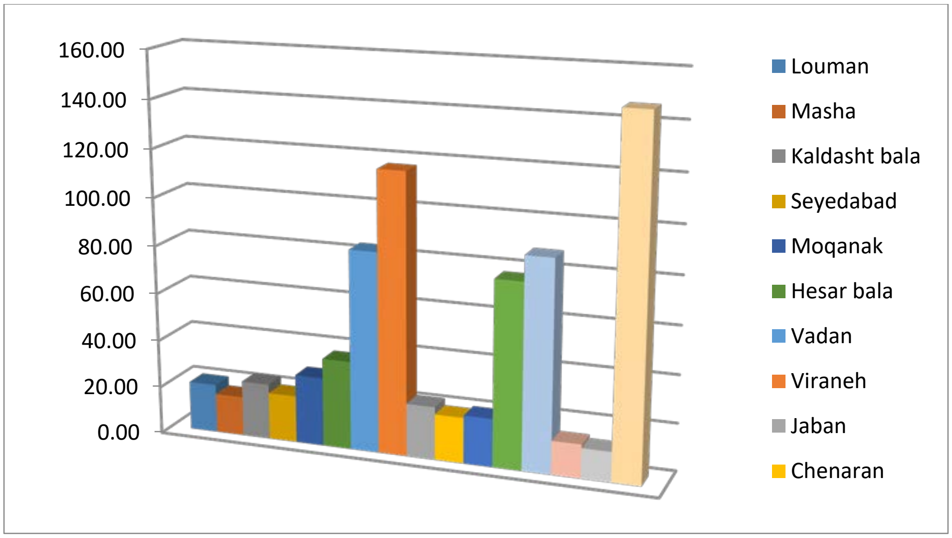

Figure 3: GWQI for dry period of 2016

CONCLUSION

In wet period GWQI is high for Viraneh. Therefore, this village has a serious problem with groundwater quality for drinking usage. Moreover, it is average in Zerehdar, Estalak, and Vadan. Figure-4 shows GWQI for the dry period of 2016.

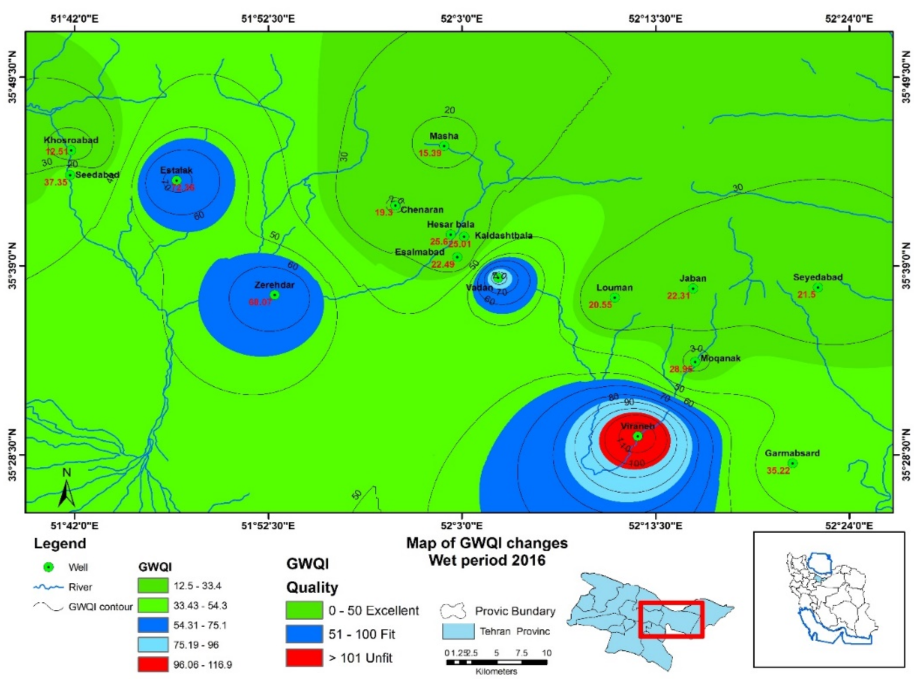

Figure 4: GWQI for wet period of 2016

Unfortunately, Garmabsard and Viraneh do not have a good condition for drinking water; hence, their drinking water must be supplied from another source as surface water or special treatment must be used for the groundwater water. Groundwater quality for drinking is average in Zerehdar, Estalak, and Vadan. Hence, if water follows the previous trend, they may have a problem in the near future. Maybe, study of land use study for agriculture or industries can help people in this area.

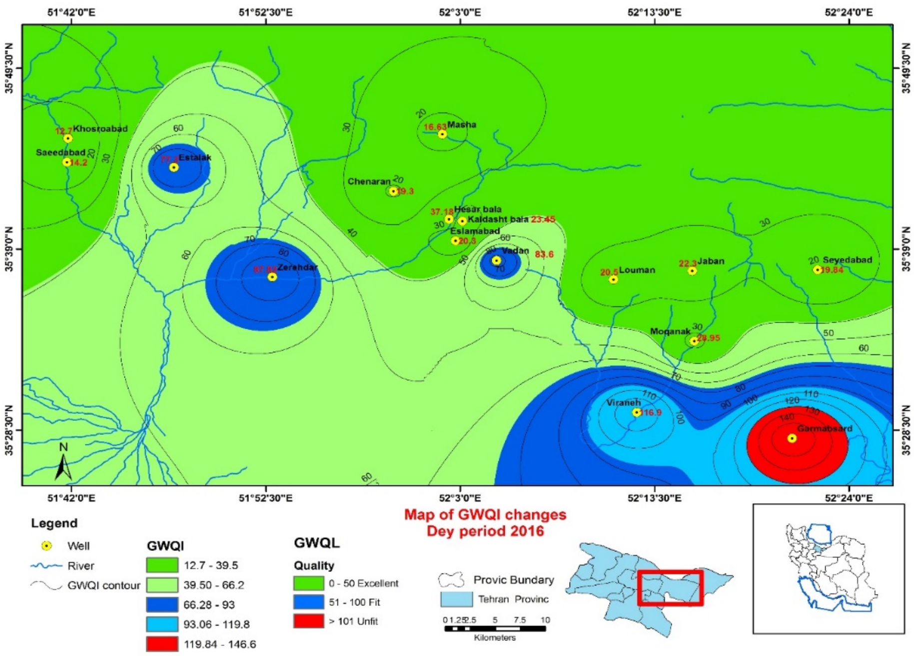

Figure 5: GWQI for the dry period of 2016

The situation in dry period is same as wet period and in Garmabsard and Viraneh villages, GWQI is more than 100. Therefore, these villages have a serious problem with groundwater quality for drinking usage. And it is average in Zerehdar, Estalak, and Vadan. Also, this is important that groundwater movement is from north-west to south-east and it is obvious that ions soluted in water are more in the south-east.

Suggestions for future studies:

- Making proper caps for wells in Masha prevents surface drainage penetrate to wells and increases the Turbidity.
- Cementation of wells in Estalak and Zerehdar can prevent clay falling in the dry period.
- It is obvious that GWQI is very bad in Viraneh in both wet and dry periods. Therefore, organizations should supply water to this village from another source.
- GWQI in Vadan is not good enough because of Nitrate. Therefore, wells near farmland should not be used for drinking water.
- Some other parameters as heavy metals can be analyzed and calculated in future studies because some of them are used in herbicides and pesticides.
- Maybe, the study of land use for agriculture or industries can help people in this area.

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