

**ASSESSMENT OF GROUNDWATER QUALITY IN BORUJEN, FARADONBEH, AND SEFIDDASHT PLAINS****Rahim Alimohammadi Nafchi, Manoj Khanna, Singh, D.K., Singh. M and R.N. Sahoo\***

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**ABSTRACT**

The Borujen, Faradonbeh and Sefiddasht, watershed in Chaharmahal and Bakhtiari, Iran, is one of the semi arid regions. Layers of earth are calcareous in the watershed. Assessment of water quality has been carried out to determine the sources of dissolved ions in groundwater. Groundwater is an important water resource in the study area; these resources are under threat of pollution from human activities. The quality assessment is made through the estimation of  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ , and total hardness as  $\text{CaCO}_3$ , EC, and pH. Based on these analyses, parameters like sodium adsorption ratio (SAR), percent sodium (%Na), residual sodium carbonate (RSC), potential salinity, and permeability index (PI) were calculated. Groundwater quality, forecasting water quality in response to groundwater recharge, discharge with another sources and cited calcareous geological region (through (to pass) from the sediment and dissolution of water soluble minerals), Groundwater quality assessment indicated that water is suitable for irrigation purpose as per FAO standards except higher value of Electrical Conductivity (EC) in some area. Water for drinking purpose was found to be good as per WHO (1982) standards except for high values of water hardness. The results of this study will be used for developing ground water management plans.

**Key words:** Groundwater quality, assessment, quality, electrical conductivity and water management.

**INTRODUCTION**

The usage of groundwater has gradually increased because of the increase of water demand and the shortage of surface water during growth of population and rapid industrialisation. In many cases groundwater is polluted by the inflow of pollutants such as sewage and industrial wastewater (Freeze and Cherry, 1979). Generally, groundwater quality depends on the quality of recharged water, precipitation, inland surface water and subsurface geochemical processes (Twarakavi and Kaluarachchi, 2006). The study of Babiker *et al.*, (2007) showed that major chemical elements including pH, EC,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ,  $\text{SO}_4^{2-}$  and water hardness played a significant role in classifying and assessing groundwater quality. Groundwater is under threat of pollution from human activities. The groundwater quality is growing concern in the area. Because in the region due to expansion, and various activities including agriculture (with the using of pesticides and chemical fertilizers), residential and industrial (factories are with different products etc.) and there is artificial recharge project in the study area, there are cases that, we selected this project and carried out it. Several studies were carried out to assess the ground water quality in relation to water demand for an area to develop groundwater utilization and management plans. Following paragraphs details some of key research works (Ghorban *et al.*, 2011).

Khazaei *et al.*, (2004) carried out a study the groundwater samples were analysed for 43 wells in the study area for nitrogen, phosphorous, chloride and bacterial contaminations. The study observed that the system of absorbing wells are a good source for groundwater recharge, however, was the

main cause of aquifer pollution. The heavy impact of urbanization was observed through the deterioration of water quality in the aquifer. The study recommended improving waste water disposal system to improve water quality of aquifer. Srivastava and Ramanathan, (2008) carried out geochemical and study the landfill effect on groundwater quality. The results showed that there was high contamination of groundwater due to leaching pollutants from the landfill. The nitrate, fluoride and heavy metal pollution was at alarming state with respect to drinking purpose.

Khodapanah *et al.*, (2009) carried out groundwater quality assessment, through their chemical composition and suitability for irrigation use. The results of the study indicated that, the study concluded that salinity is the principal concern in irrigated agriculture in Eshtehard area. For sustainable agricultural development in the study area, special management of salinity control with salt-tolerant plantation should be implemented. Srinivasamoorthy *et al.*, (2009) concluded that the results indicated that there is an abundance of major ions in the groundwater which were order of  $\text{Na} > \text{Ca} > \text{Mg} > \text{K} = \text{Cl} > \text{HCO}_3^- > \text{SO}_4^{2-} > \text{NO}_3^-$  Hydro chemical facies demarcated was Ca-Mg-Cl, Na-Cl, Ca-HCO<sub>3</sub>, Ca-Na-HCO<sub>3</sub> and Ca-Cl type.  $\text{NO}_3^-$ , Cl,  $\text{SO}_4^{2-}$  and F exceeded the permissible limit during both the seasons. The influence of anthropogenic activities such as intense agricultural practices like application of fertilizers, irrigation practice, urban and industrial waste discharge influenced the quality of groundwater in the study area. Aghazadeh and Mogaddam, (2010) taken result that, the sequence of the abundance of the major ions was found to be in order of:  $\text{Ca} > \text{Mg} > \text{Na} > \text{K}$

and  $\text{HCO}_3^- > \text{SO}_4^{2-} > \text{Cl}^-$ . The dominant hydro chemical facieses of groundwater was Ca,  $\text{HCO}_3^-$  and Ca, Mg,  $\text{HCO}_3^-$ . Distribution of the groundwater samples in rectangular diagram revealed that all of the samples fell under the calcium-magnesium-bicarbonate category. Irrigation waters classified based on SAR had indicated that 83% of samples belonged to the excellent, 11% samples good and remaining to doubtful category. Base on the classification of irrigation water according to the PI values, the groundwater quality of the study area could be designated as class II (25–75%) indicating suitability of groundwater for irrigation purposes.

Studies presented in the previous review used chemical analyses which determined the concentration of cations (calcium, magnesium, sodium and potassium) and anions (chloride, bicarbonate and sulphate), pH and EC. Some studies calculated some indexes including: SAR, water hardness, pH, RSC, PI, %Na, TDS and EC. Most of these parameters are used in various standards like ISI, WHO, and FAO. Knowledge of these parameters will be helpful in setting proper management for drinking and agriculture use. In this study FAO standard were used to check suitability for irrigation purpose and WHO standard for drinking water quality (APHA, 1992).

## MATERIAL AND METHODS

**Description of study area:** The study area is located between  $31^\circ, 15'$  to  $31^\circ, 45'$  Northernly Latitude and  $51^\circ, 25'$  to  $51^\circ, 40'$  Eastern Longitude in port of Iran (Borujen, Faradonbeh and Sefiddasht catchment in Chaharmahal and Bakhtiari province, South western Iran). Soils of study area are heavy and fertile. Area suffers from water shortage due to this large part of the area is not under productive use. The maximum, minimum and average temperature of the region (Borujen Metrological Station) is  $34.6^\circ$ ,  $-24.6^\circ$  and  $10.6^\circ$  C respectively. The annual average rainfall, evaporation and mean relative humidity of the area are 243 mm, 2087 mm and 38% respectively.

**Assessment of Groundwater Quality:** The Different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis. Borujen, Faradonbeh and Sefiddasht are alluvial aquifer, which provides a source of water for different consumptions, has encountered serious groundwater depletion and quality degradation due to developing industrialization and agricultural activities. Groundwater quality assessment was carried out in the Borujen, Faradonbeh, and Sefiddasht watershed through the hydro-chemical evaluation of various parameters. The samples of number of tube wells were collected periodically for the year 2003- 04, 2004- 05, and 2005- 06 by Chaharmahal & Bakhtiyari Province Regional Water Organization. The data collected by Chaharmahal & Bakhtiyari Province Regional Water Organization

was used for the assessment of groundwater quality in this study. The samples were analysed for  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{HCO}_3^-$ , total hardness as  $\text{CaCO}_3$ , EC, and pH. This study utilized seasonal (four seasons: spring, summer, autumn and winter) groundwater quality data collected from the field in observation wells. The data collected from the source were transferred into a database hosted on a GIS platform for spatial analysis and data visualization. The quality parameters estimated were like Sodium Adsorption ratio (SAR), Percent Sodium (%Na), Residual Sodium Carbonate (RSC), water hardness and Permeability Index (PI). The groundwater quality is categorized into various levels based on the FAO and WHO standards for the purpose of irrigation and domestic use respectively.

**Water index for Irrigation:** The characteristics of irrigation water that have been used in determining its quality are including, pH, EC, SAR, %Na ratio PI and RSC. These standards are presented in Table 2. The drinking water quality is analysed based on WHO standards based on water hardness, Cl, Na and  $\text{SO}_4$  values. These standards are presented in Table 1.

## RESULTS AND DISCUSSIONS

**Groundwater quality assessment:** Groundwater quality was assessed based on key elements and parameters for the Borujen, Faradonbeh and Sefiddasht watershed. The observed values of key elements and parameters were analysed through GIS and various periodic maps were developed. Following sections details the results of the groundwater quality assessment

**a) Potential of Hydrogen (pH):** The pH values area monitored periodically (October, January, April and July) during the year. The results indicate that majority of the groundwater is of good quality. However, there was variation in the pH values year to year depending upon the rainfall and runoff in the region. pH values in autumn and winter of 2003-04, 2004-05 years was about 88.5 per cent of plain area with suitable value (6.5- 8.4) and 11.5 per cent area under the range higher than normal ( $> 8.5$ ). The reason for high pH values could be attributed to artificial recharge project and domestic waste water disposal in that region (Figure 1).

**b) Electrical Conductivity (EC):** The value of EC in majority of the study area is found to be between 0.7 and 3 dS/m. The value of EC higher than 1.0 not generally suitable for vegetable cultivation. The higher value of EC in groundwater could be attributed to excessive use of chemical fertilizers and untreated disposal of surface, domestic and industrial waste water into aquifer system.

**c) Sodium adsorption ratio (SAR):** It was observed that for all the study area SAR values of groundwater was below 3.0 which is suitable for irrigation purposes. There was no variation observed between the years of monitoring.

**d) Percent sodium (%Na):** Figure 2 presents the periodic variation of %Na in the study area. Majority of the groundwater %Na values are less than 40 which is suitable for irrigation purpose. Very small area covered with groundwater with %Na values higher than 40 and less than 60 (Figure 2).

**e) Permeability Index (PI):** Permeability index is a parameter computed to evaluate the suitability of water for irrigation. The permeability index values of the plain water ranged from minimum (0.395) to maximum (0.689) during, spring (0.395 to 0.689), summer (0.41 to 0.592), autumn (0.398 to 0.625), and winter (0.395 to 0.597). All of area was in good class for irrigation.

**e) Residual sodium carbonate (RSC):** Residual sodium carbonate (RSC) has been calculated to determine the hazardous effect of carbonate and bicarbonate on the quality of water for agricultural purpose by Eaton equation. All the study area is in Class I: (Less than 1.25 meq/l) which is suitable for irrigation. Groundwater quality assessment of study area indicated that majority of the parameters representing the suitability of water for irrigation purpose are in good quality range except for EC values. The EC values for part of the study area are in high range which may not be suitable for the cultivation of vegetables and food grains. However, this water may be used for growing of alfalfa and turf grass. Also, suitable water recharge mechanism may be used to improve the water quality in that area. Following paragraphs details the parameters used for indicating the water quality for drinking purpose. The water quality for drinking purpose is analysed based on WHO standards.

**Water hardness:** Water hardness of the study area is more than normal. This could be attributed to calcareous geological region. Water hardness could be managed by adding powdered or liquid water softeners to a batch of water. Ion exchange softening units could also reduce water hardness. However, the effectiveness of physical water treatment devices to control scale or manage hardness has not been scientifically assessed.

**Chloride (Cl):** World health organization (WHO) classified groundwater into two classes based on Cl for drinking purpose; class I < 250 mg/l suitable and class II > 250 mg/l unsuitable. All the groundwater has no Cl problem i.e. suitable for drinking purpose.

**Sodium (Na):** Similarly, Sodium values are suitable for drinking purpose as per WHO standards.

**Sulfate (SO<sub>4</sub>):** Sulfate is one of world health organization method for evaluating drinking water. The analysis shows that all the groundwater is safe for drinking purpose as per sulfate range is concerned. The previous paragraphs analysed that water quality for drinking purpose. The results shows that groundwater is suitable for drinking purpose barring the high values of water

hardness. This water hardness could be treated with several water purification techniques.

## CONCLUSIONS

The Borujen, Faradonbeh and Sefiddasht are one of the important plain, with extensive and fertile lands in Chaharmahal and Bakhtiyari province. Increasing water demand, day by day in various activity (agriculture, domestic and industrial), semiarid climate and deteriorating groundwater quality suggested to assess the groundwater quality in the region. Groundwater quality assessment was carried out. The groundwater availability and utilization should be planned in such a way that water security is not threatened. Water quality assessment indicated that aquifer system is still safe from deterioration of quality. Water quality is good for irrigation as well as drinking purpose. However, proper management is needed maintain this level of quality.

## REFERENCES

- Aghazadeh, N. and Asghari\_Mogaddam. 2010, Assessment of Groundwater Quality and its Suitability for Drinking and Agricultural Uses in the Oshnavieh Area, Northwest of Iran, *Journal of Environmental Protection*, **1**: 30-40
- APHA. 1992, Standard Methods for the examination of water and wastewater, 18th, 20th ed., Am. Public Health Assoc. Washington, DC, USA.
- Babiker I. S., Mohamed. M. A. A. and T. Hiyama. 2007, Assessing groundwater quality using GIS, *Water Resource Manage*, **21**: 699-715.
- Freeze, R. A., and J.A. Cherry. 1979, *Groundwater* Prentice-Hall Inc., New Jersey.
- Ghorban Ghorbaninasrabad, Rajput, T.B.S and Neelam Patel. 2011. Distribution and leaching of salt under different saline water in subsurface drip irrigation. *Global J. of Engg. & Appl. Sciences*, **1** (3): 109-113.
- Khazaei, E., Mackay, R and J. Warner. 2004, The Effects of Urbanization on Groundwater Quantity and Quality in the Zahedan Aquifer, southeast Iran, *Water International*, **29**(2): 178-188.
- Khodapanah, L., Sulaiman, W.N.A and N. Khodapanah. 2009, Groundwater Quality Assessment for Different Purposes in Eshtehard District, Tehran, Iran, *European Journal of Scientific Research* **4**: 543-553.
- Srinivasamoorthy, K., Chidambaram, S., Sarma, V. S., Vasanthavigar, M., Vijayaraghavan, K., Rajivgandhi, R., Anandhan, P., and R. Manivannan. 2009. Hydro geochemical Characterisation of Groundwater in Salem District of Tamilnadu, India, *Research Journal of Environmental and Earth Sciences* **1**(2): 22-33.
- Srivastava, K. S. and A. L. Ramanathan, 2008, Geochemical assessment of groundwater quality in vicinity of Bhalswa landfill, Delhi, India, using graphical and multivariate

statistical methods, Environ Geol **53**: 1509–1528.

Twarakavi, N. K. C. and J. J. Kaluarachchi, 2006, Sustainability of groundwater quality considering land use changes and public health risks, J. Environ. Manag., **81**: 405-419.

WHO. 1989, Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture, Report of a WHO Scientific Group – Technical Report Series 778, WHO Geneva.

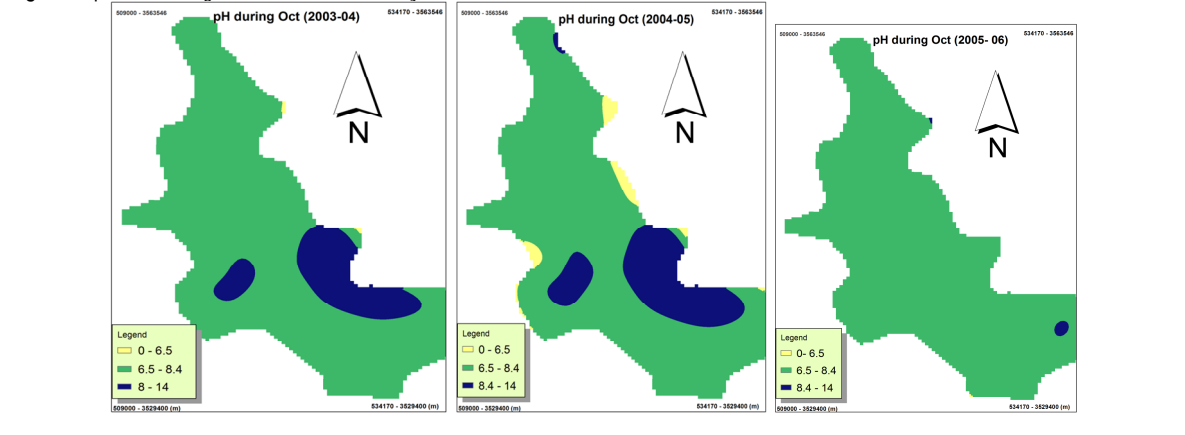
**Table 1.** Water quality standards for drinking purpose

Parameter	Classes	Standard	Water Classes
Water hardness (mg/l)	> 60	WHO	Soft
	60- 120		Medium hard
	120- 180		Hard
	> 180		Very hard
Cl (mg/l)	< 250	WHO	Suitable
Na (mg/l)	< 200	WHO	Suitable
SO <sub>4</sub> (mg/l)	< 500	WHO	Suitable

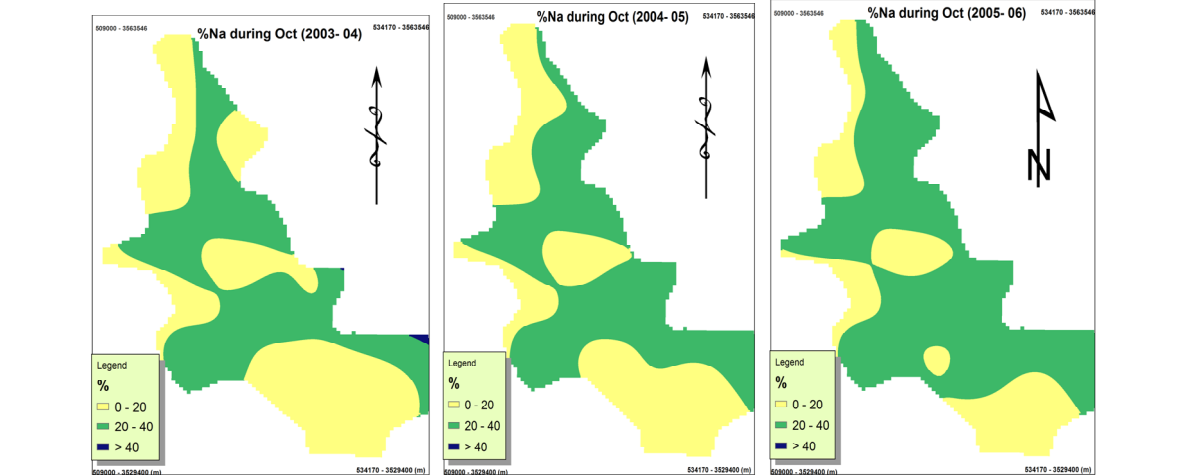
**Table 2.** Water quality standards for irrigation purpose

Parameter	Classes	Standard	Water Classes
pH	<6.5	FAO	Acidic
	6.5- 8.4		Normal range
	> 8.4		Alkaline
EC (ds/m)	< 0.7	FAO	None
	0.7 – 3		moderate
	> 3		Severe
SAR (meq/l)	0- 3	FAO	Low
	3- 9		Moderate
	>9		Severe
%Na	< 20	Scofield	Excellent
	20- 40		Good
	40- 60		Permissible
	60- 80		Doubtful
PI (%)	< 25	Doneen	Suitable
	25- 75		Good
	> 75		Unsuitable
RSC (meq/l)	< 1.25	US Salinity Laboratory	Safe
	1.25- 2.5		Marginal
	> 2.5		Unsuitable

**Figure 1.** pH values of groundwater in the study area



**Figure 2.** Percentage of Na values of groundwater in the study area



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