Iran. J. Environ. Health. Sci. Eng., 2007, Vol. 4, No. 4, pp. 257-262

VARIATIONS OF CHEMICAL QUALITY FOR DRINKING WATER SOURCES IN ZARAND PLAIN

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Received 15 February 2007; revised 13 July 2007; accepted 27 September 2007

ABSTRACT

A comprehensive investigation was conducted in order to evaluate the quality of the groundwater in Zarand plain of Chatrood region which supplies drinking water of Zarand city. Zarand plain with longitude of 55°, 46′- 57°,7′ and latitude of 30°,20′-31°,44′ is one of Iran's plains located in sub-basin of Daranjir desert. Groundwater of Zarand plain supplies drinking water of many cities and villages located in and near the plain. Samples were collected from 11 water wells used as drinking water sources in Zarand plain "Chatrood region", at least once at the middle of each month. By means of the standard methods, a number of parameters were analyzed for each sample for the period of 7 years from 1996 to 2003. Tests included measuring pH, electrical conductivity, total dissolved solid, total hardness, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and nitrate ions. Data analysis was done by using t and Z-Test. Results indicated that water quality of water wells during studied period did not show any undesireable change. The quality of each parameter in drinking water wells of Zarand plain was within permissible limit and did not exceed neither the Iran's standards nor WHO guidelines. Meanwhile, the quality of raw water resources of the plain in the final year of experiment was within "good" potability limit based on Schuller's diagram; it means raw water resources still kept its quality. Although the quality of Zarand plain water resources comply with Iran's standards and WHO guidelines increasing trend of water consumption and consecutive droughts in the studied region as well as severe water shortage, ask for conservation, preservation and monitoring of water resources.

Key words: Ground water, Chemical quality, Zarand plain

INTRODUCTION

The ultimate source of most dissolved ions in water is the mineral assemblage that occurs in rocks near land surfaces. The solids that dissolve into groundwater from this point, form part of the geochemical. Rock composition, purity, crystal size of its minerals, rock texture and porosity, regional structure, degree of fissuring and length of previous exposure time also influence the composition of water passing over and through rocks. The natural chemical content of groundwater is consequently influenced by type, depth of soils, and subsurface geologic formations through which groundwater passes (Pye *et al*., 1983). Contamination of ground water/subsurface systems (GWSS) by leachate from sanitary landfills and human wastes (septic tanks, land application of sewage sludge, and municipal waste water) and industrial effluents, have become an issue of major concern and public attention in the last decade (Ventullo and larson, 1993). One particular issue has been the question of whether the entry of anthropogenic "human made" organic materials into subsurface soil or groundwater represents a permanent contamination problem or whether removal processes are available that prevent the accumulation of such material (Chakraborti *et al*., 1998).

Human health is remarkably dependant upon safe and clean drinking water. Preserving the water resources and hindering them from being polluted is preferred to the treatment of polluted water and rendering it suitable for consumption. Due to the variety and plurality of the contamination sources, the experts have been persuaded to endeavor assiduously to spot the ways through which the pollutants enter the water resources. Municipal, industrial and return agricultural wastewaters

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containing various contaminants such as: phosphate, nitrate, toxic compounds, heavy metals, salts and minerals seriously threaten the water resources (Khablarian, 1989; Chester, 2000; Novotny, 2002).

The rainfall rate and the manner through which they enter the surface water resources and their penetrating through various layers of ground to reach the subsurface water are other influential factors on water quality and quantity (Chester, 2000). Improper rainfall distribution, climatic changes, over- withdrawal of subsurface waters, surface and subsurface waters contamination, droughts, drastic reduction of annual water production per capita, financial and operational deficiencies all in all notify prospective serious water crises. (Taleb- Beidokhti and Hooshyari, 2001). Subsurface water recharge employing surface waters particularly the surface runoffs, besides controlling the storm waters, enriches subsurface water resources. This strategy not only impedes water evaporation and water loss, but augments the subsurface water resources as well (Taleb-Beidokhti and Hooshyari, 2001).

Kerman province is viewed to be among the arid regions stretching along Iran Plateau, therefore its geographical situation accounts for the remarkably low rainfall rate and lack of permanent rivers in its plains. Reservoir volume fluctuation of aquifers in the plains of Kerman are indicative of negative balance in the majority of these plains as well as subsurface water drawdown (Iranian Ministry of Power, 1999). Drinking water of the most cities in Kerman province is supplied from the subsurface resources which have suffered intense drawdown due to frequent droughts and low rainfall rate. The number of these resources tends to diminish as a consequence of the improper irrigation practices and the lack of natural recharge. The inappropriate withdrawal of water resources resulted in alteration of the chemical quality and consequently to the saltiness of the water in some particular regions (Iranian Ministry of Power, 1999). Subsurface water is sole water source of drinking water in most cities of the studied region. One of the consequent occurrences of subsurface water drawdown is ground subsidence, a problem which now exist in some regions of plains in Kerman, Rafsanjan, Zarand and Ravar (Iranian Ministry of Power, 2006). The most prominent point is the improper manner of utilization of subsurface waters in the plains which makes them vulnerable and leads to evil social, economical outcomes, in additon to unrecoverable impairments such as well yield reduction, ground subsidence, dryness of running Ghanat and chemical quality alteration of subsurface waters due to advance of improper water to deeper parts of aquifers.

The variation trend of subsurface water drawdown in Zarand plain of Chatrood region has been dropping during previous years. The average drawdown rate is 136.1cm annually (a 16-year average from 1990 to 2006) (IMP, 2006). Intense subsurface water drawdown and inadequate rainfall particularly in recent years led to dryness of some observation wells and consequently the piezometric network change of the plains (IMP, 2006). Similar researches have also been conducted on the effect of water chemical quality on drinking water resources of some villages in Zanjan and Mianeh. Moreover, the quality of piped water from Zayanderood river to Yazd has been compared to the quality of the well drinking waters of Yazd. These researches brought about noticeable success on the preservation of the water resources of the mentioned cities (Sadeghi *et al.*, 2005; Safari *et al.*, 2003; Kargar and Shiranian, 2001).

This research has been carried out to study these variations trend in order to control chemical quality of drinking water resources and also to determine limitation of utilization types concerning with chemical quality of drinking water resources in Zarand plain “Chatrood region”.

MATERIALS AND METHODS

Zarand Plain with longitude 55°,46´- 57°,7´ and latitude of 30°,20´ -31°,44´ is one of Iran’s plains located in sub- basin of Daranjir desert. Groundwater of Zarand plain supplies drinking water of many cities and villages located in and near the plain (Fig. 1).The plain is situated on the north of Kerman province characterized by arid climate accompanying customary desert specificstions and considerable temperature diversity between days and night times, and low average rainfall rate of 130mm annually (Iranian Ministry of Power, 2006).

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To evaluate the drinking water quality of Zarand city, samples were collected from 11 water wells located in Zarand plain during seven years from 1996 to 2003. Various parameters such as: pH, EC, TDS, TH, K^+, Na^+, Mg^{+2}, Ca^{+2}, SO_4^{2-}, Cl^-, NO_3^-, NO_2^-, and HCO_3^-, were scrutinized at least once at the middle of each month. Afterwards, annual maximum, minimum, average and the standard deviation of each parameter of each well were determined and the average variation trend in different years was studied. Additionally, in each case the maximum and minimum of each parameter results were compared to the ratified standard of Iran and WHO guidelines, then required results were concluded (ISIRI, 1997). The employed methods of all the experiments have been extracted from the "Standard methods for the examination of water and wastewater" (APHA, 1998). Data analysis was done using t and Z-Test.

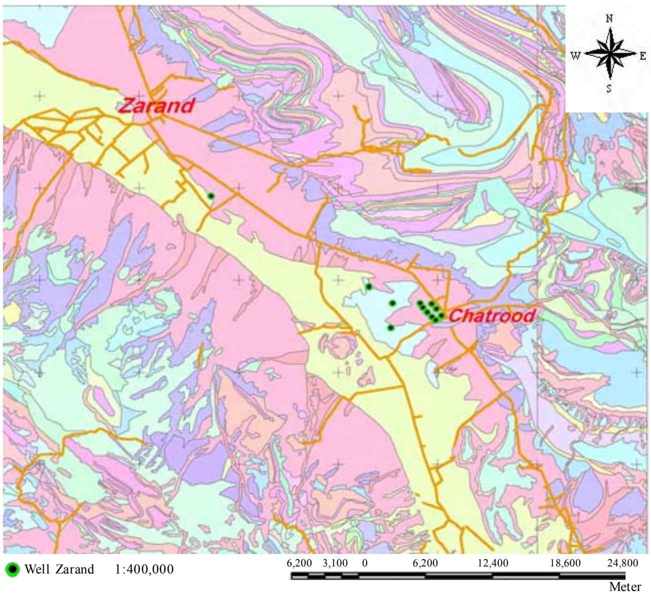

Fig. 1: Location of Zarand Plain

RESULTS

The results of the experiments on the maximum, minimum and average measured amounts of chemical quality of well drinking water in Zarand palin Chatood region are illustrated in Table 1. Fig. 1 shows the trend of variations of chemical parameters in drinking water. In Fig. 2, the average variation trend of EC and pH is shown.

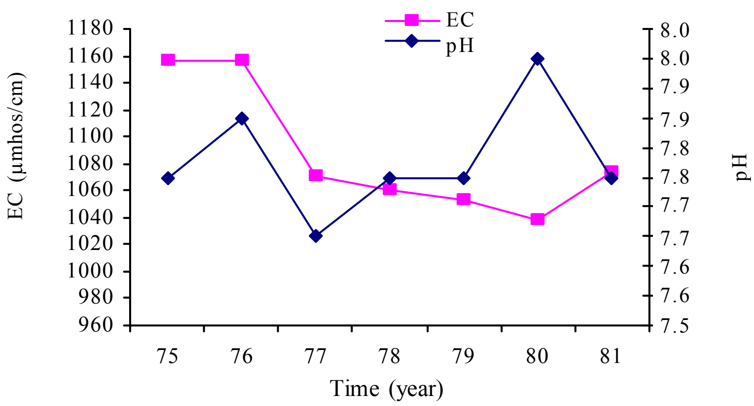

Fig. 2: The trend of average pH and EC during 1996-2002

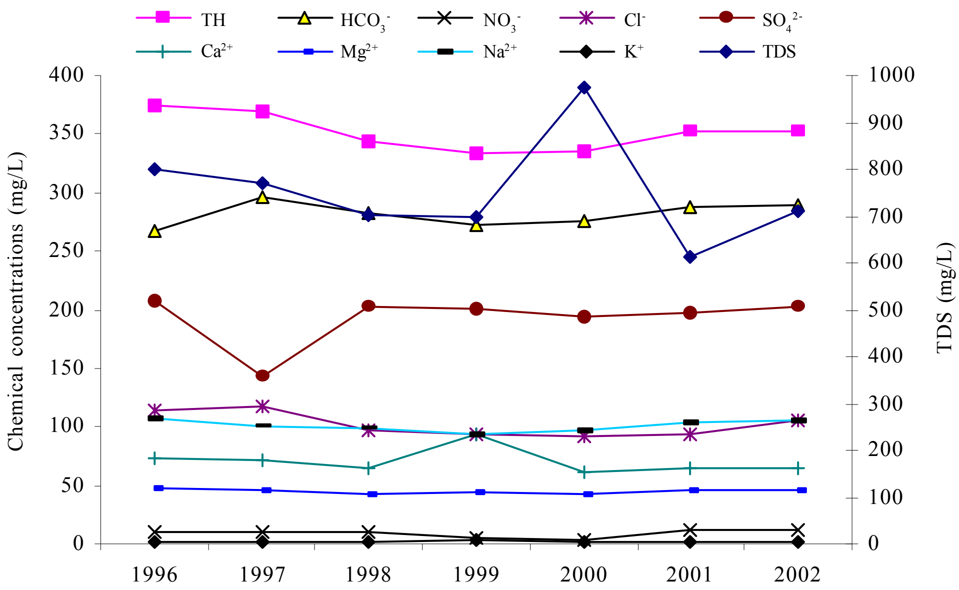

Fig. 3: The variation trend of different chemical quality parameters in well drinking water during 1996-2002

DISCUSSION

The results of the experiments on the chemical quality of 11 water wells in Zarand plain indicated that in no case, except for magnesium cation, the maximum and minimum amounts of qualitative parameters of water did not exceed neither the permitted maximum limit in Iran's standards nor WHO guidelines (Sadeghi *et al.*, 2005 and WHO, 2006). Z-Test was used for hypothesis testing. The average concentration rate of SO_4^{2-}, Cl^-, NO_3^-, NO_2^-, and HCO_3^-, TH, EC., TDS, pH, K^+, Na^+, Mg^{2+},Ca^{2+} compared to the approved standards of Iran and WHO guidelines annually. The results showed a significant difference in the direction of water quality improvement at 95% confidence limits and $p<0.05$ (Table 1).The average variation trend of the chemical quality parameters in water wells revealed no undesirable change during 1996-2002 (Figs. 2 and 3). T-Test was also applied to compare the concentration of various parameters in 1996 to that of 2002. The results showed that difference between the average variations of EC, TDS, total hardness and calcium in 1996 and 2002 is significant and in the direction of quality improvement.($p<0.05$ for EC, TDS and total hardness and $p<0.01$ for Ca^{2+}).There is no significant difference between the concentration of Mg^{2+} between 1996 and 2002 ($p<0.05$). Bicarbonate concentration difference between the average of 1990 and 2002 is significant notifying the tendency of bicarbonate increase in subsurface water ($p<0.05$) (Table 1). The chemical quality of raw water resourses of plain in the final year of measurement (2002) has been also compared to Schuler's diagram. The results signify that all the parameters lie on "good" potability limit. Based on Schuler's diagram the amount of sodium and magnesium cations and sulfate anion in some instances has been escalating which is not significaut regarding the comparison of the escalation in 1996 using T-Test ($p>0.05$).The average concentration of each measured parameter has been compared to maximum values in Schuler's table annually using Z-Test. The results showed a significant difference in the direction of quality improvement in all cases at 95% confidence limit ($p<0.05$), that means raw water resources of the plain are still keeping their quality. The quality of groundwater in dry and desert regions are often more undesirable than wet

Table 1: Average, minimun, maximum and standard deviation of various chemical quality parameters of ground watertable in Zarand plain of during 1996-2002 and comparison of condition in 1996 to that of 2002 at 95% confidence limits

Year	State	pH	TDS(mg/L)	EC(µs/cm)	TH(mg/L)	HCO_3^-(mg/L)	NO_3^-(mg/L)	NO_2^-(mg/L)
	Max.	8.3	979.4	1370	432	323.7	20.3	0
1996	Mean	7.8	801.7	1156.4	375.1	267.5	11	0
	Min.	7.3	624.1	942.8	318.3	211.3	2	0
	SD	0.23	88.8	106.8	28.4	28.1	4.6	0
	Max.	8.3	1117.4	1441	438.7	363.7	19.5	0
1997	Mean	7.9	172	1156.7	369	295.5	10.7	0
	Min.	7.6	426.6	872.5	299.3	227.3	2	0
	SD	0.17	172.7	142.1	34.8	34.1	4.4	0
	Max.	8.1	818	1208.4	377.2	301.8	17.8	0
1998	Mean	7.7	702	1071.2	343.2	283.2	10.4	0
	Min.	7.3	586	934	309.2	264.5	3	0
	SD	0.2	58	98.6		9.3	3.7	0
	Max.	8	759.1	1126.3	370	295	8.1	0
1999	Mean	7.8	695.8	1059.9	333.6	273	4.9	0
	Min.	7.6	632.5	993.6	309.2	251	1.5	0
	SD	0.11	31.6	33.2	15.2	11	1.6	0
	Max.	8.2	737.7	1145.4	366.5	302.5	6.7	0
2000	Mean	7.8	975	1052.4	335.3	276.2	3.3	0
	Min.	7.4	612.4	959.5	304	250	3	0
	SD	0.22	31.3	46.4	15.6	13.1	0.2	0
	Max.	8.4	1021	1185.8	402.3	311	16.5	0
2001	Mean	8	614	1037.6	352.7	287.5	11.5	0
	Min.	7.6	207.3	889.4	303.1	264	6.5	0
	SD	0.2	203.3	74.1	24.8	11.6	2.5	0
	Max.	8	982.2	1404	440.6	317.4	16.4	0
2002	Mean	7.8	712.2	1073.4	353	288.8	11.2	0
	Min.	7.5	422.8	742.6	265.4	260.2	6	0
	SD	0.15	134.8	165.4	43.8	14.3	2.6	0
Iran's	standards	6.5-6.0	1500	-	500	-	50	3
1996	vs 2002	-	T=2.84 P<0.05	T=2.16 P<0.05	T=2.16 P<0.05	T=4.22 P<0.05	T=0.22 P<0.05	- -

Year	State	Cl^-(mg/L)	SO_4^{2} (mg/L)	Ca^{2+}(mg/L)	Mg^{2+}(mg/L)	Na^+(mg/L)	K^+(mg/L)
	Max.	161	228.4	88.1	66	138.7	3
1996	Mean	114.5	207	73.7	47.3	106.4	2.4
	Min.	68	185.6	59.3	28.5	74.2	1.8
	SD	23.3	10.7	7.2	9.4	16.1	0.3
	Max.	181	190.2	86.6	57.9	146	3
1997	Mean	117.3	142.2	71.7	45.9	100.3	2.5
	Min.	53.5	94.2	55.7	34	54.7	2
	SD	31.9	24	7.7	6	22.8	0.2
	Max.	115.2	244.6	76.6	51.2	121.5	3
1998	Mean	96.3	203	65.4	43.2	98.1	2.5
	Min.	77.4	161.4	54.2	35.2	74.7	2
	SD	9.4	20.8	5.6	4	11.7	0.2
	Max.	104	224	71	50	107	3
1999	Mean	93	201	63.1	43.5	94.2	2.6
	Min.	82	178	55.1	36.9	81.4	2.2
	SD	5.6	11.5	4	3.3	6.4	2
	Max.	105.2	201.5	78	52.2	112.4	3
2000	Mean	91.6	193.6	61.8	43.4	97.6	2.5
	Min.	78	185.7	45.7	34.6	82.8	2
	SD	6.8	7.9	8	4.4	7.4	0.2
	Max.	106	223	73.4	57.6	116	3
2001	Mean	93.4	196.8	64	46.3	104.4	2.5
	Min.	81.2	170.7	54.6	35	93	2
	SD	6.1	13	4.7	5.6	5.7	0.23
	Max.	174.6	280	83.7	60	148	3
2002	Mean	106	202	64.5	46.3	106	2.5
	Min.	37	124	45.3	32.7	64	2
	SD	34.3	39	9.6	6.8	21	0.3
Iran's	standards	400	400	250	50	200	-
1996	vs 2002	T=1.05 P<0.05	T=0.36 P<0.05	T=4 P<0.05	T=0.01 P<0.05	T=0.08 P<0.05	T=1.3 P<0.05

and humid regions due to higher evaporation, lack of surface flow and shortage of atmospheric precipitation. The result of the study, however, showed good groundwater quality at the studied region because of its location within the recharging part of the plain. This is why most drinking and industrial water wells are located in this region. The quality of water in the mentioned plain is changing from southeast to northwest in the direction of movement of groundwater and become more undesirable as get closer to the exit point of the plain. The most important issue in the studied region is the severe shortage of fresh water which is asked for the need for the preservation and control of the existing resources from pollution. Regulating industrial wastewater discharged to the environment requires guiedelines that support the approach of pollution prevention and the implementation of cleaner technology by putting stress on the industry (Bishop *et al.*, 1998). The type of approach that is used for the balance between environmental and technological aspects is also important. Understandable priorities must be emphasized and combined with available technology. Contamination impacts of generated waste on groundwater can be major, especially if municipal sewers leak into the watertable.

ACNOWLEDGEMENTS

The authors would like to thank the students of the Department of Environmental who have helped to the conduction of this study during their field courses.

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