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QUALITATIVE ASSESSMENT GROUNDWATER ASADABADAQUIFER, WEST IRAN

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ABSTRACT: Contamination of drinking groundwater is a worldwide problem that has economic and human health impacts. Such contamination is caused normally for some dissolved chemical constituents such as NO_3^-N, F^- which are mostly either geogenic or anthropogenic in origin.This study was conducted to assess the potential of NO_3^-N and F^- contamination in drinking groundwater as a function of lithology, soil characteristics and agricultural activities in an intensively cultivated district in west Iran, Hamadan. 30 groundwater samples were collected at different depths from various types of wells and analyzed for pH, EC, NO_3^-N load and F^- content. The fluoride and nitrate concentration in underground water was determined in area where it is the only source of drinking water. Various other water quality parameters such as pH**,** electrical conductivity, total dissolved salts, total hardness, total alkalinity as well as K^+, Ca^{+2}, Mg, HCO_3^-, Cl^-, SO_4^- and Na^+ concentrations were also measured. The analytical results indicated considerable variations among the analyzed samples with respect to their chemical composition Majority of the samples do comply with Iran as well as WHO standards for most of the water quality parameters measured. The fluoride and nitrate concentration in the underground water sampling points was between 0.203 and 1.03 mg/l and 9.6 and 33 mg/l respectively. Overall water quality was found satisfactory for drinking purposes any prior treatment.

Key words: Contamination, Groundwater quality, Fluoride, Nitrate, Asadabad

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INTRODUCTION

Water plays an important role in the development of a healthy society and it's an essential natural resource for sustaining life and environment that we have always thought to be available in abundance and free gift of nature however chemical composition of surface or subsurface water is one of the prime factors on which the suitability of water for domestic, agriculture and industrial purpose depends. Fresh water occurs as groundwater and surface water in this groundwater contributes only 0.6 percent of the total water resources on earth [1,2,3]. Water content many minerals like NO_3^-, Ca^{+2}, Mg^{+2} and F^- etc. in this fluoride essential in minute quantity for normal mineralization of bone and teeth (for formation of dental enamel) fluoride stimulate growth of many plant species but on other hand when fluoride is taken up in excessive amount may prove toxic to plant and on feeding may toxic to animal and human as fluorosis. Fluoride concentration in drinking water is important for public health. Fluoride contributes to dental health and to the maintenance of appropriate bone density. Groundwater with high and low concentration of fluoride is found in many parts of the world. Fluorosis is endemic in several countries viz. Sri Lanka, Holland, West indices, Ethiopia, China, Spain, South Africa and Italy etc. People of different regions of India, are also badly affected from Fluorosis. An inventory of fluoride concentration in drinking groundwater is important to curb spread of the disease fluorosis[4].

Contamination of groundwater with nitrate is a global problem. High levels of nitrate in groundwater not only may be a good indicator of groundwater contamination but also may lead to animal and human health problems [5,6,7]. The most important source of the nitrate is biological oxidation of organic nitrogenous substance which come in sewage and industrial wastes or produced indigenously in the waters. Domestic sewage contains very high amounts of nitrogenous compounds [8]. Run-off from agricultural fields is also high in nitrate. High amounts of nitrate are generally indicative of sewage pollution. Nitrate levels when exceeds 100 mg/l, are of prime concern because of, Methamoglobinemia, also called Blue baby disease. This disease causes the skin to become blue due to decreased efficiency of haemoglobin to combine with oxygen. In cattle, the high concentration of nitrates is reported to cause more mortality in pigs & calves and abortion in brood animals. Beneficial effect of nitrate on crop production has been reported specially in brackish waters. The presence of K&NO_3^- ions in appreciable amounts has been found to partially counteract the effect of salinity and sodium hazards of irrigation on crop growth. The nitrate ion is the common form of combined nitrogen found in natural waters. It may be biochemically reduced to nitrite by denitrification processes, usually under anaerobic conditions. The nitrite ion is rapidly oxidised to nitrate. Natural sources of nitrate to surface waters include igneous rocks, land drainage and plant and animal debris. Nitrate is an essential nutrient for aquatic plants and seasonal fluctuations can be caused by plant growth and decay [8].

Natural concentrations, which seldom exceed 0.1 mg/l NO_3^-N, may be enhanced by municipal and industrial wastewaters, including leachates from waste disposal sites and sanitary landfills [9,10]. In rural and suburban areas, the use of inorganic nitrate fertilizers can be a significant source. When influenced by human activities, surface waters can have nitrate concentrations up to 5 mg/l NO_3^-N, but often less than 1 mg/l NO_3^-N. Concentrations in excess of 5 mg/l NO_3^-N usually indicate pollution by human or animal waste, or fertiliser run-off. In cases of extreme pollution, concentrations may reach 200 mg/l NO_3-N. The World Health Organization recommended maximum limit for NO_3- in drinking water is 50 mg/l and waters with higher concentrations can represent a significant health risk [1]. Concentrations of nitrate in excess of 0.2 mg/l NO_3^-N tend to stimulate algal growth and indicate possible eutrophic conditions. Nitrate occurs naturally in groundwater as a result of soil leaching but in areas of high nitrogen fertilizer application it may reach very high concentrations (500 mg/l NO_3^-N). In some areas, sharp increases in nitrate concentrations in groundwater over the last 20 or 30 years have been related to increased fertilizer applications, especially in many of the traditional agricultural regions of Europe [11,12]. Increased fertilizer application is not, however, the only source of nitrate leaching to groundwater. Nitrate leaching from unfertilized grassland or natural vegetation is normally minimal, although soils in such areas contain sufficient organic matter to be a large potential source of nitrate (due to the activity of nitrifying bacteria in the soil) [13]. On clearing and ploughing for cultivation, the increased soil aeration that occurs enhances the action of nitrifying bacteria, and the production of soil nitrate. Result shows the high concentrations of nitrate in some villages. Nitrates are one of the important parameters since it is directly related with flora& fauna. It affects the human being by causing Methamoglobinemia or Blue baby disease.

This study was carried outto assess the quality of ground water Asadabad aquifer in west of Iran. The fluoride and nitrate concentration along with various chemical parameters in ground water samples was determined in this region. The Asadabad aquifer with an area of 962 square kilometers is situated in western Iran. The location of the aquifer is between 48º 07 to 34º 47 east longitude and 37º 07 to 37º 25 north latitude. Figure 1 shows location map of the study area in Asadabad basin. In the region under study, almost 1.5 percent of the irrigation water that is about 4 million cubic meters (MCM) infiltrates into the groundwater per year. In addition part of the municipal wastewater i.e. about 4 MCM, from the cities of Asadabad, percolates into the groundwater annually [14]. These factors have resulted in the groundwater in some parts of the aquifer being polluted, making it necessary to have an precise plan to prevent more damage to the groundwater resources[15].

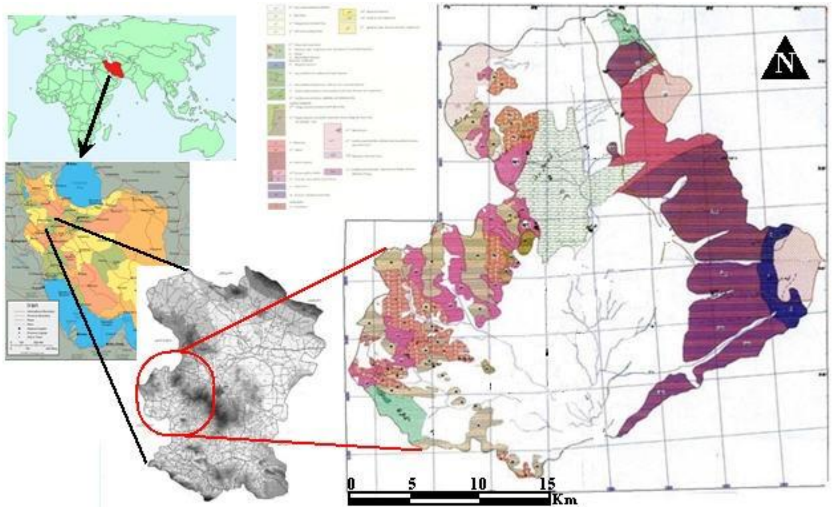

Fig-1: Geology and Location map of the study area[16]

MATERIAL AND METHODS

Number 30 groundwater samples were collected from the study area during September 2014. Sample location map of the study area is shown in Figure2. The samples were collected from wells which were extensively used for drinking and other domestic purposes. The samples were collected in pre-cleaned and sterilized polyethylene bottles of two litre capacity. The depth of the wells varied between 20 and 135 feet. The groundwater samples were analyzed using APHA (2012) procedure, and suggested precautions were taken to avoid contamination [17]. The various parameters determined were pH, EC (Electrical Conductivity), total dissolved solids, Total Hardness, Calcium, Magnesium, total alkalinity, Carbonate, Bicarbonate, Chloride, Sulfate, Sodium, Potassium, Nitrate and Fluoride. pH and EC were determined by pH, conductivity meter, TDS by TDS meter, TH, Ca^{2+},Mg^{2+}, CO_3^{2-}, HCO_3^- and Cl^- were estimated by titrimetry, where as Na^+ and K^+ by flame photometry (Systronics-128). F was estimated by using ion selective electrode (Orion 4 star ion meter, Model: pH/ISE). All the experimental were carried out in triplicate and the results were found reproducible with in a ± 3% error limit.

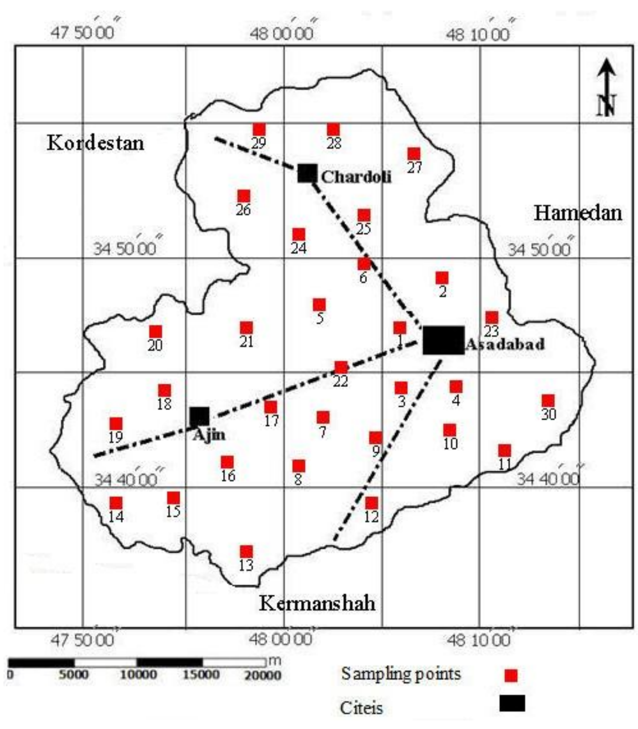

Fig-2: Location map the sampling points in the study area

RESULTS AND DISCUSSION

The results show in Table 1. Various physicochemical parameters such as pH, electrical conductivity, total alkalinity, total hardness as well as calcium, magnesium, sodium, potassium, chloride, nitrate, carbonate, and bicarbonate were analyzed with the determination of fluoride concentrations. In general, the ground water had no colour, odour and turbidity except few samples. The pH varies from 7.4 to 8.3, with a mean of 7.9 indicating an alkaline condition which favours the solubility of fluoride-bearing minerals (Table 2). In acidic medium (acidic pH), fluoride is adsorbed in clay; however, in alkaline medium it is desorbed, and thus alkaline pH is more favorable for fluoride dissolution activity. The electrical conductivity of the groundwater varies from 371µs/cm to 704µs/cm. Elevated concentration of electrical conductivity may possibly be credited to high salinity and high mineral content. Total dissolved solids, a salinity indicator for the classification of groundwater, varies from 237 mg/l to 457 mg/l in the study area. The bicarbonate content varies from 201.3 mg/l to 298.9 mg/l. The calcium content in the ground water of the study area varies from 36 mg/l to 68 mg/l and a sodium value of groundwater is varying from 6.67 mg/l to 68.54 mg/l.

Table-1: Analytical data of the chemical analyses of groundwater in Study area

TH	NO_3^- mg/l	F^- mg/l	K^+ mg/l	Na^+ mg/l	Mg^{2+} mg/l	Ca^{2+} mg/l	SO_4^- mg/l	Cl^- mg/l	HCO_3^- mg/l	PH	TDS	EC µs/cm	No
190	33	0.341	0.391	9.43	18.3	50	25	14.2	201.3	8.05	280.3	438	1
175	27.3	0.32	0.391	19.78	15.86	42	7.2	16	231.8	7.8	262.4	410	2
200	31.7	1.03	0.391	13.34	22	52	28.8	17.8	225.7	8.2	301.4	471	3
150	30.1	0.305	0.391	15.87	13.42	38	2.88	14.2	201.3	7.83	237.4	371	4
195	29.7	0.531	0.391	12.42	23.18	48	31.2	26.6	201.3	8	299.5	468	5
155	24.2	0.361	0.782	31.74	12.2	44	28.8	14.2	213.5	8.2	270.7	423	6
200	22.3	0.417	0.782	40.94	18.3	42	41.28	21.3	244	7.8	369.3	577	7
205	18.5	0.376	0.391	17.71	17.08	54	9.6	14.2	250.1	7.8	311.7	487	8
300	19.5	0.272	0.391	43.7	24.4	38	64.8	17.8	231.8	8	355.2	555	9
180	20.4	0.382	0.782	68.54	26.84	38	76.8	39.1	256.2	7.95	457.6	704	10
200	19.6	0.368	0.391	15.41	19.52	50	14.4	21.3	244	7.84	311.7	487	11
205	18.1	0.203	0.391	36.57	23.18	48	69.6	23.1	237.9	8.1	378.2	591	12
200	19.8	0.552	0.391	34.96	21.96	50	43.2	21.3	256.2	8	368.6	576	13
185	16.7	0.392	0.391	11.73	18.3	68	26.4	21.3	250.1	7.85	329.6	515	14
200	14.3	0.377	0.391	17.02	20.74	42	6.24	14.2	237.9	7.8	291.2	455	15
190	10.5	0.264	0.782	11.5	20.74	60	33.6	16	244	8.2	323.2	505	16
135	16.3	0.289	0.782	27.83	18.3	36	21.12	17.8	213.5	8	291.8	456	17
210	13.5	0.261	0.391	60.26	14.64	60	77.28	23.1	268.4	8.3	418.6	654	18
185	9.6	0.32	0.391	27.37	15.86	60	16.8	17.8	274.5	7.99	358.4	560	19
240	12.7	0.28	0.391	6.67	19.52	42	14.4	12.4	201.3	7.88	266.9	417	20
200	13.1	0.371	1.173	13.11	25.62	54	36.96	14.2	268.4	7.66	347.5	543	21
205	14.4	0.833	0.782	12.65	18.3	50	20.64	14.2	231.8	7.65	295	461	22
275	15.1	0.204	0.782	37.49	20.74	58	41.28	21.3	298.9	7.4	384.6	601	23
185	13.3	0.483	0.78	68.52	26.84	39	76.8	39.1	256.7	7.95	457.6	704	24
190	14.3	0.205	0.782	31.7	12.2	45	28.6	14.2	213.5	8.2	270.7	423	25
190	16.2	0.362	0.391	13.34	23	52	28.5	17.8	225.7	8.1	301.4	480	26
185	13.5	0.338	0.392	15.88	13.4	38	2.87	14.2	201.3	7.83	237.4	371	27
210	14.7	0.294	0.393	6.69	19.5	41	14.5	12.4	201.3	7.83	266.9	420	28
165	17.4	0.209	1.173	13.13	25.62	56	36.9	14.2	268.4	7.67	347.5	554	29
195	16.2	0.277	0.372	28.3	18.4	37	32.1	17.3	201.4	7.4	287	548	30

A strong negative correlation between Ca^{2+} and F^- in the ground waters that containCa^{2+} in excess of that required for the solubility of fluoride minerals has been observed by many researchers. The concentrations of magnesium, chloride, sulfates were found to be 19.59, 18.75, 31.95 mg/l respectively. Excessive chlorides bitter tastes to water corrode steel and may cause cardio-vascular problems. The value of hardness varies from 135 mg/l to 300 mg/l. The high value of total hardness in supply water may cause corrosion of pipes, resulting in the pressure of certain heavy metals such as cadmium, copper, lead and zinc in drinking water. Enhanced nitrate concentration9.6 mg/l to 33 mg/l, which was exceeding the permissible limits of 45 mg/l recommended by the WHO, was not of the samples in out of limited [1]. It is well known that the nitrogenous fertilizers are one of the important sources for groundwater nitrate for the past two decades. Many investigators have reported that the contribution of nitrate from the fertilizer to the groundwater can vary from as little as 3 mg/l to as much as 1800 mg/l. Further nitrogenous materials are rare in geological system. High NO_3^- concentrations may cause a potential fatal blood condition known as methaemoglobinaemia, which especially affects infants [1].
Fluoride concentrations in the study area varied between 0.203 to 33 mg/l that shown in Figure3. WHO has suggested maximum permissible limit of fluoride 1.5 mg/l in drinking water [1]. None of the samples of the study area was no exceeding the permissible limits of fluoride. Fluoride concentration in natural waters depends on several factors such as temperature, pH, presence or absence of ion complexes or precipitation of ions and colloids, solubility of fluorine-bearing minerals, anion exchange capacity of aquifer materials for F, the size and type of geological formations through which the water flows and the time water is in contact with a particular formation. Principally, controls are governed by climate, host rock composition and hydrogeology. Areas of semiarid climate, crystalline rocks and alkaline soils are mainly affected.

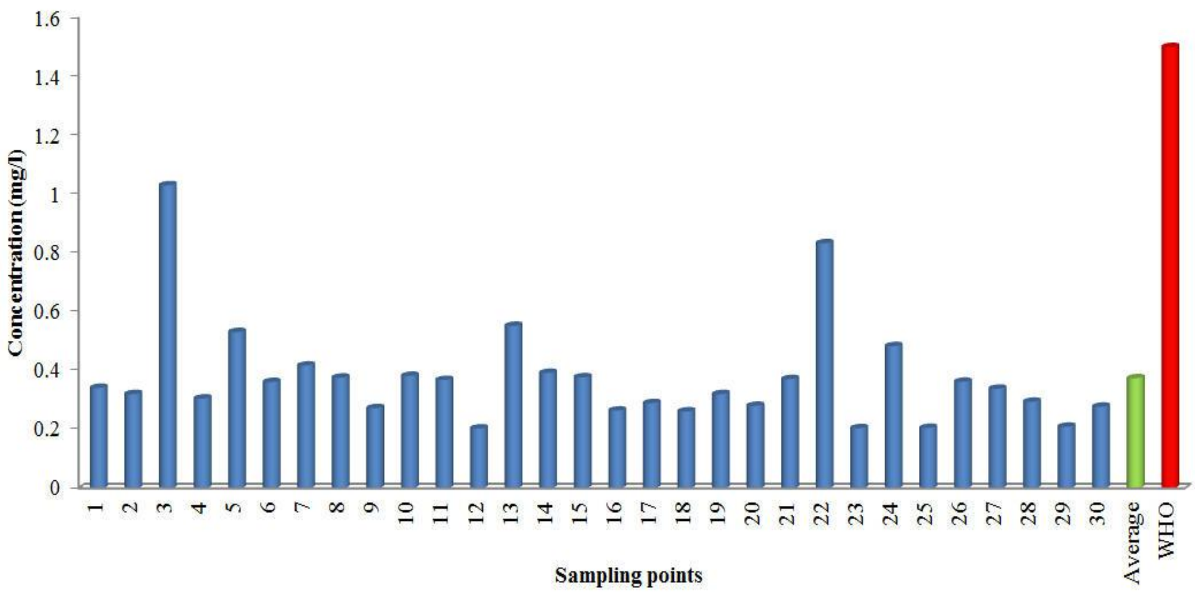

Fig-3: Fluoride concentration in ground water of the study area

The results show concentration of nitrate in Asadabad groundwater is variable between 9.6 and 33 mg/l (Figure4). Such values can be attributed to various human activities including onsite sanitation in urban centers and agricultural activities in rural areas. Furthermore, there are some signs of increasing concentration of nitrate in groundwater with time in some areas in response to increased human activities. For area to appropriately address the issue of groundwater contamination, a deliberate moves to determine nitrate concentration in groundwater is required, as well as protection of recharge basins and improvement of onsite sanitation systems.

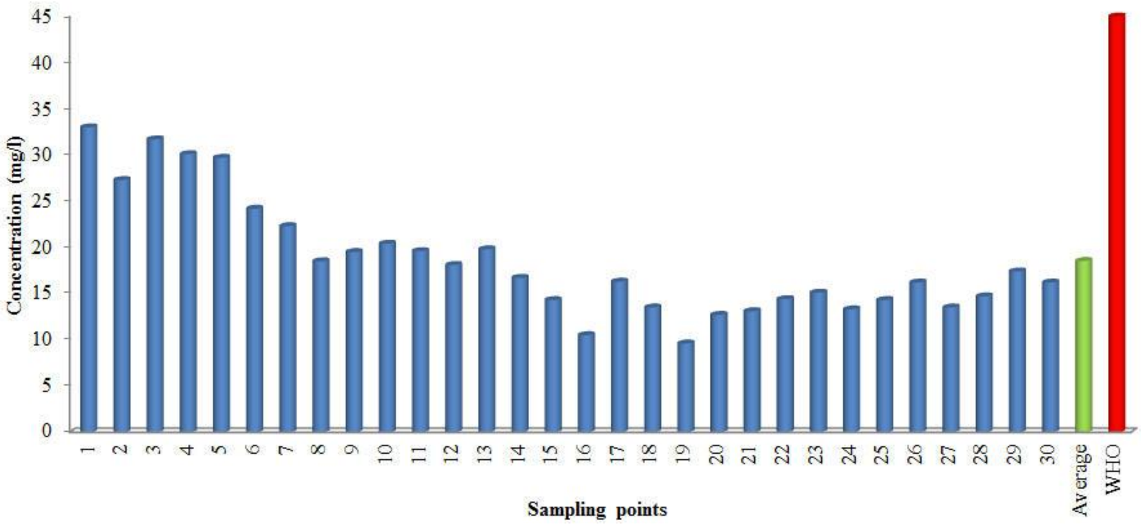

Fig-4: Nitrate concentration in groundwater of the study area

Table-2: Calculation of some of the parameters analyzed in the desired area

TH	NO_3^- mg/l	F^- mg/l	K^+ mg/l	Na^+ mg/l	Mg^{2+} mg/l	Ca^{2+} mg/l	SO_4^- mg/l	Cl^- mg/l	HCO_3^- mg/l	PH	TDS	EC µs/cm	Parameters
196.6	18.53	0.37	0.55	25.4	19.5	47.7	31.9	18.7	235.07	7.9	322.6	507.5	Average
300	33	1.03	1.173	68.54	26.84	68	77.28	39.1	298.9	8.3	457.6	704	Max
135	9.6	0.203	0.372	6.67	12.2	36	2.87	12.4	201.3	7.4	237.4	371	Min
31.9	6.31	0.17	0.24	17.2	4.18	8.4	21.9	6.6	26.6	0.22	58.03	88.6	STDEV

CONCLUION

The ground water which were taken from the various places of in and around western of Hamadan district were analyzed and the analysis reports that the water quality parameters like pH, EC, Cl^-, SO_4^{2-}, TDS, Ca^{2+},Mg^{2+}, total hardness and suitability for drinking purpose with special reference to fluoride. Most of the water samples do meet the water quality standards.

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