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Groundwater Quality and the Sources of Pollution in Baghan Watershed, Iran

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Abstract**—**The protection of groundwater resources is the great important many semiarid and arid environments. Baghan watershed is located in the north of Kangan in the Boshehr province in Iran. The groundwater resources have a vital role in supplying agricultural, drinking, domestic and industrial water demand in Baghan watershed. For our investigation into the water quality we collected 30 samples to chemical and physical analysis. The result showed the marl and evaporation deposits that contain anhydrite and gypsum is the main source of groundwater pollution, and one part of the groundwater was polluted by oil and gas industrial. Another part of the groundwater was contaminated by urban waste water. The electrical conductivity and captions and anions increased around of towns and gas refinery. Although the negative impact of untreated domestic wastewater is relatively low but the results showed strongly the negative impact of wastewater refinery is very considerable. This negative impact increased in downstream due to shallow aquifer. Additionally, the agents that adversely affect the quality of groundwater come from a variety of sources, including geology, domestic wastewater and the Jam refinery in Baghan watershed.

Keywords**—**Baghan watershed, Chemical quality, Groundwater, Pollution sources.

I. INTRODUCTION

INCREASING water pollution causes not only the deterioration of water quality but also threatens human health and the balance of aquatic ecosystems, economic development and social prosperity[1].

Groundwater pollution, often due to contaminant seepage from waste disposal sites, is a worldwide problem. Such contamination of groundwater resources potentially poses a substantial risk to local resource users and to the natural environment. Assessing risk involves identifying the hazard associated with a particular occurrence, action or circumstance and determining the probability of that hazard occurring[2]. Smith (2001) describes three categories in recognizing the threat from environmental hazards:(hazard to people (e.g. death, disease), hazard to property (e.g. damage or destruction) and hazard To the environment (e.g. loss of biodiversity)[2].For hazards in general pollution hazards result from the overlap of environmental, technological and social processes. In the case of groundwater pollution, the environmental factors controlling the hazard (and accordingly the risk) are the rates of progression of the polluted plume and the remediation of pollution through processes of precipitation, adsorption or attenuation. Technological processes of the hazard invariably pertain to the source of pollution and the characteristics of that source (i.e. the process of pollution generation and the nature, concentration and volume of pollutant produced).Social factors include the actions of individuals or communities that increase their exposure and their susceptibility to the hazard [3].

Sources of contamination on the ground surface may be a result of many known and unknown processes occur ring between chemical contaminants, soils, aquifer litho logy, and water in the vadose and saturated zones [4, 5].

Four main factors control the rate of contaminant growth in the aquifer.

First is the hydraulic situation. In shallow aquifers, not well protected from anthropogenic contamination on the ground surface, groundwater quality may be rapidly altered due to the pollution leakage from the surface and air-borne salts [6].

In confined aquifers, where pumping exceeds a safe yield, groundwater quality changes due to lateral or sub-aquifer sources and not due to direct influence of pollution from the ground surface, so that groundwater quality is usually more stable than in shallow aquifers.

A second factor is the extent of groundwater exploitation in inland areas. In agricultural and industrial regions located in highly stressed pumping areas, where ground water is consumed locally, depression cones or sinks are created. As a consequence, the groundwater utilization is replenished by return flow from the ground surface, so that groundwater in such depression cones is mostly recycled. This prevents flushing of water and contaminants to the sea, leading to an accumulation of salinity and pollution in the area.

A third factor is stress management of the aquifer near the sea.

A fourth factor is the extent of polluted lakes, rivers and other polluted surface water found in industrialized areas [7, 8].

II. MATERIALS AND METHODS

The study site is located in the Baghan watershed, Boshehr province, southern Iran and its area is 909.12 km^2 (Fig. 1). The main river is Baghan which has been formed by the mergence of two Jamoriz and Hermiak River. Data concerning precipitation and mean annual air temperature were available

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from seven meteorological stations located in Baghan watershed. The mean air temperature various between 16.3 °C and 30.4°C , whilst the annual rainfall varies between 82mm and 729.5mm.water use covers mainly industrial and agricultural needs, and to a lesser extent, domestic needs. There is an increasing water demands in industrial, agricultural and domestic needs in Baghan watershed. The Baghan watershed hosts numerous rare and protected species and a biodiversity of habitats. The study area consist of there plains which are known as Jam, Riz and Baghan. The Fajr gas refinery is located in this watershed.

Geologically, the study area characteristic by different lithology and consist of eight formation (Fig. 2).

1-Bangestan formation: consist of lime of Jurassic and Cretaceous time.

2- Khami formation: consist of lime of Cretaceous time.

3- Pabede formation: consist of marl, shale and lime marl of Paleocene to Oligocene time.

4- Asmari formation: consist of lime and dolomite marl of Oligocene time.

5- Ghachsaran formation: consist of gypsum and marl of Miocene tome.

1-Bangestan formation: consist of lime of Jurassic and Cretaceous time.

6- Mishan formation: consist of limestone, grey marl and lime marl.

7- Aghajari formation: consist of sandstone, siltstone, marl and siltstone.

8- Bakhtiari formation: consist of semi hard to hard conglomerate of Pliocene.

9- Quaternary deposits: consist of old and young alluvial plains [9].

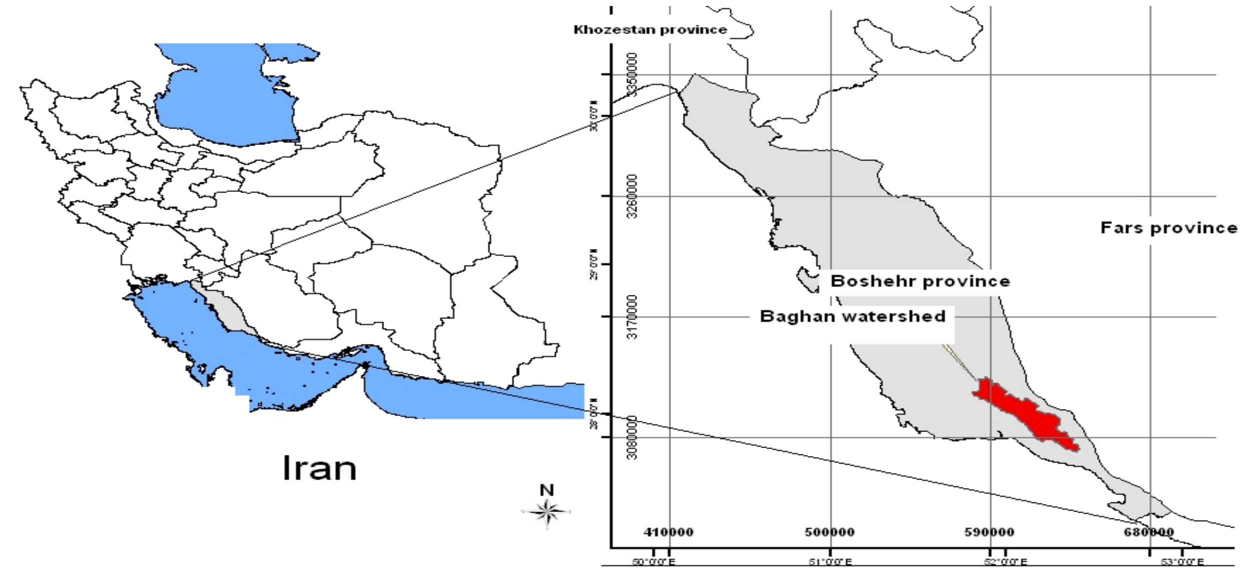

Fig. 1 Map showing Iran, The Boshehr province and The Baghan watershed

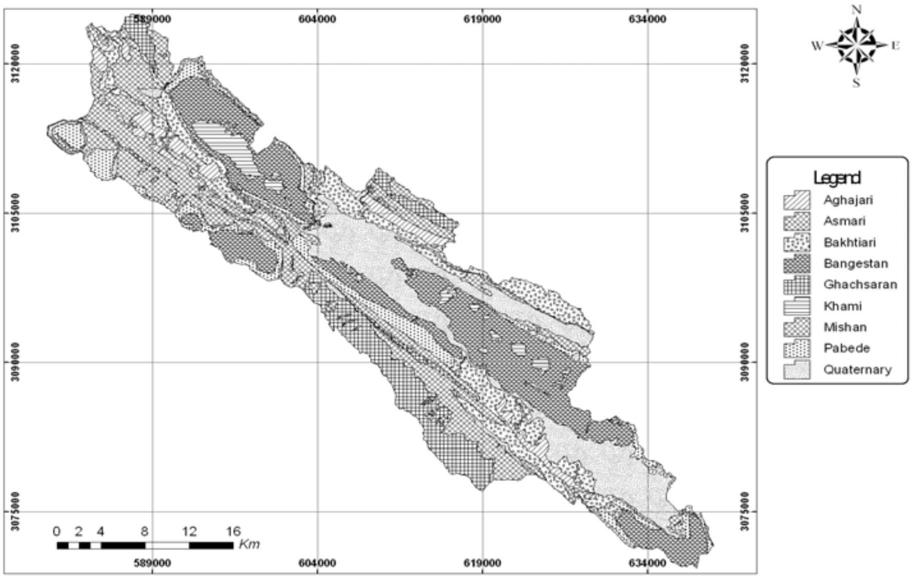

Fig. 2 Geology (Formation) map of the study area (legend of formation)

The evaluation of the groundwater quality is very important for the management of water resources in the drainage basin of Baghan. The our investigation, water samples were optioned by using flint glass containers with a capacity one and tow liter, to collected from 30 sampling stations (Fig. 3).

The dataset originated 15 samples from springs and 25 samples from wells (Fig. 3). The collected groundwater samples were analyzed for $HCO3^-$, Cl^-, $SO4^{-2}$, Ca^{+2}, Mg^{+2}, Na^+, K^+, pH, EC, %Na, SAR, TDS, Alkalinity, Hardness and chemical type.

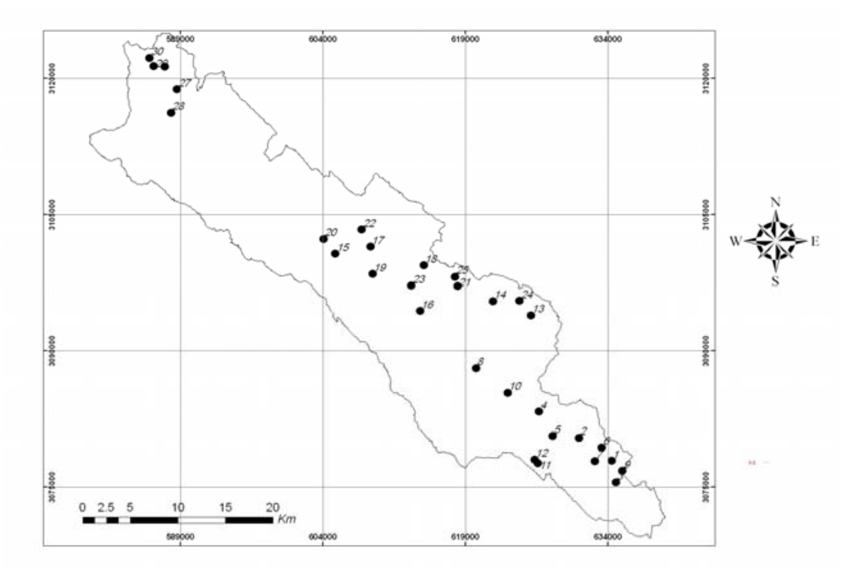

Fig. 3 Location map of the groundwater samples

III. RESULTS

Results of groundwater analyses of the different parameters are shown in Table I to IV.

TABLE I
HYDROCHEMICAL DATA (ANIONS AND CATIONS) OF THE STUDIED GROUNDWATER SAMPLES

Sample no.	Anions(mg.liter)				Cations(mg.liter)				
	HCO3	CL	SO4	Total	Ca	Mg	Na	K	Total
1	326.4	88.8	396.0	811.1	146.0	64.8	77.3	9.4	297.5
2	308.1	142.0	600.0	1050.1	179.0	107.4	105.3	18.8	410.5
3	339.2	63.9	245.3	648.3	116.0	51.6	52.7	7.4	227.7
4	317.2	209.5	600.0	1126.7	144.0	124.8	143.5	13.3	425.6
5	442.3	124.3	360.0	926.5	140.0	91.2	73.6	7.8	312.6
6	366.0	195.3	480.0	1041.3	180.0	118.8	85.1	9.0	392.9
7	289.8	42.6	96.0	428.4	48.0	49.2	25.3	3.9	126.4
8	292.8	103.0	420.0	815.8	165.0	66.6	62.1	6.3	300.0
9	305.0	106.5	360.0	771.5	118.0	80.4	78.2	7.8	284.4
10	366.0	395.8	960.0	1721.8	180.0	192.0	282.9	12.1	667.0
11	244.0	49.7	144.0	437.7	77.0	39.0	35.7	2.3	154.0
12	207.4	28.4	64.8	300.6	66.0	15.6	16.8	1.6	100.0
13	216.6	35.5	64.8	316.9	69.0	13.8	21.4	2.7	106.9
14	225.7	56.8	120.0	402.5	72.0	31.2	43.7	3.9	150.8
15	271.5	282.2	720.0	1273.7	190.0	96.0	195.5	12.1	493.6
16	286.7	291.1	840.0	1417.8	200.0	156.0	212.8	10.6	579.3
17	274.5	71.0	192.0	537.5	80.0	51.6	47.6	5.1	184.3
18	244.0	127.8	288.0	659.8	82.0	66.0	69.0	13.7	230.7
19	259.3	205.9	672.0	1137.2	170.0	98.4	165.6	10.2	444.2
20	320.3	177.5	672.0	1169.8	200.0	86.4	154.6	10.2	451.1
21	228.8	53.3	96.0	378.0	72.0	20.4	39.1	4.3	135.8
22	228.8	177.5	528.0	934.3	129.0	104.4	105.3	8.6	347.3
23	201.3	120.7	480.0	802.0	154.0	65.4	62.1	6.3	287.8
24	302.0	113.6	264.0	679.6	120.0	54.0	66.7	5.9	246.6
25	237.9	234.3	480.0	952.2	109.0	78.6	157.3	8.6	353.5
26	180.0	69.2	624.0	873.2	175.0	83.4	40.3	8.6	307.3
27	173.9	326.6	480.0	980.5	163.6	63.6	186.3	12.1	425.6
28	180.0	236.6	552.0	968.6	158.0	79.8	143.8	9.8	391.3
29	189.1	124.3	720.0	1033.4	186.0	104.4	78.2	9.8	378.4
30	210.5	310.6	600.0	1121.1	182.0	93.6	172.5	10.6	458.7

TABLE II
HYDROCHEMICAL DATA OF THE STUDIED GROUNDWATER SAMPLES

Sample no.	pH	EC	TDS	NA (%)	S.A.R	Total Hardness	Alkalinity
		Ds/m	(mg/l)			(PPM)	(PPM)
1	7.07	1412	1037	21.00	1.33	635	268
2	7.09	2180	1487	20.00	1.53	895	253
3	7.18	945	750	18.00	1.02	505	258
4	7.20	2046	1505	26.00	2.10	880	260
5	7.04	1666	1160	18.00	1.19	730	363
6	7.00	2151	1397	16.00	1.21	945	300
7	7.31	734	509	14.00	0.61	325	238
8	7.15	1476	1060	16.00	1.03	690	240
9	7.12	1476	1014	21.00	1.35	630	250
10	7.20	3206	2355	33.00	3.47	1250	300
11	7.90	742	556	18.00	0.82	355	200
12	7.97	523	355	14.00	0.48	230	170
13	7.92	556	379	17.00	0.61	230	178
14	7.42	768	520	23.00	1.08	310	185
15	7.13	2404	1692	32.00	2.87	875	223
16	7.17	2494	1901	28.00	2.73	1150	237
17	7.29	1064	711	20.00	1.01	415	225
18	7.41	1265	850	23.00	1.37	480	200
19	7.17	2193	1519	30.00	2.49	833	213
20	7.22	2109	1526	28.00	2.29	860	263
21	7.41	766	467	24.00	1.04	265	188
22	7.31	1940	1270	23.00	1.67	758	188
23	7.28	1518	1047	17.00	1.05	658	165
24	7.30	1265	879	21.00	1.27	525	247
25	7.28	1898	1266	36.00	2.79	600	195
26	7.26	1856	1306	10.00	0.63	785	148
27	7.32	2024	1383	42.00	3.73	615	143
28	7.38	2147	1380	30.00	2.31	728	148
29	7.28	1835	1363	16.00	1.13	900	155
30	7.28	2320	1555	30.00	2.58	845	173

Electrical conductivity varies between 700 to 2200 ds/m in Jam plain aquifer. Maximum level is observed in north, east and central boundary of this aquifer. Minimum level of EC was observed in south and west boundary of this plain. Additionally, EC appears as increasing trend from upstream to downstream. The existence of low level of EC in Palangi and Bidkhar valleys indicated positive impact of induced recharge of aquifer in this region that performed former.

Increased values of EC around of Jam town are an indicator of untreated domestic wastewater discharge from town which seems to affect quality of groundwater but this effect isn’t very critical now. One of the important factors that increase and subsequently change the trend of EC at the west north and the end of plain is minerals which present in evaporational Aghajari rock formation.

Electrical conductivity varies between 1200 to 2400 ds/m in Riz plain aquifer. High level of EC is in the lower part of Riz affected by the Jam refinery. The Jam refinery deteriorates quality of groundwater in this region. The amount of EC around the Riz town is 2200 ds/m. The high level of EC around the Riz town was affected by domestic wastewater discharge from town and shallow aquifer and high accumulation of operational well.

Electrical conductivity varies between 2000 to 2300 ds/m in Baghan plain aquifer. The high level of electrical conductivity at upstream is due to uploading of bedrock, shallow aquifer and evaporational formation.

The trend of alteration of cations and anions is the same as one of EC in the Baghan watershed.

The trend of hardness alteration follows with ca^{+2} and $Hco3^{-}$ .The minimum and maximum of total hardness were 300 ppm and 950 ppm in Jam. In the Jam plain the minimum of total hardness is related to the Palangi and Bidkhar valley and the minimum level of total hardness was observed in the north and waste north of the Jam town. The value of hardness was relatively high and altered between 600 to 900 ppm in the Baghan plain. Additionally, the type of groundwater in the study area was hard water ($Caco_3$ > 300 mg/lit).The high value of hardness in Baghan plain showed the effect of calcareous formation but the increased value around of Jam refinery results from industrial wastewater refinery.

The value of SAR altered between 1 and 4. The trend of SAR alteration was the same as one of anions, cations and specially Na^{+}. The value of SAR in the Jam plain varies between 0.5 and 3. Thus the value of SAR isn't critical .In general; due to low level of SAR in the groundwater there is no concern about alkalinity of aquifer.

IV. Discussion

The evaporational and marl formation as Aghajari, Ghachsaran, Mishan and Bakhtiari and the existence of calcareous layers as Bangestan that they have gypsum and anhydrite, lithologically, are the main agent that affects quality of groundwater in Baghan watershed. The faults or other structure features enhance the erosion and gelifraction rock and the climate conditions increase theirs erodibility and weathering. The groundwater quality and especially the alluvium quality deteriorate due to the high concentration of soluble components that recharge of these formations (geology). Saleh &et.al show that the salinity increases in old alluvial plains and decrease in the dissected wadis of limestone plateaxe, while vertical distribution decrease with depth. It is found that the groundwater is supersaturated with respect to calcite and dolomite, and undersaturated with respect to gypsum on the Nile west bank [10].

The increased value in the around of the Jam town and increasing trend of electrical conductivity, anions and cations around the Jam refinery indicated the pollution induced by the domestic waste water and especially by the Jam refinery. Although the negative impact of untreated domestic wastewater is relatively low but the results showed strongly the negative impact of wastewater refinery is very considerable. This negative impact increased in downstream due to shallow aquifer. The high density of operational wells and subsequently water discharge increasing is the other agents for the deterioration of groundwater and alluvium quality. The increased trend of anions and cations and EC value in the beginning of plain is an abnormal condition, because the groundwater quality in this part of plain is better than the end of plain. Therefore, this abnormality shows the negative impact of the Jam refinery. Thus because of the Jam refinery location in the beginning of plain, it can spread pollution to whole of aquifer. The best solutions for this risk are the utilization of methods of treatment, upgrading the existing water treatment plant and water and soil conversation works e.g. artificial recharge, flood spreading and watershed management.

Although quantification of the hazard and risk associated with the pollution of groundwater within the Baghan watershed is beyond the scope of this work, a qualitative assessment based on the principles discussed here allows contextualization of potential social and environmental impacts associated with the contamination of groundwater through wastewater.

Identification of the hazard involves an assessment of potential effects of groundwater pollution on the people, their property and natural environment. Although some impact on property is possible in this study, these effects are likely limited owing to little exposure of property to the polluted groundwater. Greater potential hazards are associated with the health impacts in the human population and changes in the natural environment through death of fauna and flora, loss of biodiversity and disturbance of ecosystem stability. Human health impacts through exposure to the contaminated groundwater arise due to the use of groundwater for domestic purposes. Although the present risk is low, an assessment of future risk requires elucidation of the reasons for low concentrations of toxic metals coupled with an analysis of the conditions that may increase the risk of exposure to the hazards.

Some environmental problems concerns water deficiency. Anthropogenic influences, urban, industrial and agricultural activities, increase the consumption of water resources. The amount of water which is used for irrigation continues to increase because the irrigation network system is not managed properly. There are significant losses of water from the pipe network that distributes the water load. However, water resources management is incomplete and ineffective in Baghan watershed and that no methods of integrated management exist. The most crucial problem is the lack of coordination of various actions of different institutions toward water management; this may also involve conflict of interests and definitely no exchange of information between the different institutions.

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