

Heavy Metal Contamination Assessment of Groundwater Resources in Behbahan Plain Southwest Zagros

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Abstract

Ground water is an important issue in environmental engineering and water supply systems, so preservation and purification of ground water have a critical role in any community. This paper investigates the concentration of several elements such as Pb, Cd, As, Se, Co and Zn for ground water in Behbahan (a city in southwest of Iran), to this purpose a group of 30 wells were studied to determine the heavy metal concentration, physical parameters (PH, EC, TDS, Temperature) *in situ*. The major ions' values of HCO_3^{2-} , SO_4^{2-} , Cl^- , Na^+ , Mg^{2+} , Ca^{2+} , K^+ were measured for the wells based on the titrimetrical and flame photometry and optical emission spectrophotometer. Results of the analyses indicated the concentration of Pb, As, Cd and Se in 33, 13, 56, 100 percent greater than normal range of WHO standard respectively. No pollution of Co and Zn was seen in any specimen. There is a low correlation between Pb and major ions value, so it can be concluded that Pb over-concentration is caused by human contamination. The high correlation between Se, As and major cations and anions, implies that they can originate from dissolution and liquidation of mineral evaporation in the zone. The high rate of Cd concentration in urban sewage water is due to the small industries, workshops and mills wastewater.

Keywords

Heavy Elements, Ground Water, Pollution, Waste Water

1. Introduction

Over the last few decades, competition for economic development, associated with rapid growth in population

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and urbanization, has further affected the groundwater quality due to over exploitation and increasing demand for agriculture, domestic and industrial water supply, as well as improper sewage flow and solid waste disposal [1] [2]. The effluents discharged from industries and urban sewage find their way into surface water bodies. These water bodies in turn act as recharge source for groundwater, thus making it vulnerable. Few of the heavy metals considered as micronutrients become detrimental to human health when their concentrations exceed the permissible limits [3]. The present study tries to quantify the heavy metal pollution, in Behbahan plain of ground water along with its suitability for drinking purposes. The importance of this subject is highlighted if we know that some part of drinking water of the urban and rural residential areas is provided from the ground water in the study area.

2. Geological Setting

Study area is Behbahan Plain with an area of about 1320 km² and is located between 30°30' and 31°00' northern and 50°00' and 50°30' eastern, southeastern part of Khuzestan province and southwest of Iran (Figure 1). This area is a part of Jarrahi river catchment area that located in the south and southwest of middle Zagros domain. Climate of the study area is semiarid, the annual average precipitation being approximately 336 mm. The annual potential evaporation exceeds the annual rainfall with amount of approximately 3401 mm. In this area generally, slope decreases from north to southeast and southwest.

Geologically, the study area lies in the Zagros folded belt (Stocklin, 1968). Outcrop of the Formations in the study area is related to Upper Cretaceous to Quaternary in age. These formations include Pabdeh and Gurpi marl formations, Asmari limestone formation, gypsum and marl layers Gachsaran formation, Mishan formation with limestone shellfish and Gray marl, Aghajari limy sandstone and red marls, Lahbari Member weathered siltstone from old to new, respectively. Alluvial sediments, that are the youngest sediments in the study area, are composed of gravel, sand silt and clay (Figure 1). Groundwater resources in the study area are located in alluvium. The aquifer average thickness is about 75 m in which sediments of Bakhtiari formation in the southwest and west and northwest of the study area made the bed rock and also sediments of Gachsaran formation with low infiltration in north and east and central parts. The general direction flow of groundwater is toward west throughout the area. Groundwater has been used for various purposes, such as drinking, agricultural, domestic, and industrial needs.

3. Materials and Methods

Water samples were obtained from 30 wells during Jul 2014. Two 250-ml bottles were collected at each site. The first sample, which was intended for anion analyses, was left unfiltered and unacidified. The filtered water of the second sample was acidified with 2 ml of concentrated nitric acid (Merck, Ultrapure). The second sample was used later for heavy metals analysis. Physicochemical parameters including temperature, EC and pH were measured *in situ* using portable measuring instruments immediately after sampling. Dry, clean and sterilized polyethylene bottles were used for water sampling. The bottles were triple washed by the water to be sampled before sampling. The collected samples were labeled, sealed and transported to the laboratory and preserved in refrigerator at a temperature of about 4 °C until analysis. Water samples were analyzed for chemical constituents such as HCO_3^{2-} , SO_4^{2-} , Cl^- , Mg^{2+} , Ca^{2+} , Na^+ , K^+ and TDS in the laboratory using titration flame photometry and evaporating a pre-filtered method respectively, within 48 h after sampling. Heavy metals were analyzed using optical emission spectrophotometer. Then, distribution pattern of each element was determined in the surfer software. After wards correlation of heavy metals concentration and major anions and cations (HCO_3^{2-} , SO_4^{2-} , Cl^- , Na^+ , Mg^{2+} , Ca^{2+} , K^+) was used to determine the probable sources of heavy elements contamination.

4. Results and Discussion

Hydro chemical results of groundwater revealed Pb content varies from 0 to 0.83 mg/l as 33% of the analyzed samples display content above the standard value (Figure 2). From its low correlation coefficient with major cations and anions it can be seen that Pb set on the soil and planets and penetrated to the groundwater in raining. The high concentration of cadmium in southwest and northwest parts of the area can be considered as the effects of Gachsaran formation and Cd tendency to substitute minerals containing Ca [4] (Figure 2). The high rate of Cd concentration in urban sewage water is due to the small industries, workshops and mills wastewater. As content

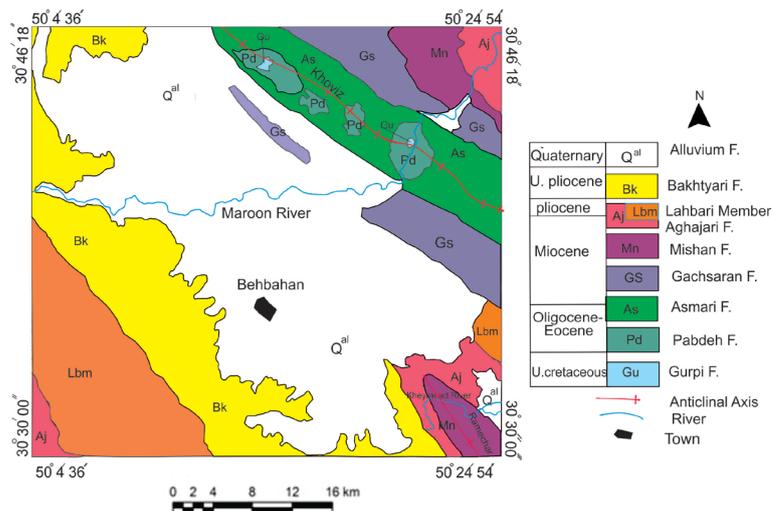


Figure 1. Geological setting of the study area.

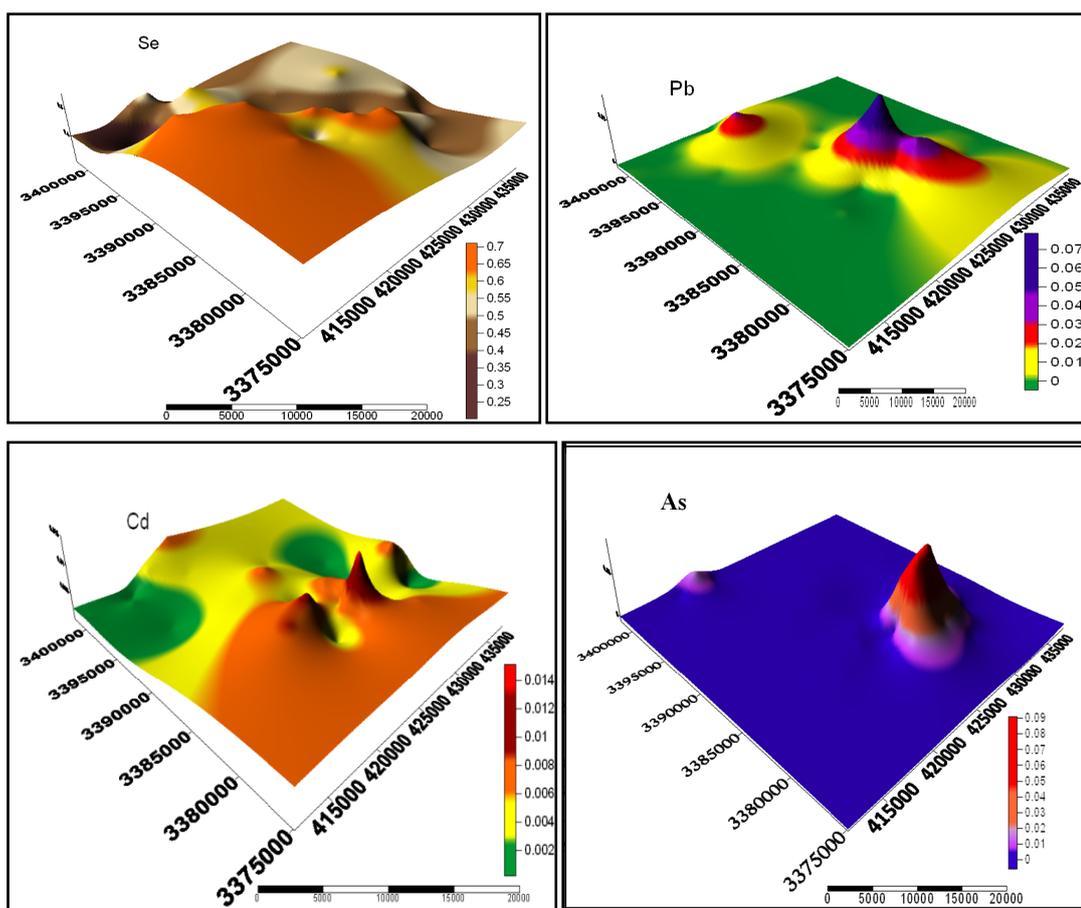


Figure 2. Geochemical map showing the concentration of heavy metals in the study area.

ranges from 0.009 to 0.094 mg/l, whereby, 13% of samples exceed WHO standard (Table 1). According to high correlation between As and major cations and anions its high concentration in some parts of the area might possibly be related to the dissolution of evaporates minerals (Table 2). As concentration increase can be caused by pesticides used in garden and other agricultural land in urban and suburban areas (Figure 2).

Table 1. Basic statistical parameters for the heavy metals.

Parameters	Se	pb	cd	AS
Mean	0.523	0.215	0.484	0.009
Maximum	0.691	0.838	0.159	0.094
Minimum	0.19	0	0	0
Standard deviation	0.124	0.02	0.035	0.024
Maximum permissible limit (WHO)	0.01	0.01	0.003	0.01
Samples exceeding maximum permissible limit (%)	100	33	56	13

Table 2. Pearson's correlation matrix of groundwater samples.

	PH	TDS	EC	K ⁺	Na _e	Mg ²⁺	Ca ²⁺	HCO ₃ ²⁻	CL ⁻	SO ₄ ²⁻	NO ₃ ⁻	As	Cd	Pb	Se
PH	1														
TDS	<u>0.05</u>	1													
EC	<u>0.45</u>	<u>0.9</u>	1												
K ⁺	0.32	<u>0.64</u>	0.65	1											
Na ⁺	0.35	<u>0.84</u>	<u>0.88</u>	<u>0.7</u>	1										
Mg ²⁺	0.22	<u>0.53</u>	0.49	0.38	0.3	1									
Ca ²⁺	0.31	0.48	0.48	0.15	0.17	0.36	1								
HCO ₃ ²⁻	0.34	0.36	0.38	0.04	0.43	0.12	0.1	1							
CL ⁻	0.31	0.16	0.18	0.01	0.11	0	0.21	0.12	1						
SO ₄ ²⁻	0.37	<u>0.82</u>	<u>0.76</u>	0.44	<u>0.5</u>	<u>0.66</u>	<u>0.73</u>	0.18	0.06	1					
NO ₃ ⁻	0.04	0.02	0.25	0	0	0.01	0.22	0	0.11	0.04	1				
As	0.23	<u>0.69</u>	0.7	0.48	<u>0.64</u>	0.24	0.22	0.19	0.2	0.42	0.06	1			
Cd	0	0.05	0.04	0	0	0	0.33	0	0.18	0.11	0.22	0.1	1		
Se	0.21	0.05	0.2	0.2	0.01	0.21	0.39	0.09	0.08	0.21	0.2	0.08	0.04	0	1

In general, Se is vital for regulating biological processes in human bodies; however, beyond the permissible limit it can cause health hazards. Se content ranges from 0.52 to 0.69 mg/l where by 100% of samples exceed WHO standard (**Table 1**). Relatively good correlation coefficient is also observed between Se and Mg²⁺ + Ca²⁺ and SO₄²⁻, which indicates the dissolution of gypsum and dolomite as the main source of selenium (**Table 2**). Geochemical evaluation (**Figure 2**) shows the nearly uniform concentration of Se in the study area.

Also hydro chemical results of the groundwater revealed that concentration of Zn and Co was below the water standards. Concentration of Cobalt and zinc is dependent on the bed rock (Mico, 2006). The low concentration of Co and Zn is compatible with geochemical characteristics of alluvium plain.

The metal index (MI) can be used for trend evaluation of the pollution status. According to [5], the MI is calculated using the Equation (1):

$$MI = \sum_{i=1}^n \frac{C_i}{(MAC)_i} \quad (1)$$

where, C_i : the concentration of each element, MAC: maximum allowable concentration (from the WHO standard).

The higher the concentration of a metal compared to its respective MAC value, the worse the quality of the water. MI value > 1 is a threshold of warning [6]. The metal index is used to estimate the metal pollution of ground water in the study area for drinking. Metal index denotes the trend evaluation of the present status by computing Pb, Cd, As, Se concentrations (**Table 3**). According to metal index values, all selected stations in

Table 3. Metal index for water drinking in Behbahan plain.

Number of well	Metal Index	Number of well	Metal Index
1	71.38	16	71.66
2	59.7	17	37.8
3	39.06	18	53.2
4	50.03	19	53.73
5	65.54	20	62.61
6	40.36	21	59.2
7	58.46	22	38.37
8	39.16	23	50.18
9	44.1	24	71.85
10	42.4	25	71.99
11	19.66	26	56.41
12	68.34	27	47.72
13	51.5	28	56.06
14	71.07	29	82.66
15	70.7	30	78.99

Behbahan plain threatened with metal pollution for drinking usage ($MI > 1$).

5. Conclusion

The hydrochemical analysis of the present study reveals that the groundwater in the study area is contaminated with trace metals, such as Cd, Se, As and Pb. The mean concentration of heavy metals (mg/l) displays the following decreasing trend: $Se > Pb > As > Cd$. The spatial distribution maps of Cadmium, Selenium, Arsenic and Lead showed that the maximum concentration of Se, As, Cd, Pb occurs in the southern part of the study area and their concentration decreases towards the north-west. Due to correlation coefficient of elements of As, Se, Pb, Cd, and major cations and anions, dissolution evaporates minerals can be considered as probable sources of As, Se, while probable sources of Cd, Pb consist of anthropogenic activities. Metal index indicates that the groundwater quality is severally deteriorating. The overall quality states that Behbahan Plain is an area which demands urgent attention and the results of this paper are important for the development of proper management and remediation strategies to decrease source pollution.

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