Cadmium, Arsenic, Lead and Nitrate Pollution in the Groundwater of Anar Plain

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Introduction

This study deals with the variations of Cd, As, Pb and NO_3^- levels in the groundwater of Anar Plain. Anar plain is located in southeast part of Iran (west of Rafsanjan plain) between 55° ,10′ to 56° eastern longitude and 30°, 30′ to 30°, 58′ northern latitude. This plain, stretching in a northwest- southeast direction, resembles a rectangle about 42 km in width and 82 km in length and is bounded by Badbakht-Kuh Mountain from the north and Dahaj-Sarduieh Mountain from the south (figure 1). About half of the plain in the north and west parts is occupied by barren salt playas. In addition to Anar and Koshkuieh towns, there are tens of villages in the plain which are mainly located in the medial part, where the Qantas supplying them with water emerge at the surface. Also, there are several asphalt roads in the plain, the main one connecting Kerman via Yazd to Tehran.

Geologically, the Anar plain separates two zones of central Iran, namely Urimieh- Dokhtar in the south and flysh zone in the north. Badbakht- Kuh in the north is composed mainly of upper Cretaceous flyshes which are strongly tectonized and as a result of being low and narrow, has negligible role in recharging the alluvial aquifer of Anar plain. In contrast, the high and broad southern mountains which are mainly composed of volcanic rocks play a key role in recharging the aquifer.

Hydrogeologically, the Pelio-Quaternary alluvial soils create the groundwater aquifer of the Anar plain. The huge recharging alluvial fans are located in the south and the salt playas (as discharging areas) in the north. In contrast to the north, groundwater in the southern and medial parts of the plain is not saline. Groundwater being recharged from the south flows slowly towards the north (the salt playas) and as a result of being in contact with basal Miocene red beds during this migration, its salt content increases. Obviously, residential areas, roads, agricultural activities (pistachio gardens), several small industries as well as several mines are potential pollution sources in the area. However, red beds, mineralization and hydrothermal processes are considered as natural agents of groundwater pollution.

Materials and Methods

In order to reveal the pollution conditions of groundwater, 21 samples were taken from discharging deep wells during a four day period (21-24 April 2009). The samples were taken from the outlet of discharging wells and the sampling points selected are scattered across the plain. Also, the sampling polyethylene bottles were first washed up with the sampling water and two samples were taken at each point, one for analyzing major ions and the other for heavy metals. The latter samples were acidified and their temperature and pH was measured at the sampling site. Geographical coordinates were determined using GPS sets. Major ions were measured using chromatography technique and heavy metals were tested by Atomic Absorption Spectrometry (table 1). Isoconcentration maps were prepared using Arc GIS software. Anthropogenic pollution sources (roads, residential areas and pistachio gardens) are mainly located in the medial part of the plain. So, in order to reveal their role, the average concentrations in southern, medial and northern parts of the plain were compared using histograms.

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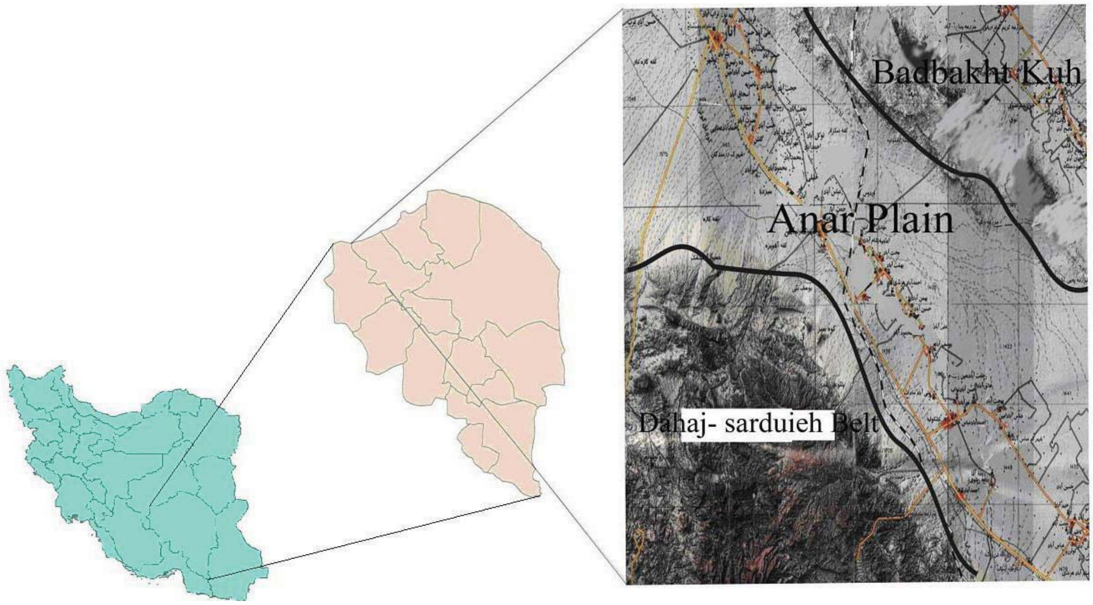

Fig. 1: Location of Anar plain

Table. 1: samples analysis results

Sample number	Cd (ppb)	As (ppb)	Pb (ppb)	NO_3^{2-} (ppm)	Sample number	Cd (ppb)	As (ppb)	Pb (ppb)	NO_3^{2-} (ppm)
1	2.63	57	20	12	12	0.78	<10	12	14
2	0.11	34	1	16	13	0.05	<10	17	19
3	0.09	96	3	29	14	0.66	25	17	30
4	0.28	<10	1	16	15	0.17	15	14	14
5	0.15	<10	1	12	16	0.08	<10	15	21
6	0.37	<10	13	18	17	0.34	<10	14	21
7	0.25	<10	15	13	18	0.11	<10	14	24
8	0.17	13	11	24	19	0.29	16	13	25
9	0.06	11	15	15	20	0.11	19	13	30
10	0.29	<10	15	64	21	0.06	<10	10	16
11	0.06	17	13	97					

Discussion of results

The isoconcentration map of Cd reveals that the level of this element is higher in the vicinity of copper mines in the southeast.

So it is most probably released from sulfide vein mineralization in this zone. According to the average concentration histogram, the level of Cd is higher in recharge (southern) part, indicating natural enrichment.Since the groundwater pH in this part is lower; it increases the solubility of Cd.

The average level of Cd in the medial part of the plain with the majority of anthropogenic pollution sources is the least, almost suggesting the absence of human influence on its concentration.

According to the isoconcentration map of As, the level of this element is the highest one in the southern and southeastern parts of Anar plain (figure 2). Since copper mineralization is obvious in this zone, this element which commonly accumulates in sulfides is supposedly released from this zone. Interestingly, the concentrations of As, Pb, Cd as well as temperature are high in sample14 which is low in pH and has been taken from near the active Anar fault. So here hydrothermal conditions prevail and have led to high levels of these elements. Adsorption by iron oxy-hydroxides is considered as the major process leading to decrease in As level towards the north.

The concentration of Pb is high in major parts of Anar plain aquifer so that in several samples, Pb level is higher than MCL standard (15 ppb). Also, the average concentration of Pb in medial and northern parts of the plain is higher than the southern part which is the recharge zone. The anthropogenic increase in Pb seems certain, the main agent of which is the high-traffic Kerman-Yazd road. As a result of combustion of Pb containing fuels, this element is released into the environment and enters the aquifer via infiltrating surface water.

The average nitrate level has also increased in the medial part of the plain, showing anthropogenic source of this anion. Its concentration around the Anar town reaches to 96 ppm which is higher than the permissible level (50 ppm) for drinking water. Leakage from sewage disposal wells is considered as the main agent.

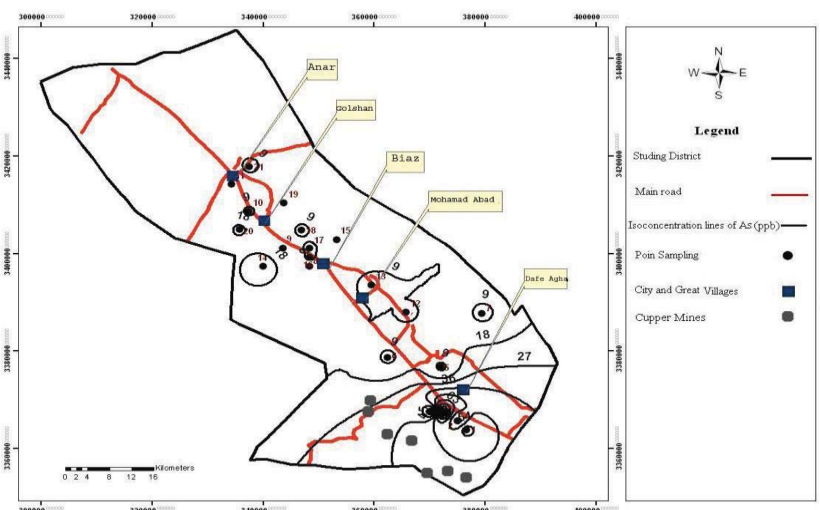

Fig. 2: Isoconcentration map of As

Conclusion

A set of natural agents (sulfide mineral weathering and hydrothermal water) and anthropogenic sources (Pb from road traffic and urban sewage waste) have polluted some parts of the alluvial aquifer of Anar plain. So in order to exploit groundwater resources, these pollution sources must be taken into consideration.

Key word

Anar plain, Arsenic, Cadmium, Lead, Nitrate, Groundwater, Pollution.