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Environmental effects of boron element on Gharabagh groundwater contamination and provide methods to reduce or eliminate its impact

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Abstract

Groundwater is one of the main sources of drinking water and agriculture in Salmas, Agh ziyarat and Gharabagh plains. Since drinking water of Gharabagh plain supplied through two deep wells within the village, but after successive droughts in the selected area as a result of water shortages and low quality of drinking water and consumers dissatisfaction with drinking water after sampling and chemical analysis of water it is determined that concentration of Boron element is much higher than standard limit. Currently to diagnose contamination strategies to prevent environmental impacts some investigations have been conducted. From available water resources, 45 samples a few years ago and 15 samples were prepared in 2014 in order to determine boron concentration by using GIS package. According to the results of analysis and geological maps of studying area identified that origin of pollution is underground mineral water. This water after passing through layers of rock containing boron and dissolving it, some of that reached to the ground surface as hot springs enter the groundwater and contaminate Agh ziyarat and Abegarm regions, and some part transferred to the Khorkhoreh Chay and Ghapagh Tappeh villages through faults and cause pollution in groundwater of these areas. In this research, to prevent further contamination of the groundwater and environmental impacts in the area, solutions in order to reduce the contamination are recommended.

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Introduction

Physical, chemical and biological characteristics of water, considerably known as the main factors of controlling the health and condition of living organisms (Kazi *et al*, 2009). Water pollution with heavy and light metals resulted mostly by natural processes such as: weathering, erosion and leakage of mineral and human activities such as: mining, agriculture and industry (Sracek *et al*, 2011). These processes reduce water quality and damage the consumers (living creatures, agriculture and industry) (Krishna *et al*, 2009). Drinking water usually depends on local and regional geochemistry.

Among the environmental contaminants, heavy metals because of being non-decomposition and physiological effects on living organisms at low concentrations are important (Mohr, 2008). Due to the low mobility, these elements are accumulated in the soil over time (Gisbert *et al* 2003). Due to the toxicity and pathogenesis of these parameters in the groundwater researchers should focus on groundwater and surface water in more polluted areas and due to available technological possibilities, practical strategies to eliminating contaminants will offer. Groundwater and surface water is affected by the regional geology.

Reaction between rain water and host rock determines the amounts of the various components in the water. Most of the heavy and light metals with specific concentrations are needed for living creatures. However, high concentrations of these metals may have toxic effects. Metals like Boron are highly toxic, because of their long term toxicity and devastating environmental impacts (Muhammad *et al*, 2011). Environmental effects of Boron on groundwater of Gharabagh and Agh Ziyarat plains contamination and potential risks to human health and the environment will be evaluated.

In this study, concentration of Boron in groundwater and tap water in the area has been investigated.

Materials and methods

Study area

Gharabagh and Agh Ziyarat plains located around Salmas in West Azerbaijan province. This plain is placed about 65 km in the north of Urmia city and 1400 meters above sea level. Geographically located in 44° 50´ to 45° 00´ longitude and 38° 01´ to 38° 12´latitude. Arial photo of studying area is shown in fig. 1. Selected area surrounded from three sides by high mountains and from north and northeast ends to the Urmia lake, according to fig. 2.

This area due to the division of constructional - sedimentary units of Iran is a part of metamorphic and ophiolitic structure of Sanandaj – Sirjan zone. This area is separated by Khoy-Mohabad subdivision from Alborz-Azerbaijan zone. Oldest outcrop rocks in the area consist of a series of metamorphic rocks that degree of their transformation is from greenschist to amphibolite facies, but age of them is not known exactly.

Low metamorphic rocks of kahar Formation are placed in the same area. Miocene units in the region with angular unconformity cover the older units that consists of sandstone, conglomerate, shale and marl with seams of limestone and gypsum. Pliocene conglomerate unconformably exist in the area.

Finally, lavas and pyroclastic rocks from volcanic activities and alluvial deposits cover the selected area. Sediments are mostly silt, sand and pebbles along with clay layers that are dispensed in different ratio. Furthermore, wind alluvial deposits in the West region and Travertine formation in the junction of Quaternary sediments and metamorphic rocks are visible. In this area there are some major and minor faults with West – East length which are effective in charging the groundwater resources, according to the fig. 3 and 4. Also values of Boron, TDS and EC presented in table 1.

Fig. 1. Arial photo of studying area.

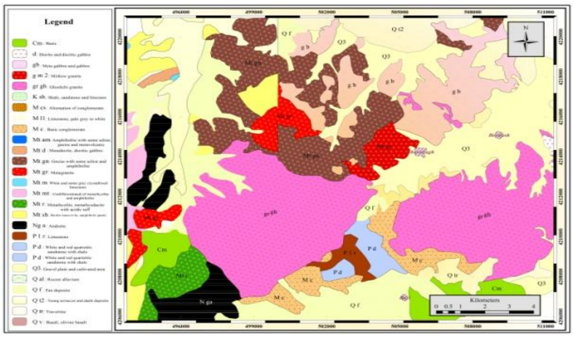

Fig. 3. Geological map of studying area.

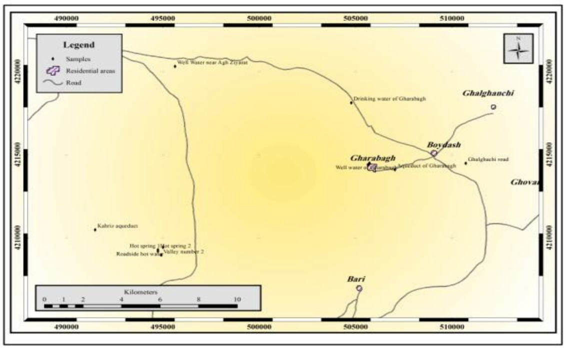

Fig. 2. Location of selected area.

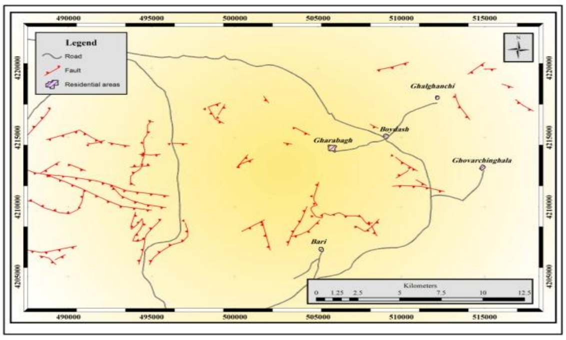

Fig. 4. Location of faults.

Table 1. values of Boron, TDS and EC in sampled wells.

Sampling area	Boron mg/l	TDS mg/l	EC µS/cm
Hot spring 1	442	10960	16860
Hot spring 2	450	10890	16750
Cold spring	446	10220	15730
Outlet of hot water(branch 3)	451	11280	17450
Right stream of hot water(branch 2)	265	4360	6710
Spring of two streams confluence	410	10240	15750
Confluence of 2 and 3 streams	380	7410	11400
Left stream of hot water(branch 4)	0.48	291	450
Confluence of streams 1, 2 and 3	215	3540	5450
Stream of branch 1	3.48	505	777
Deep well 1	16.08	577	887
Deep well 2	16.68	627	964
Deep well 3	8.66	429	660
Deep well 4	9.21	427	657
Deep well of Morad khan	6.74	683	1050
Deep well of Tamar	8.2	638	981
Deep well of Gharabagh downstream	6.65	569	875
Deep well of Agh Ziyarat 1	7.34	670	670
Deep well of Agh Ziyarat 2	10.94	857	857
Spring of Shor Gol	1.03	530	815
Drinking water of Shor Gol	2.46	945	1453
Drinking water of Tamar	4.7	_	_
Drinking water of Minas	8.2	_	_
Drinking water of Ghara Gheshlagh	1.01	_	_
Drinking water of Soltan Ahmad	0.44	_	_

Sampling area	Boron mg/l	TDS mg/l	EC µS/cm
Drinking water of Ghezeljeh	0.76	_	_
Drinking water of Habashi	0.65	_	_
Drinking water of Akhteh Khaneh	0.77	_	_
Drinking water of Ghabakh Tappeh	9.6	_	_
Drinking water of Salmas	0.85	_	_
Well water of Agh Ziyarat	15.42	_	_
Well water of Khan Takhti	7.8	_	_

Analyzing method

After transferring the samples to the laboratory of analytical chemistry of west Azerbaijan Province, to perform the analysis in the first phase we poured 20 mg of curcumin in a 50cc balloon. Next, 2.5 g of oxalic acid is added to the balloon. Then 40cc ethanol is added to the contents of the balloon and shaked in order to solve it. After dissolving we brought the balloon to the volume.

Then we prepared 5 standard methods for determining the amount of Boron contamination that put in five separate container with different volumes (ppm100, ppm75, ppm50, ppm25, ppm0) (Table 2). After preparation the standards of boron, 1 mg of each sample taken and poured in plastic containers with taking notes and 4 ml of curcumin (acid which were prepared initially) added to the sample and standard methods and we put all samples into a hot bath. It has left at room for 3 hours to evaporate all liquid of containers. The contents of the container depending on the concentration of Boron, color changed to red.

Next, 10 ml of ethanol was added to each of containers and solved the contents of the containers. Then we poured 25ml of each container to special balloons and added ethanol again Bring to volume with ethanol. After completion of the work all samples are ready to analyze and determine Boron contamination by standard methods in atomic absorption spectrophotometer. Zoning maps of Boron with different GIS methods shows the contamination in each part of sampled area (fig. 5, 6 and 7).

Table 2. Standards of Boron.

Boron value	Standard (ppm)
0.011	0
0.214	0.25
0.377	0.5
0.464	0.75
0.664	1

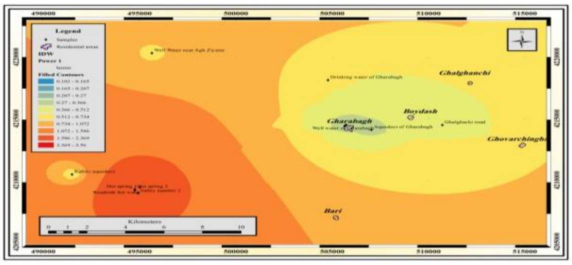

Fig. 5. zoning map with IDW method.

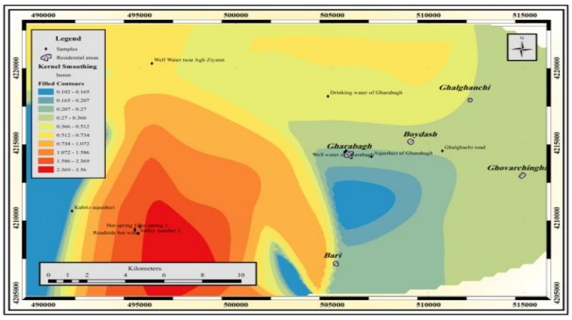

Fig. 6. zoning map with Kernel smoothing method.

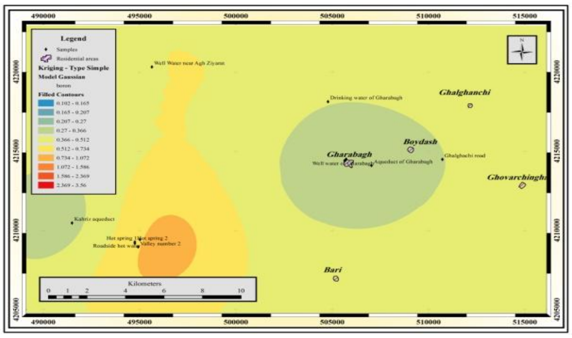

Fig. 7. zoning map with kriging method.

Detection of contamination at the sampling areas

Contamination levels based on the degree of pollution is divided. With sampling spa rooms with opaque blue and yellow and smell of sulphate sulfur without any vegetation and based on analysis, concentration of Boron is more than standard limit (934.4 ppm). Location of the hot water outlet which is devoid of vegetation has a white sulphate and sulfur deposits that indicates contamination (fig. 7). Water samples collected from roadside hot spring that has lower temperature to the other hot springs, sulphate sulfur deposits are seen significantly with earthworms particularly in black parts. Amount of Boron in this area is 2.612 ppm (fig. 8). According to people welcoming to use the hot water for therapeutic properties, unfortunately adverse environmental impacts, such as: throwing trash and confounds the nature by passengers is clearly seen (fig. 9). Another sample is taken about 20 meters below which has higher temperature to the other springs. There is no vegetation around the area. Boron is an indicator of high levels of pollution with 2815 ppm. Another sample is taken from confluence of 2 and 3 branches. There is no vegetation and effects of lime and sulphate sulfur is detectable. Concentration of Boron is 2237 ppm that shows high contamination. This element affected plants and caused them to dry around selected area according to fig. 10. Samples taken in the range 3, vegetation are obviously seen and there is no organic material and smell of sulfate sulfur. Concentration of Boron is 0.293ppm that indicates lower contamination.

Fig. 8. hot water outlet with sulfate deposition.

Fig. 9. roadside area hot water with earthworms.

Fig. 10. environmental effects of hot water.

Fig. 11. dried trees irrigated with polluted water.

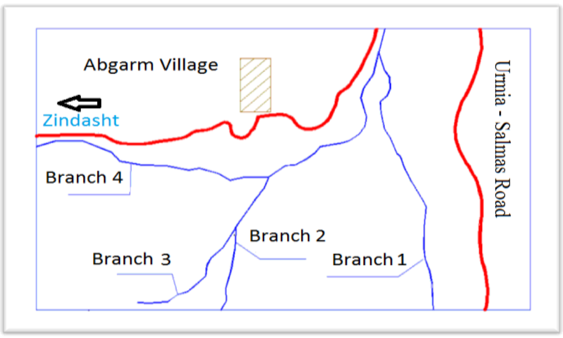

Fig. 12. Branches of the River hot water.

Discussion and conclusion

Results demonstrate high boron contamination in wide range of southeast groundwater of Salmas city. Transmission of experimental results on geological map and use of GIS software show the precise range of contamination. Origin of contamination is Warm water in the ground that dissolves Boron compounds and transfers to the surface in form of springs. It should be mentioned some hot water enter to the groundwater through faults. Polluted areas except hot springs and Gharabagh are unique to alluvial areas which are affected by origin of contamination. Groundwater contaminated with boron currently provides drinking water to many villages including Gharabagh, Agh Ziyarat, Khan Takhti, Minas, Tamar, Shorgol, and Ghabakh Tappeh. Effects of boron contamination in land irrigated with contaminated water are obvious. First, there are no plants sensitive Boron such as vegetables and fruit trees in this area. Then, efficiency of cultivated products limited to wheat, barley, alfalfa and trees such as willow and poplar are too low and toxic effects (yellowing and drying of leaves) are seen. Due to the rich and not contaminated groundwater in Salamas plain, there is possibility of providing clean water for villages with contaminated drinking water. Due to the low flow of hot water and limitation of area basin it would not possible to extract the contaminated water from groundwater.

Suggestions

According to the results of the project, solutions in order to control groundwater contamination and agriculture soil pollution and drinking water supply in selected area are recommended:

✓ Villages that supply drinking water from contaminated wells, consumption of contaminated water should be prevented by notifications from authorities, however, in some villages it is done by people.

✓ Attempt to substitute new water sources and construct the transmission line to the villages and prevent penetrating contaminated surface water to groundwater resources.

✓ After determining the exact boundaries of contaminated area, to prevent transmission of pollution through groundwater, geochemical barriers can be used as an important factor to prevent prevalence of contamination. For surface water, dams should be constructed in order to collect the contaminated water and transfer to the refinery.

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