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Original Article

The Evaluation of Underground Water Recourses' Boron Concentration and Variation Pattern

*M Malakootian [1], A Hasibi [2], A Zeinadini [3]

[1]Dept. of Environmental Health, School of Public Health, Kerman University of Medical Sciences, Iran
[2]Kerman Province Health Center, Kerman University of Medical Sciences, Iran
[3]Kerman Agricultural Research Center, Iran

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Abstract

Background: Rafsanjan -Noogh- Anar's plain (54°, 52′- 56°, 34′ longitudinally & 29°, 51′- 31°, 31′ latitudinally) is one of the Iran's plains located in sub- basin of Daranjir desert. Anar's plain is located at the lowest part of Rafsanjan -Noogh-Anar's plain. According to the geological and field studies of the area, the presence of west and east mounts and deposits resulting from evaporation in lower parts of the area are indicative of boron contamination of Anar underground water.

Methods: In the present study, 50 deep wells covering Anar plain were selected based on statistical methods. Boron concentration in each well was measured by Azomethine- H method in the middle of each season, from 2003 to 2007.

Results: Comparing the obtained boron concentrations with WHO guidelines, Anar underground water is not safe for drinking (mean= 8.88 mg/L). In major part of the plain, the quality of water is not suitable for the growth of plants that are sensitive and unresisting to boron. Only in 17.1% of the samples boron concentration was between 0.7-3 mg/L that based on the guidelines of Food and Agriculture Organization is suitable for some types of plants. Field studies about the area flora confirm the obtained results too. Changes in the quality of underground water during the years of study, showed a worsening process over time.

Conclusion: To solve the problem, mixing of the water of low boron wells with high boron wells is recommended.

Keywords: *Boron, Water, Iran*

Introduction

The natural borate content of groundwater and surface water is usually small. The borate content of surface water can be significantly increased as a result of wastewater discharges, because borate compounds are ingredients of domestic washing agents. Naturally occurring boron is present in groundwater primarily as a result of leaching from rocks and soils containing borates and borosilicates. Concentrations of boron in groundwater throughout the world range widely, from 0.3 to 100 mg/litre (1). The majority of the Earth's boron occurs in the oceans, with an average concentration of 4.5 mg/litre (2). The amount of boron in fresh water depends on such factors as the geochemical nature of the drainage area, proximity to marine coastal regions, and inputs from industrial and municipal effluents (3). Data collected from more than 6,000 selected sampling points reveal that more than 10 percent of the water resources in the Mediterranean basin have boron levels exceeding 1 milligram per liter, the new E. U. drinking water standard (4). The highest values of boron are in areas associated with geothermal activity, such as in Tuscany, Italy, and Chalkidiki, Greece. In addition, high boron levels have been detected in the groundwater basins in the central part of Cyprus, in the southern coastal aquifer that is shared between Israel and the Gaza Strip, in some regions of California and Minnesota in U.S.A, and Turkey (1, 4, 5). Boron does not in-

*Corresponding author: Tel +98 341 3205426, Fax: +98 341 3223029, E- mail: m.malakootian@yahoo.com

fluence on water taste, therefore to distinguish it in water, chemical tests have to be done (6).
Trace quantities of boron are an essential component for plants growth; nevertheless a quantity exceeding the permitted limit endangers them of being poisonous. The plants vulnerability and resistance against boron vary in different plants. Prolonged utilization of waters containing boron quantity of more than 2 ppm has been prohibited for plant irrigation (7-9). The studies on cell wall structure and membrane structure and their functions influenced by boron betoken that the boron affect mechanism on plants is the same as on human and animals (10).
Boron is viewed as an essential element for human and animals, lack of which leads to instigate diseases, however its excess brings about intoxication. It has been acquired through studies that boron is of trace and dynamic elements for human affecting on the metabolism of numerous chemical factors involved in life process such as calcium, magnesium, copper, nitrogen, glucose, reactive oxygen, triglycerides, and estrogen (1). Boric acid and borates are rapidly absorbed from gastrointestinal tract with more than 90% efficiency, and are mostly excreted through urine (11). Boron does not accumulate in animals soft tissues but in bones, the same happens in human body (12). It is accumulated in human bones more than other parts affecting on their forms and function (13).
Studies betoken that boron is an influential factor on metabolism of mineral constituents, and membrane function both in human and animals (14, 15). Boron deficiency exerts obnoxious effects on brain function, calcium and energy metabolism; therefore it is considered a nutrient (1, 14). There is some uncertainty as to the health effects of low levels of boron in humans when the studies examined high levels of boron, the Minnesota Department of Health issues conservative drinking water advice, to err on the side of protecting human health (6, 16).
Comparable researches have been carried out of boron concentration in underground water of Mediterranean region, Minnesota (U.S.A) and Mania Lake in Turkey, through which consequences and degree of the contamination have been analyzed (4, 17, 18).
Rafsanjan - Noogh - Anar's plain (54°, 52′- 56°, 34′ longitudinally & 29°, 31′- 31°, 31′ latitudinally) is one of the Iran's plains located in sub-basin of Daranjir desert. Anar's plain is located at the lowest part of Rafsanjan - Noogh - Anar's plain (19, 20) (Fig. 1). According to the geological and field studies of the area, the presence of west and east mounts and deposits resulting from evaporation in lower parts of the area are indicative of boron contamination of Anar underground water (21, 22).
This study has been conducted in order to evaluate the Anar's underground water status in terms of boron quantity and its variation pattern.

Materials and Methods

Undergrounds water is the main source of drinking water and agricultural practices in Anar's palin. To evaluate the quality of underground water in the region, 50 deep wells have been selected in a way to cover all the area of study by means of field observations and topographical maps (Fig. 1). This study has been carried out from 2003 to 2007. Water samples were provided from each well at the middle of each season according to Standard Methods (23). The total number of the samples was up to 800 during the examination period. Evaluation has been achieved based on Azomethine-H method (24). Data have been analyzed applying *t*- est.

Results

Boron concentration and statistical indices are shown in Table 1 and 2.

Fig. 1: Location of Anar Plain

Table1: Average, Minimum, Maximum and Standard Deviation of boron concentration of groundwater in Anar Plain during 2003 to 2007 (mg/ L)

Year	Mean	S.D.	Season	No. of samples	Min.	Max.	Mean	S.D.
			Winter	50	1.25	15.02	7.13	4.002
			Spring	50	1.90	15.20	7.80	3.97
2003	7.65	4.04	Summer	50	1.68	16.00	8.28	4.19
			Autumn	50	1.48	15.20	7.385	4.002
			Winter	50	1.28	15.20	7.26	4.02
			Spring	50	1.52	16.10	8.57	4.51
2004	8.32	4.44	Summer	50	1.53	16.10	9.08	4.66
			Autumn	50	1.52	16.10	8.36	4.46
			Winter	50	1.51	16.10	8.29	4.46
			Spring	50	1.60	17.20	9.76	5.08
2005	9.48	4.98	Summer	50	1.80	17.50	10.31	5.18
			Autumn	50	1.60	17.10	9.55	5.05
			Winter	50	1.40	17.00	9.43	5.04
			Spring	50	1.80	17.20	10.08	5.28
2006	10.07	5.21	Summer	50	1.80	17.20	11.00	5.44
			Autumn	50	1.60	17.10	9.73	5.05

Table 2: Comparison of statistical indices of various concentrations of boron in underground water of Anar plain in different years

Year of comprision	*P*	*T*
2003 and 2004	0.115	-1.58
2003 and 2005	0.0001	-4.04
2003 and 2006	0.0001	-5.19
2004 and 2005	0.014	-2.46
2004 and 2006	0.0001	-3.61
2005 and 2006	0.252	-1.15

Discussion

Boron concentration average in underground of this region has been determined as 8.88 mg/L during the measurement years based on the obtained results. The concentration of this substance has been varying from 1.25 mg/L in winter of 2003 up to 17.5 mg/L in summer of 2005 in the studied region. WHO guidelines declare 0.5 mg/L as the permitted maximum of boron concentration (1, 25). Drinking water standards have determined the permitted boron concentration maximum as 1 mg/L for the Europeans (26). USEPA has not designated any standard for boron quantity; nevertheless Minnesota Department of Health Service has recommended substituting the water with boron concentration exceeding 600 ppb with water with lower boron concentration (6, 17, 27). The comparison of measured results with WHO guidelines and EU standards signify that boron concentration had exceeded the permitted portability limit in all cases during the examination period. Merely 17.1% of the samples contained boron of 0.7 up to 3 mg/L which are applicable for some kinds of plants growth and irrigation, based on FAO guidelines (7). Groundwaters in the most part of the plain are not suitable for the vulnerable plants growth. No significant diversity has been recorded between the boron concentration average in 2003 and 2004 (P= 0.115), 2005 and 2006 (P= 0.252) (Table 2), however variation trend of boron concentration during 2003 to 2007 convey that underground resource quality tend to diminish, and the significant diversity of boron concentration between 2003 and 2006 (P= 0.0001) confirms the quality diminution. (Fig. 2)

Boron concentration has a stable trend in different seasons of the year. It is the least in winter when water tables have less discharge and more recharge and it is highest in summer when discharge is high and recharge is low. As a result,

the major problem will be for summer and fall of each year. Proper management of water resources, using modern irrigation techniques and artificial recharge will allow us to overcome the problem (Fig. 2).
Review of boron concentration in wells distributed in the plane based on their geographical position shows that underground water contamination decreases from East of the plane towards the West and the North West. Most contamination was found in Eastern and Southeastern areas. Field survey showed that in North and East of Anar plane due to high evaporation, boron deposits were seen despite high water table of aquifer. Furthermore, alluvial sections in the West and North West of the plane have high permeability. Therefore, results of the field survey are completely compatible with the outcomes of measuring boron concentration in different areas of the plane (Fig .1)

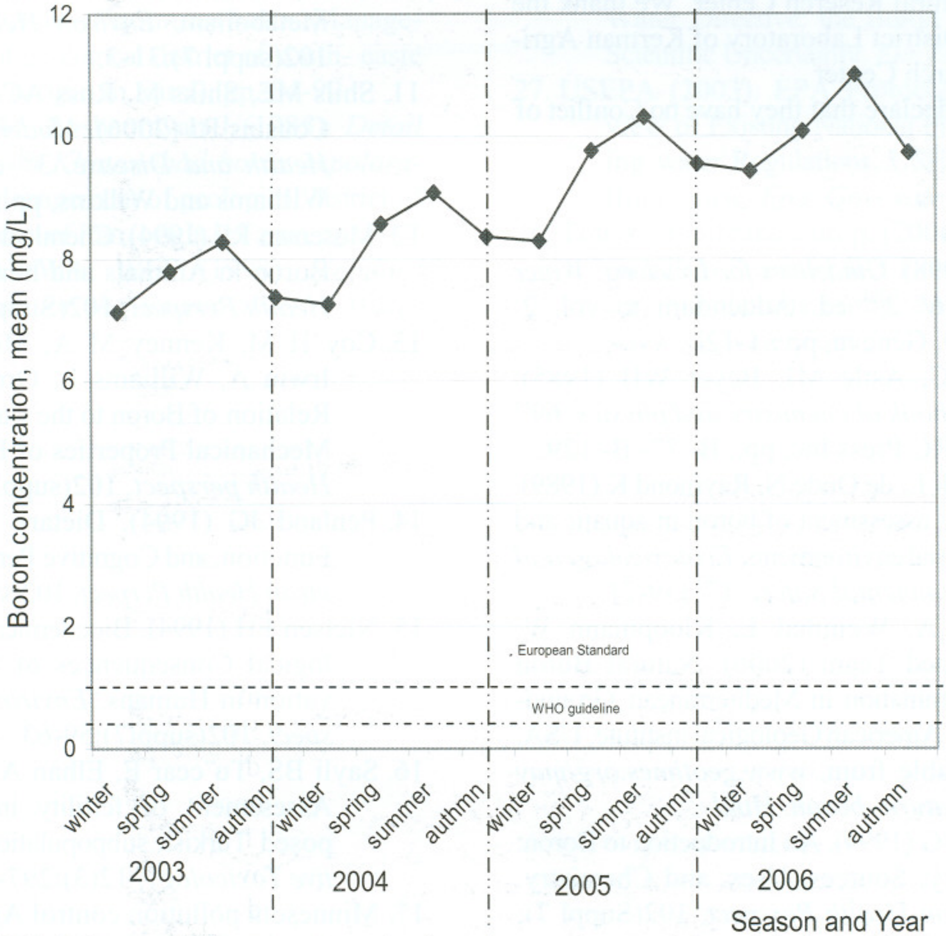

Fig. 2: Variation trend of boron concentration in underground water of Anar plain during 2003 to 2007

Conventional water treatment (coagulation, sedimentation, filteration) does not significantly remove boron, and special methods would have to be installed in order to remove boron from waters with high boron concentrations. Ion exchange and reverse osmosis processes may enable substantial reduction but are likely to be prohibitively expensive. Blending with low boron supplies might be the only economical method to reduce boron concentrations in waters where these concentrations are high (1, 4, 28).
In conclusion, to utilize the underground water of this region, this method is recommended as a short-term strategy. The farmers of this region pro-

vide the appropriate water applying this method (well waters with low boron concentration) through their long-time experiences. Regarding the project of piping Karoon water to Rafsanjan plain the problem to provide water with low boron concentration is supposed to be solved as a long-term strategy.

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The authors declare that they have no Conflict of Interests.

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