

Boron concentration in water wells samples of Basrah Governorates using ICP/OES techniques

Thaer M. Salman, Sawsan S. Fleifil

Abstract— Intake of boron from food and drinking water may pose a risk to the public health above a certain concentration level. Therefore, knowledge of boron concentration in drinking water and food items is essential. In this context, samples of drinking water were collected from Basrah governorates (Southern of Iraq). The measurements were performed by analyzing the water samples collected from 37 locations using inductively Coupled Plasma (ICP/OES) is an analytical technique used for the detection of trace metals in environmental samples. The Boron concentrations which are obtained ranged from 1.8647 ppm in Khor Al-Zubair to 10.312 ppm in Umm Qasr Al-Hadama in water samples. The results are presented and compared with other studies. The study reveals that's 38 surface water well samples have boron concentration higher than the WHO limit. It may be due to higher leaching of boron during monsoon rains from surface soils beyond the root zone. Thus, there is possibility of severe pollution problem with boron in near future.

Index Terms—Boron, Wells water, ICP/OES.

I. INTRODUCTION

Water quality of wells, important drinking water sources in rural areas is monitored by Public Health Authorities, chemical and microbiological quality of these sources is often inadequate because water is not treated and/or the pollution sources, especially from agriculture and zootehny, are multiple [1].

Boron is a naturally occurring element that is widely distributed in nature in minute concentrations [2]. It is released into the ground water as a result of leaching from rocks containing boron, soil, and volcanic activity [3]. Boron enters into human bodies primarily from fruits, vegetables, and drinking water [4–6]. Occupational exposures from dust of consumer products are other potentially significant sources of boron that may pose a risk to the general public above a certain concentration level [7]. A small amount of boron in drinking water is not harmful because it is regularly excreted in faeces and urine over a period of several days. It is generally believed that low-level boron intake from natural water and food is beneficial for bones, osteoarthritis, osteoporosis, brain function, metabolism of minerals, and hormonal regulation [8]. Boron has two stable isotopes ^{10}B (19.8%) and ^{11}B (80.2%) that are distributed unevenly in the Earth's crust [5].

It does not appear on the earth in elemental form but is found in combined state as borax, boric acid, tourmaline, colemanite, kernite, ulexite and borates [9-12]. In aqueous solution at $\text{pH} < 7$, it occurs mainly as undissociated boric acid (H_3BO_3) but at higher pH boric acid accepts hydroxyl

Thaer M. Salman, Physics Department, University of Basrah/ College of Education for pure sciences, Basrah, Iraq,

Sawsan S. Fleifil, Physics Department, University of Basrah/ College of Education for pure sciences, Basrah, Iraq

ions from water thus forming a tetrahedral borate anion [13]. Boric acid and borates are used in glass manufacture, soaps and detergents, flame retardants, and neutron absorbers for nuclear installations can cause boron toxicity in environment. Borates have various agricultural uses as fertilizer, insecticide and herbicide because they are not carcinogenic to mammalian and lack of insect resistance compared with organic insecticides [14-15].

This work describes the preliminary findings from Boron concentration measurement data collected from water well samples in Basrah Governorates. The general aim is to investigate the complex interactions and exchanges with water, and to estimate how much hazards brought with waters. In fact, the study area is located inside Basra Governorate which is located in the extreme southern part of Iraq, see Fig. 1. Al-Basra Governorate sited at the southern rim of the Gulf, part of the Iraqi Southern Desert in the west and south and relatively short coast on the Gulf. In the northern part of Basra Governorate, Tigris and Euphrates merge forming Shatt-Al Arab river which flows southward to the Gulf.

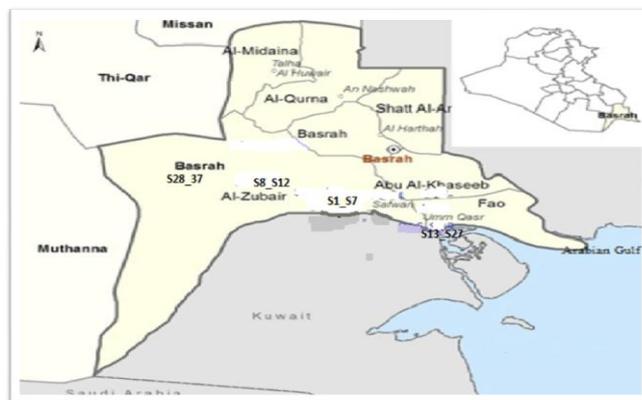


Fig. 1. Basra Governorate, dots represent the places where samples taken from, numbering in station number (S). Basra map is from Google earth.

II. MATERIAL AND METHOD

In Basra governorate, the samples from 38 stations and locations were collected during April 2014. The collected, 0.25 L, bottles completely filled with water wells and well sealed to avoid any connection with air. The measurements of Boron concentration water were carried out by using ICP/OES method [16].

Inductively coupled plasma/optical emission spectrometry (ICP/OES) is a powerful tool for the determination of metals in a variety of different sample matrices. With this technique, liquid samples are injected into a radiofrequency (RF)-induced argon plasma using one of a variety of nebulizers or sample introduction

techniques. The sample mist reaching the plasma is quickly dried, vaporized, and energized through collisional excitation at high temperature. The atomic emission emanating from the plasma is viewed in either a radial or axial configuration, collected with a lens or mirror, and imaged onto the entrance slit of a wavelength selection device. Single element measurements can be performed cost-effectively with a simple monochromator/photomultiplier tube (PMT) combination, and simultaneous multielement determinations are performed for up to 70 elements with the combination of a polychromator and an array detector. The analytical performance of such systems is competitive with most other inorganic analysis techniques, especially with regards to sample throughput and sensitivity.

The samples of water coming from wells have been sampled in glass bottles (0.25 liter) for the chemical parameters determinations and in polyethylene bottles for boron determinations. For the calibration graph a stock solution of borate was used of which a calibration solution was prepared by ICP/OES devices at 249.772 nm. A linear calibration was observed, followed by the calculation of the slope factor. The results are experimented in mg B/l.

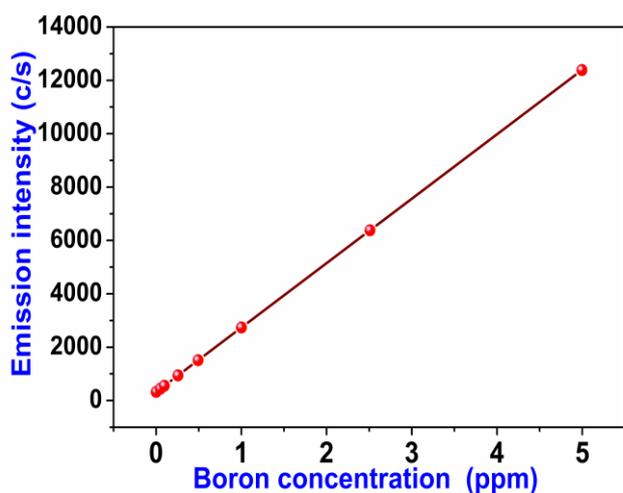


Fig. 2. Calibration curve for concentration of boron (ppm) vs emission intensity (c/s), Regression equation $y = 2414.52x + 323.735$; $R^2 = 0.999995$.

III. RESULTS AND DISCUSSION

The results of boron concentration measured in all 38 water wells samples was determinate in water source by the ICP-OES technique which are collected from different springs of Basrah Governorates are summarized in Table 1.

For the measurement of boron concentration level water wells, table 1 and Fig.3, reflect the fact that, there was some high level of boron concentration in this water wells higher than the most of public tap and washing surface water in the governorate. The results for these 37 samples categorized into 38 locations, from s1 to s38, shown in Fig.3.

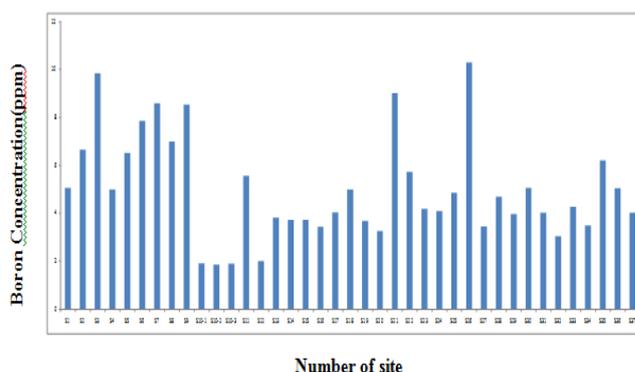


Fig.3. Boron concentrations in water wells samples in Basrah Governorate, Iraq.

Boron content found maximum (10.312 ppm) in Umm qasr/Al-hadama belt and minimum (1.8647 ppm) was recorded in Khor-Al-zubair belt. Out of the 38 soil water samples 11 samples recorded higher which are beginning from 5.5569 ppm to 9.8578 ppm while the 25 water wells samples are beginning from 1.9262 ppm to 5.0165 ppm. The World Health Organization (WHO) in 1993 the WHO established a health-based Guideline of 0.3 mg/L for boron. This value was raised to 0.5 mg/L in 1998 primarily. Furthermore, in 2000 it was decided to leave the guideline at 0.5 mg/L until data from ongoing research becomes available that may change the current view of boron toxicity or boron treatment technology [17,18]. The European Union established a value of 1.0 mg/L for boron in 1998 for the quality of water intended for human consumption [19,20]. New Zealand has established a drinking water standard for boron of 1.4 mg/L [21,22].

The interim maximum acceptable concentration (IMAC) for boron in Canada is 5 mg/L. The Canadians have established this value on the basis of practical treatment technology. They believe available technologies are inadequate to reduce boron concentrations to less than 5 mg/L. They will review this IMAC periodically as new data becomes available [23,24].

Higher amount of Boron in water wells samples may be due to leaching of soil boron as maximum amount of mobile boron is present in the acidic water in the study area. Moreover use of boron compounds as fertilizer, insecticide and herbicides at regular intervals are subjected to wastewater irrigation disposal hence possibility of boron leaching in under water.

IV. CONCLUSION

To conclude, boron concentration in studied samples of water wells varied from to 5.0165 ppm mg/l. Most of the high level concentrations are ranging from 5.5569 mg/l to 9.8578 mg/l. Present measured values are lower than most of the values reported for other countries of the world. The observed values are below the IMAC - recommended limit of 5 mg/l and this may related to the penetration of the deplete uranium used in the Gulf wars. Hence, health hazards related to the boron in water wells of the Basrah Governorates are very high.

Table 1. Boron Concentration Measured in Water wells Samples from Different Localities of Basrah Governorates (mg/l)

No	Sample No	Location	Boron concentration by ICP-OES (ppm)
1	S ₁	Safwan-Umm Qasr roud 17 /Al-zubair /The Eastern star	5.0768
2	S ₂	Safwan-Umm Qasr roud 17 /Al-zubair / The Eastern Star	6.6704
3	S ₃	Safwan-Umm Qasr roud 17 /Al-zubair / The Eastern Star	9.8578
4	S ₄	Safwan-Umm Qasr roud 17 /Al-zubair The Eastern Star	4.9888
5	S ₅	Safwan-Umm Qasr roud 17 /Al-zubair the Eastern star	6.5299
6	S ₆	Safwan-Umm Qasr roud 17 /Al-zubair the Eastern Star/ Versus petrochemical	7.861
7	S ₇	Al-zubair /the Southern star / near petrochemical	8.6066
8	S ₈	Al-zubair /Southern Star/ Beside the liquid gas plant	7.0004
9	S ₉	Al-Zubair/Southern Star/behind the liquid gas plant	8.548
10	S ₁₀₋₁	Khor Al-Zubair	1.9262
11	S ₁₀₋₂	Khor Al-Zubair	1.8647
12	S ₁₀₋₃	Khor Al-Zubair	1.9075
13	S ₁₁	Khor Al-Zubair/Versus iron and steel plant	5.5569
14	S ₁₂	Khor Al-Zubair/Alrafedia/Versus iron and steel plant	2.0142
15	S ₁₃	Safwan-Umm Qasr roud 17 /Al-zubair	3.8249
16	S ₁₄	Safwan-Umm Qasr roud 17 /Al-zubair	3.719
17	S ₁₅	Safwan-Umm Qasr roud 17 /Al-zubair From artesian wells	3.718
18	S ₁₆	Safwan-Umm Qasr roud 17 /Al-zubair Alhadama	3.4356
19	S ₁₇	Safwan-Umm Qasr roud 17 /Al-zubair /AL-hadama erea/From artesian wells	4.0384
20	S ₁₈	Safwan-Umm Qasr roud 17 /Al-zubair /AL-hadama erea	4.9881
21	S ₁₉	Safwan-Umm Qasr roud 17 /Al-zubair /Alhdama	3.6801
22	S ₂₀	Safwan-Umm Qasr roud 17 /Al-zubair Alhdama/from artesian wells	3.2673
23	S ₂₁	Safwan-Umm Qasr roud 17 /Al-zubair Al_hadama /from artesian well	9.0118
24	S ₂₂	Safwan-Umm Qasr roud 17 /Al-zubair Al-hadama	5.7432
25	S ₂₃	Safwan-Umm Qasr roud 17 /Al-zubair /Al-hadama	4.205
26	S ₂₄	Safwan-Umm Qasr roud 17 /Al-zubair Alhadama	4.0956
27	S ₂₅	Safwan-Umm Qasr roud 17 /Al-zubair Alhdama	4.8683
28	S ₂₆	Safwan-Umm Qasr roud 17 /Al-zubair /Al-hadama	10.312
29	S ₂₇	Safwan-Umm Qasr roud 17 /Al-zubair east of Safwan	3.456
30	S ₂₈	Al-liheise1	4.6982
31	S ₂₉	Al-liheise2	3.9717
32	S ₃₀	Al-liheise3	5.0665
33	S ₃₁	Al-liheise4	4.0254
34	S ₃₂	Al-liheise5	3.0299
35	S ₃₃	Al-liheise6	4.281
36	S ₃₄	Al-liheise7	3.4949
37	S ₃₅	Al-liheise8	6.2175
38	S ₃₆	Al-liheise9	5.0594
39	S ₃₇	Al-liheise10	4.0165

REFERENCES

- [1] xxx: Health Effect Support Occurement for Boron.MS Environmental Production Agency.Document Number EPA-821-R-06-005,2006.
- [2] Woods WG (1994) An introduction to boron: history, sources, uses, and chemistry. *Environ Health Perspect* 102 (Suppl 7):5-11
- [3] IEHR (Institute for Evaluating Health Risks) (1997) An assessment of boric acid and borax using the IEHR evaluative process for Assessing human developmental and reproductive toxicity of agents. *Reprod Toxicol* 11:123-160
- [4] Anderson DL, Cunningham WC, Lindstrom TR (1994) Concentrations and intakes of H, B, S, K, Na, Cl and NaCl in foods. *J Food Compos Anal* 7:59-82
- [5] Naghii MR, Samman S (1996) The boron content of selected foods and the estimation of its daily intake among free-living subjects. *J Am College Nutr* 6:614-619
- [6] WHO (World Health Organization) (1998) Environmental health criteria 204: Boron.International Programme on Chemical Safety, Geneva, ISBN 92 4 157204 3.
- [7] ATSDR (Agency for Toxic Substances and Disease Registry) (1992) Toxicological profile for boron. Public health service, U.S. department of health and human services, Atlanta, GA. TP-91/05
- [8] Muhammad A. Matiullah , S. N. Husaini .,Determination of Boron Contents in Water Samples Collected from the Neelum valley, Azad Kashmir, Pakistan *Biol Trace Elem Res* (2011) 139:287-295
- [9] W.G., Woods, *Environ Health Perspective*, 1994, 102, Supplement 7, 5-11.
- [10] P. Argust, *Biological Trace Element Research*, 1998, 66 (1-3), 131-143.
- [11] D.S. Kostick, *Mineral Yearbook: Boron, United States Geological Survey*, 2006.
- [12] S. Goldberg, D.L. Suarez, P.J. Shouse, *Soil Science*, 2008, 173 (6), 368-374.
- [13] B. J. Shelp, In: U.C. Gupta,(Ed.) *Boron and Its Role in Crop Production* (CRC Press, Boca- Raton , FL, 1993), 53-85.
- [14] R.J. Weir, R.S. Fisher, *Toxicol and Pharmacol*, 1972, 25, 251-256.
- [15] D. Diaconu, V. Nastase, M.M. Nanau, O. Nechifor, E. Nechifor, *J. Preventive Medicine*, 2008 ,16(1-2), 77-84.
- [16] Boumans, P.W.J.M. *Inductively coupled plasma-emission spectroscopy-Part 1*. John Wiley & Sons. New York. 584 pp.
- [17] World Health Organization. *Guidelines for drinking water quality. Boron*, World Health Organization.2003 .
- [18] Vadivel S., Manickam A., Ponnusamy S. *Advances in Applied Science Research*, 2012,3, 219.
- [19] Council of the European Union Council Directive 98/83/EC, November3, 1998 on the quality of water intended for human consumption.1998.
- [20] Neelesh S., Mishra D. D., Mishra P. K. *Advances in Applied Science Research*, 2012,3 ,335
- [21] New Zealand Ministry of Health *Drinking-Water Standards for New Zealand 2000*. Wellington Ministry of Health. 2000.
- [22] Abdul R.H. S. , Master A. A. *Advances in Applied Science Research*, 2012, 3 , 563.
- [23] Health Canada *Summary of Guidelines for Canadian Drinking Water Quality*. 2003 , 2002.
- [24] Ogbonna O, Jimoh W.L., Awagu E. F., Bamishaiye E.I. *Advances in Applied Science Research*, 2012, 2 , 62.