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Advances in Applied Science Research, 2013, 4(1):105-112

Pelagia Research Library

ISSN: 0976-8610
CODEN (USA): AASRFC

The measurements of boron concentration rate in water using curcumin method and SSNTDs Techniques

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ABSTRACT

A technical method has been used two sets of experimental works in the measurements of Boron concentrations in water. The first measurement is by using curcumin method and the second is the passive method by using the solid state nuclear track detectors, CR39. Tap water in the governorate, has a very low Boron concentration 0.355 ppm atAl-Bedeah river, Al-Jzeera AlOula, did show a Boron level as high as 7.405 ppm at east governorate, while the waters have Boron level ranging between 7.785mg/l and 0.638 mg/l in curcumin method .A conclusion has been made, that Basra governorate tap water is safe as far as Boron concentration is concerned , while the rivers waters should be avoided. The high concentration tells us that pollutant in this part of city is larger than the other parts. Samples of water were collected during April 2011, from all locations in Basra City.

Keywords: Neutron Source, Boron, Curcumin, SSNTD, Drinking water.

INTRODUCTION

Solid state nuclear track detectors (SSNTDs) of different materials are important for investigations in basic science and technology [1].Among such applications, SSNTDs are widely used in radiation protection and environmental radiation monitoring. Their theory was developed more than 40 years ago, the basic fundamentals can be found in Somogyi [2] and in more details in Durrani et al. [3]. Even more details for detecting alpha particles, which is important from BNCT point of view, can be found in Nikezic [4]. Therefore, here we touch some aspects of interest, only. Popularly saying, an ionizing particle produces a narrow damaged zone in the plastic, 10-100 nm in diameter, which can be enlarged and visualized by a chemical treatment, so that the particle movement in the detector material, let us say the footprint of the particle or its track can be followed under optical microscope. Depending on the chemical treatment (called etching) and observation method there are basically two requirements: the range and energy deposition of the particle should be adequate.

Boron is a nonmetallic element that belongs to Group IIIA of the periodic table and has an oxidation state of +3. It has an atomic number of 5 and atomic weight of 10.81. Boron is actually a mixture of two stable isotopes, ^{10}B (19.8%) and ^{11}B (80.2%) [5]. Boron is a naturally-occurring element found in rocks, soil, and water. The concentration of boron in the earth's crust has been estimated to be <10 ppm, but concentrations as high as 100 ppm can be found in boron-rich areas[6]. Only the latter has a high thermal neutron capture cross section (3832 b). Due to its nuclear characteristics e.g. being a non radioactive element and readily available, the isotope boron-10 is often employed in application where the (n,α) reaction is of advantage and where other analytical techniques could not be employed satisfactorily. The probability for the absorption of a neutron by this stable isotope via the $^{10}B\,(n,\alpha)^7Li$ capture reaction (^{10}BNC- reaction), is given by the absorption cross section. Its value is a function of the impinging neutron energy, (www.nndc.bnl.gov). The energetic fragments emitted in the ^{10}BNC- reaction produce a high value of "Linear Energy Transfer" (LET) or dE/dx, that is, a measure of the number of ionisations per unit distance as they traverse the absorbing material. Their combined path lengths are of short distance making them quite suitable where localized damage is of advantage. Industrial processes have been devised to modify the natural boron isotopic composition in order to obtain high values for ^{10}B concentration.

The ^{10}BNC-reaction to take place requires a sample containing, even at ppb Among the known boron compounds, several hundred are employed in today's applications and a growing level, ^{10}B, a source set for irradiation with thermal or lower neutron energy (0.025eV or less) and a reaction fragment detecting device. The reaction phenomenon is related to a neutron interacting with boron nucleus, followed by breakup in two fragments of the ^{10}B+n compound nucleus (that survives a short time in the order of picoseconds). The two fragment nuclei depart acquiring kinetic energy due to a strong Coulomb field moving in opposite direction under the momentum conservation law, synthesized by the following process:

$$^{10}B + n \dashrightarrow [^{11}B] \begin{cases} \nearrow \; ^{7}Li + {}^{4}He + 2{,}79\ \text{MeV (branching ratio 6.1\%)} \\ \searrow \; ^{7}Li + {}^{4}He + \gamma\ (0{,}48\ \text{MeV}) + 2{,}31\ \text{MeV (branching ratio 93.9 \%)} \end{cases} \qquad (1)$$

The reaction occurs with different branching ratio: the first has a relatively low frequency occurrence (6.1%) but has the advantage that the reaction is photon less and therefore the induced damage leads to a higher "Linear Energy Transfer" (LET) or dE/dx. The other, with higher occurrence is accompanied by a 0,48 MeV photon. If the alpha particle ($^{4}He^{+}$) leaves the sample surface, with sufficient kinetic energy, then it can be detected e.g. by nuclear track techniques. The alpha particle fingerprint given by a suitable detecting material, provides information on the boron presence and it is recognized as a powerful analytical method for boron studies. The chemical structure of some boron compounds is found in Figure 1.

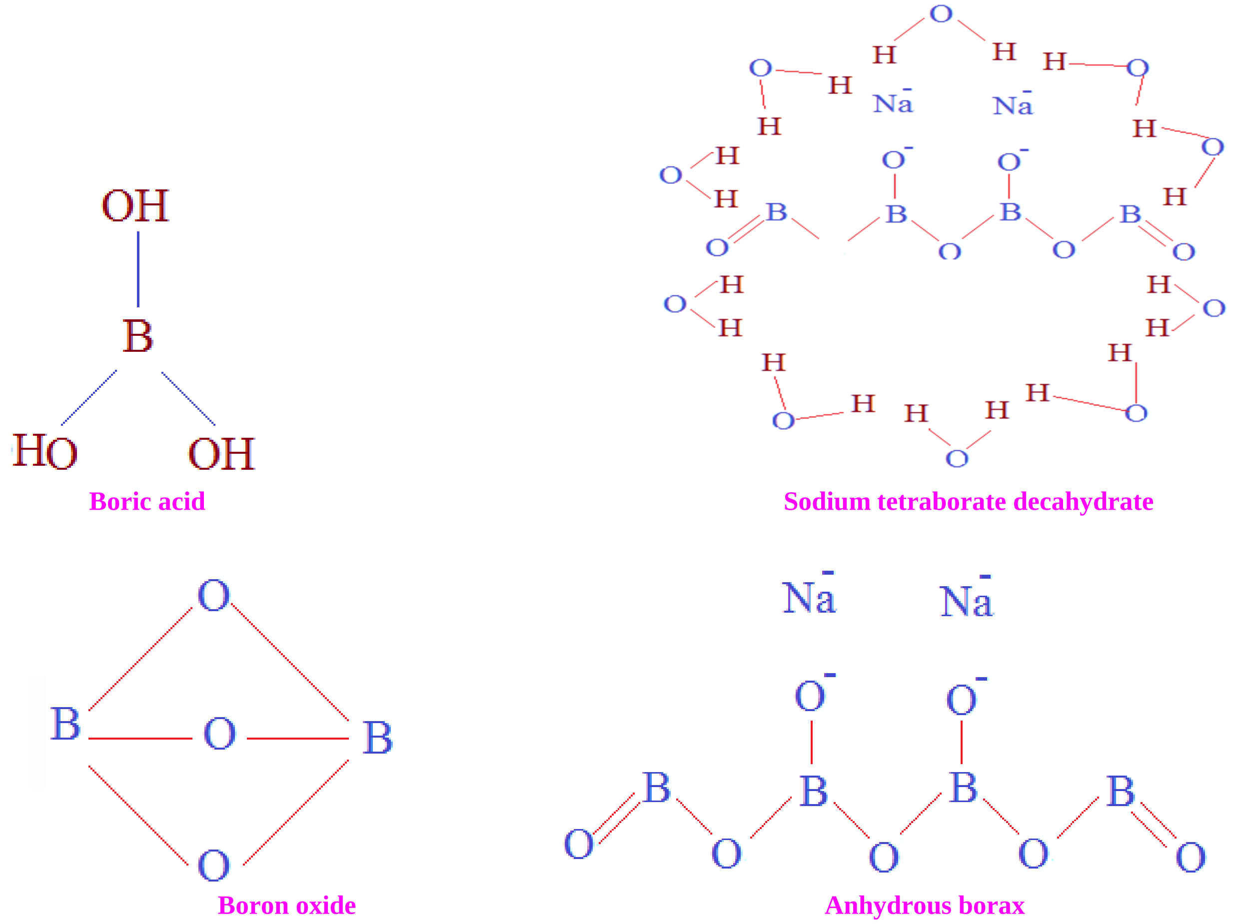


Fig. 1. Chemical Structures of some boron compounds [7] (Chemfinder.com, 2006)

Elemental boron is insoluble in water [8]. The vapor pressure of elemental boron and all the boron compounds that are the subject of this report are negligible at 20°C and 25°C [9-13]. Borax (decahydrate) does not have a boiling point. Borax decomposes at 75°C, and loses $5H_2O$ at 100°C, $9H_2O$ at 150°C, and becomes anhydrous at 320°C. The melting point for anhydrous borax is above 700°C and it decomposes at 1575°C [8]. Boric acid is a weak acid with a 9.2 pK_A and exists primarily as the undissociated acid (H_3BO_3) in aqueous solution at physiological pH [6] . Borax in solution has alkaline properties, but does not cause corrosion to ferrous metals [11]. Boron oxide reacts slowly with water to form boric acid [13] and it is corrosive to metals in the presence of oxygen [14,15].

Fig. 2. Basra Governorate, dots represent the places where samples taken from, numbering in station number (S) (Basra map is from Google earth)

This work describes the preliminary findings from Boron concentration measurement data collected in. The general aim is to investigate the complex interactions and exchanges with flow of 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. 2. 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.

MATERIALS AND METHODS

In Basra governorate, the household water is supplied from two sources; one from Bada'a (on Euphrates River) and the other from Shatt-alrab river (formed by the confluence of the Euphrates and the Tigris rivers). Samples from 40 stations and locations were collected during April 2011. The collected, 0.25L, bottles completely filled with water and well sealed to avoid any connection with air.The measurements of Boron concentration water were carried out by two methods:

1. curcumin method

Boron in water can be determined by several methods, including the curcumin method, consisting of acidification and evaporation in the presence of curcumin to produce rosocyanine, which is taken up with ethanol and compared photometrically with standards. The curcumin method is recommended for water with boron concentrations between 0.1 and 1.0 mg/L.

When a sample of water containing boron is acidified and evaporated in the presence of curcumin,a red-colored product called rosocyanine is formed. The rosocyanine is taken up in a suitable solvent and the red color is compared with standards visually or photometrically.

2. Passive Method

We used the Solid State Nuclear Track Detectors (SSNTDs), for the measurements of Boron concentration in drinking water. The SSNTD, CR39 1. x1. cm films. Many samples of water from different places have been supplied. One milliliter of each sample of water is dropped on the same area of the $CR-39$ track detector, and it is left to dry. After drying the samples are exposed to a thermal neutron source for the same period of time 3 days. A nuclear reaction of type ${}_5B^{10}(n,\alpha)\ {}_3Li^7$ has been occurred, Alpha particles are emitted with energy 2.31 MeV which can make suitable track in $CR-39$ plastic-detector. The samples, after being exposed, are washed in distilled water, then etched in a solution of 6.25 N (Normality) NaOH at 70^o temperature, 3 hrs (etching time) , by using a bath held at a constant temperature. The track diameters and track density have been carried out using transmission optical microscope and a suitable calibration curve is used to calculate the concentration of Boron. The pieces of the each to the detector sets were irradiated with neutrons that emitted from Am-Be (in contact).The yield of the neutron source was $1.1\times10^7\,n/s$ and the mean energy of its emitted neutrons was 4.5 MeV. The source was supplied by Radio-Chemical Ltd. Amersham, England. The irradiation times were 3 days.

RESULTS AND DISCUSSION

The samples of water coming from rivers have been sampled in glass bottles (0.25 liter) for the chemical parameters determinations and in polyethylene bottles for boron determinations. The principle of passive method with Track density for determination of boron is the reaction of passive which is the product of track density. For the calibration graph the boron concentration as a function of track density was used of which a calibration solution. A linear calibration was observed, followed by the calculation of the slope factor.

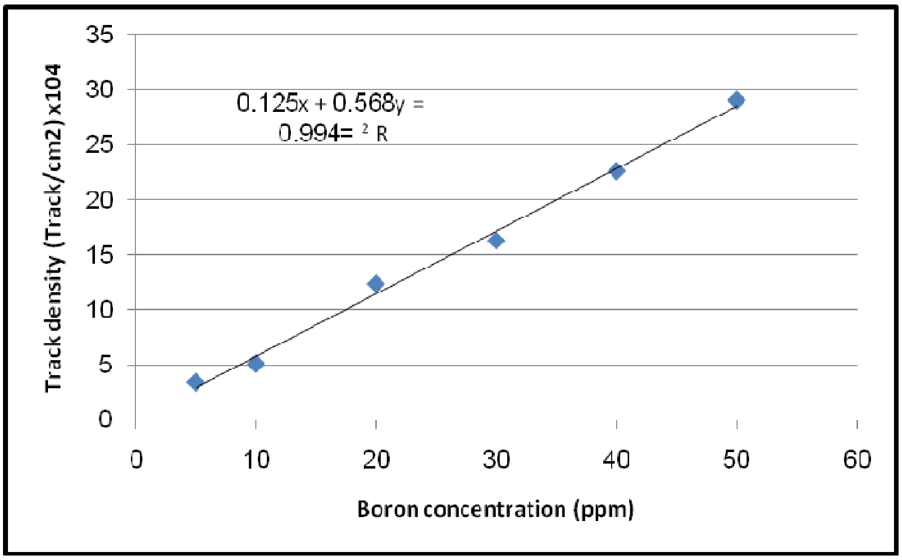


Fig. 3 The calibration graph – Boron

The results are experimented in mg B/L. Regression equation: y = 0.568 x-0.125.R^2 =0.994(fig. 3), and with respect to the second method, The principle of spectrophotometric method with Curcumin method for determination of boron is the reaction of Curcumin which is the product of rosocyanine. In the presence of dissolved forms of borates, at pH=8, formation of red complex is take place, followed by the spectrophotometric measurements (λ = 450 nm).

For the calibration graph, the r boron concentration as a function of the absorption was used of which a calibration solution. A linear calibration was observed, followed by the calculation of the slope factor. The results are experimented in mg B/l. Regression equation: y = 0.128 x – 0.022, R^2 =0.981 (Fig. 4).

Aquick term measurements using the Curcumin method for drinking and washing surface water and a long term measurement using the SSNTDs were done for 40 samples, S1 to S40, in different locations in Basra. The results are shown in table-1. fourty vials of water, S1 to 40 were collected from different locations in north and south of Basrah for drinking water and were tested by the passive methods as well. The results are presented in Table 1 and Fig.5. By looking at the details of the results, for both kinds of tests, one can recognize that there are some differences or some approximated in the results between Curcumin and SSNTDs. However, the calibration curves for the curcumin and passive detectors has been made and shown in Fig.3 and Fig.4. These differences or approximated are due to long and short time measurements.For SSNTDs the measurements were for 3 days, while Curcumin measurements were for 3hr.

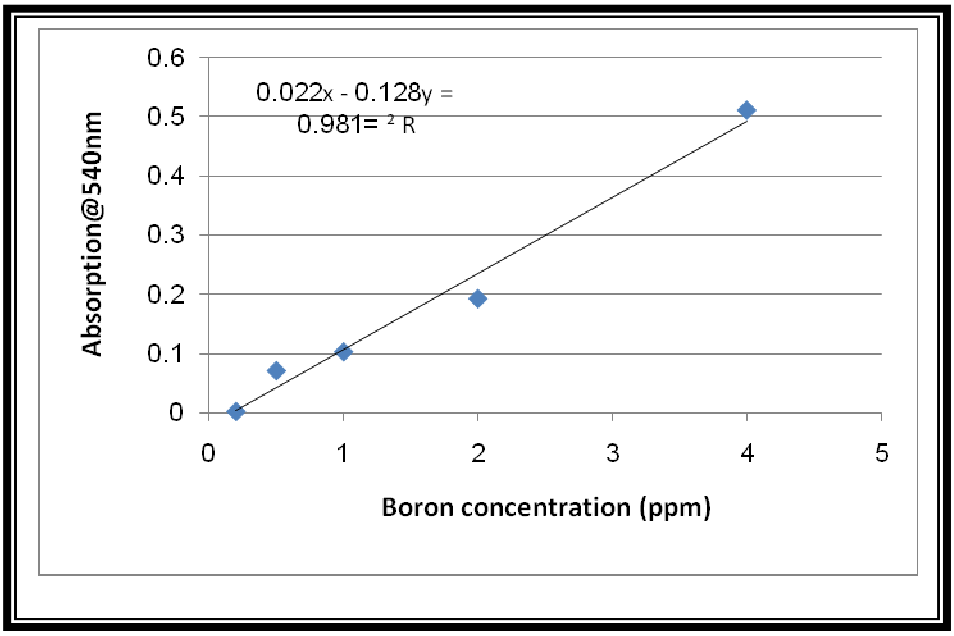


Fig.4. The calibration graph – Boron

Table 1: Measurement results for water samples (rivers, tap) in Basra Governorate by SSNTDs Method .

Site Number	Site Name	Track density (Track/cm^2)×10^4	Boron concentration In ppm using (SSNTDs)
S1	Al- Mudeina -Anter river	1.190	1.995
S2	Al- Mudeina -Salah river	1.310	2.205
S3	Shut Al- Mudeina	0.357	0.539
S4	Huwair AL-Aujan	1.071	1.787
S5	Qurna river	0.595	0.955
S6	Tigris river AL-Qurna-Muzereh	1.071	1.787
S7	Qurna – AlNahirat	0.357	0.539
S8	Al-Sharish- AlAgmaij river	0.804	1.320
S9	Al-Shafi river	0.446	0.695
S10	Al-Diar – Jrad river	3.450	5.946
S11	Al-Diar – Ali river	1.750	2.974
S12	Paper factory	0.357	0.539
S13	Al-Hartha- Hour Rajab	0.595	0.955
S14	Qarmat Ali- AlMacehab river	0.595	0.955
S15	Qarmat Ali-AlGhait	0.714	1.163
S16	Qarmat Ali- Yaman river	0.595	0.955
S17	Al- Khora	0.714	1.163
S18	Shutt Al-Qarma	0.595	0.955
S19	Shutt Al-Arab Al-Jzeera Al-Oula	4.285	7.405
S20	Shutt Al-Arab Al-Jzeera Al-Thania	3.920	6.767
S21	Shutt Al-Arab Al-Jzeera Al-Thaltha	1.666	2.827
S22	Shutt Al-Arab Al-Jzeera Al-Rabaa	1.905	3.245
S23	AL-Tennuma -Hassan river	2.170	3.708
S24	AL-Tennuma - Gurdlan river	2.140	3.656
S25	AL-Tennuma -Jaseem river	1.520	2.572
S26	Shatt Al-Basrah	0.357	0.539
S27	Ashaar river	0.595	0.955
S28	Al-Handia river	1.429	2.412
S29	Abu Floos	1.071	1.788
S30	Abu AL-Khaseeb river	1.190	1.996
S31	Abu AL-Khaseeb Ghuz river	1.310	2.204
S32	Abu AL-Khaseeb Hamdan river	1.071	1.788
S33	Abu AL-Khaseeb Abu Mgira river	0.952	1.580
S34	AL-Zubeir river	1.429	2.412
S35	Aum Qaser Harbor	3.810	6.575
S36	Ras Al-Bisha	2.817	4.839
S37	Al-Fao	2.460	4.215
S38	Al-Dawar river	2.738	4.701
S39	Tina river	2.341	4.007
S40	Al-Basra Harbor	4.246	7.337

Table 2. Measurement results for water samples (rivers, tap) in Basra Governorate Curcumin Method

Site Number	Site Name	Absorption In 540nm	Boron concentration In ppm using (Curcumin Method)
S1	Al- Mudeina -Anter river	0.254	2.160
S2	Al- Mudeina -Salah river	0.288	2.420
S3	Shut Al- Mudeina	0.060	0.638
S4	Huwair AL-Aujan	0.219	1.886
S5	Qurna river	0.135	1.224
S6	Tigris river AL-Qurna-Muzereh	0.211	1.823
S7	Qurna – AlNahirat	0.060	0.638
S8	Al-Sharish- AlAgmaij river	0.164	1.452
S9	Al-Shafi river	0.080	0.794
S10	Al-Diar – Jrad river	0.752	6.045
S11	Al-Diar – Ali river	0.371	3.073
S12	Paper factory	0.357	0.638
S13	Al-Hartha- Hour Rajab	0.117	1.086
S14	Qarmat Ali- AlMacehab river	0.595	1.054
S15	Qarmat Ali-AlGhait	0.139	1.255
S16	Qarmat Ali- Yaman river	0.113	1.054
S17	Al- Khora	0.136	1.235
S18	Shut Al-Qarma	0.113	1.054
S19	Shutt Al-Arab Al-Jzeera Al-Oula	0.953	7.621
S20	Shutt Al-Arab Al-Jzeera Al-Thania	0.857	6.866
S21	Shutt Al-Arab Al-Jzeera Al-Thaltha	0.353	2.926
S22	Shutt Al-Arab Al-Jzeera Al-Rabaa	0.406	3.344
S23	AL-Tennuma -Hassan river	0.479	3.911
S24	AL-Tennuma - Gurdlan river	0.454	3.721
S25	AL-Tennuma -Jaseem river	0.324	2.703
S26	Shatt Al-Basrah	0.064	0.670
S27	Ashaar river	0.113	1.054
S28	Al-Handia river	0.299	2.511
S29	Abu Floos river	0.220	1.887
S30	Abu AL-Khaseeb river	0.246	2.095
S31	Abu AL-Khaseeb Ghuz river	0.273	2.303
S32	Abu AL-Khaseeb Hamdan river	0.220	1.887
S33	Abu AL-Khaseeb Abu Mgira river	0.193	1.679
S34	AL-Zubeir river	0.299	2.511
S35	Aum Qaser Harbor	0.845	6.774
S36	Ras Al-Bisha	0.617	4.989
S37	Al-Fao	0.534	4.346
S38	Al-Dawar river	0.557	4.521
S39	Tina river	0.531	4.320
S40	Al-Basra Harbor	0.974	7.785

For the measurement of boron concentration level in water, table 2 and Fig.6, reflect the fact that, there was some high level of boron concentration in this water higher than the most of public tap and washing surface water in the governorate. The results for these 40 samples categorized into five locations, from s1 to s40, shown in Fig. 6. The data ranging from 0.638 mg/l in S3,s7,s12 to 7.621 at s19 . 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 [16,17].The European Union established a value of 1.0 mg/L for boron in 1998 for the quality of water intended for human consumption [18,19]. New Zealand has established a drinking water standard for boron of 1.4 mg/L [20,21].

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 [22,23].

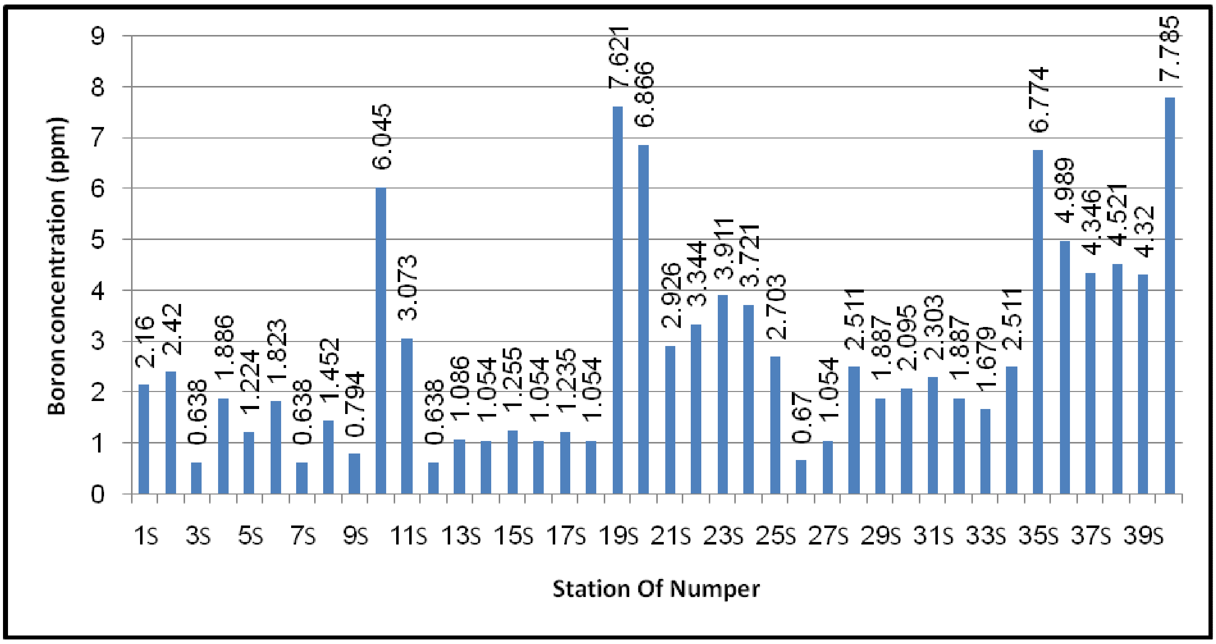
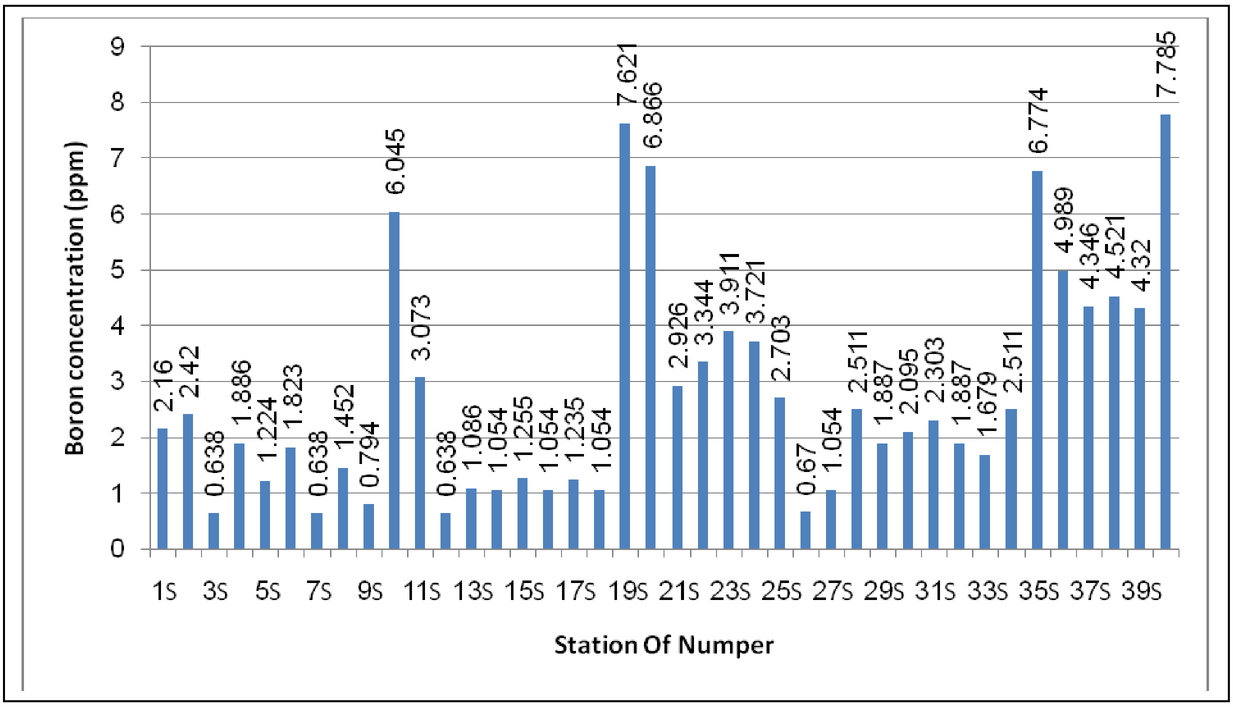


Fig 5 : Boron concentrations in rivers and drinking water at Basra Governorate.



Figu.6: Boron concentrations in rivers and drinking water at Basra Governorate.

CONCLUSION

The Boron concentrations in public drinking water were analyzed for 40 samples in Basra governorate (southern Iraq) covered most of the residential area. The concentration for 21 points, where surface water is used, range from 0.539 ppm to 2.0 ppm with an average.904 ppm which is in the low concentration range. The concentration in the 14 points, ranging from 2.205 ppm to 4.989 ppm with an average 3.316 ppm, these concentrations could be categorized into medium level of boron concentration. Most of the high level concentrations are ranging from 5.946 ppm to 7.405 ppm with an average 6.803 ppm and this may related to the penetration of the deplete uranium used in the Gulf wars. Our presented data for boron concentration in water (40 samples) clearly shows that the concentration for19 points, where surface water is used, range from 0.638 mg/l to 2.054 mg/l with an average 1.210 which is in the low concentration range . The concentration in the 16 points, ranging from 2.054mg/l to 4.989 mg/l with an average 3.240 mg/l, these concentrations could be categorized into medium level of Radon concentration. Most of the high level concentrations are ranging from 6.045 mg/l to 7.785 mg/l with an average 7.018 mg/l and this may related to the penetration of the deplete uranium used in the Gulf wars.

In general, well waters within the investigated areas, are highly mineralized. The correlation analysis revealed thestrong positive association between boron and some chemical compounds in drinking water. Access to safe drinking water is essential to human wellbeing and is a key public health issue. The maintenance of good quality of drinking water is achieved both by protecting the raw water supply and water treatment. It is possible to protect the raw waters supply by means of pollution control measures that prevent undesirable constituents from entering the water and by good watershed management practices.

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