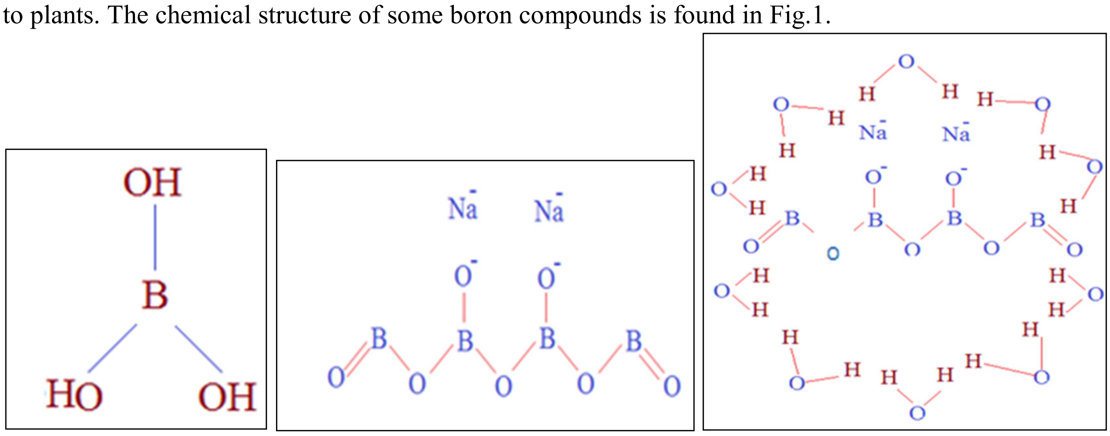
The Measurements of Boron Concentration in Water Samples of the Rivers in Basrah Governorates Using SSNTDs Techniques

Sawsan Sh. Fleifi *Thaer M. Salman
University of Basrah, College of Education, Department of Physics, Basrah, Iraq

Abstract
Significant risks for human health may results from exposure to non pathogenic toxic contaminants that are often globally ubiquitous in waters from which drinking water is derived to measure the Boron, ${}^{10}_{5}B$ concentration in water samples in Basra governorate in Iraq. The measurements were performed by analyzing the water samples collected from 15 location using SSNTDs Technique.The Boron concentrations which is obtained ranged from 0.277ppm in Shat Alarab/kerma to 1.849 ppm in AL-mdiana/Hoyer Ekab river in water samples. The results are presented and compared with other studies. The results could be utilized to make distinctive supplementary contributions when contamination event occurs and to implement water quality standards by concerned authorities to maintain radioactive contamination-free drinking water supplies for the people. The study further reveals that 15 surface water samples have boron below detection limit. The presence of boron in drinking water sources in this territory is of natural origin. Thus, there is possibility of severe pollution problem with boron in near future.
Keywords: Boron, Neutron Source , SSNTDs , Basra Governorate

1. Introduction

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%) [World Health Organization 1998]. 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 [Woods 1994]. 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 [Woods 1994; Argust 199; Kostick 2006 & Goldberg *et al* 2008]. In aqueous solution at pH < 7, it occurs mainly as un-dissociated boric acid (H_3BO_3) but at higher pH boric acid accepts hydroxyl ions from water thus forming a tetrahedral borate anion [Shelp 1993]. Boron deficiency is much more common in crops that are grown in soil that have higher amount of free carbonates, low organic matter, and high pH [Lindsay 1991]. Boric acid, borates and per borates can introduced to environment as these have been used in mild antiseptics, cosmetics, pharmaceuticals [WHO 2004]. 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 [Weir 1972 &Diaconu 2008]. Boron occurs as borosilicate in igneous, metamorphic, sedimentary rocks which are resistant to weathering and not readily available to plants. The chemical structure of some boron compounds is found in Fig.1.



Boric acid **Anhydrous borax** **Sodium tetraborate hydrat**

Figure 1. Chemical Structures of some boron compounds [Chemfinder.com 2006]

Solid state nuclear track detectors SSNTDs of different materials are important for investigations in basic science and technology [Thaer *et al* 2013].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 [Somogyi 1973] and in more details [Durrani *et al* 1987]. Even more details for detecting alpha particles, which is important from BNCT point of view [Nikezic 2003]. The ^{10}BNCreaction 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:

$$^{10}B+n\rightarrow[^{11}B]\begin{array}{l}\rightarrow {}^{7}Li+{}^{4}He+2.79MeV \quad (branching\ \ ratio\ \ 6.1\%) \\ \rightarrow {}^{7}Li+{}^{4}He+\gamma(0.48MeV) \quad (branching\ \ ratio\ \ 93.9\%)\end{array} \qquad (1)$$

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 0.48MeV 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.

This work represents the preliminary findings from Boron concentration measurement data which were collected from different regions in Basrah city. The general aim is to investigate the complex interactions and exchanges with the flow of water, and 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.

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

2. Material and Methods

In Basra governorate, the Samples from 15 stations and locations were collected during April 2014. The measurements of Boron concentration soils were carried out by passive methods; we used the Solid State Nuclear Track Detectors SSNTDs, for the measurements of Boron concentration in soils. The SSNTD, CR39 (1x1 cm) films. Many samples of soils from different places have been supplied. One milliliter from different boron concentrations standard is dropped on the same area of the *CR*-39 track detector and it is left to dry. After drying the standard samples are exposed to a thermal neutron source for the same period of time 7days. Anuclear reaction of type ^{10}B (n, α) $^{7}_{3}$Li 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 60 ^{0}C temperature, 6 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.

2.1 Irradiation of the samples

The pellets (water samples of river) were covered with *CR*-39 detector and put in a plate of paraffin wax at a distance of 5cm from the neutron source *Am-Be*, with flux of thermal neutron ($5x10^3$ n cm^{-2} S^{-1}) as shown in Fig.3[Singh *et al* 2001].

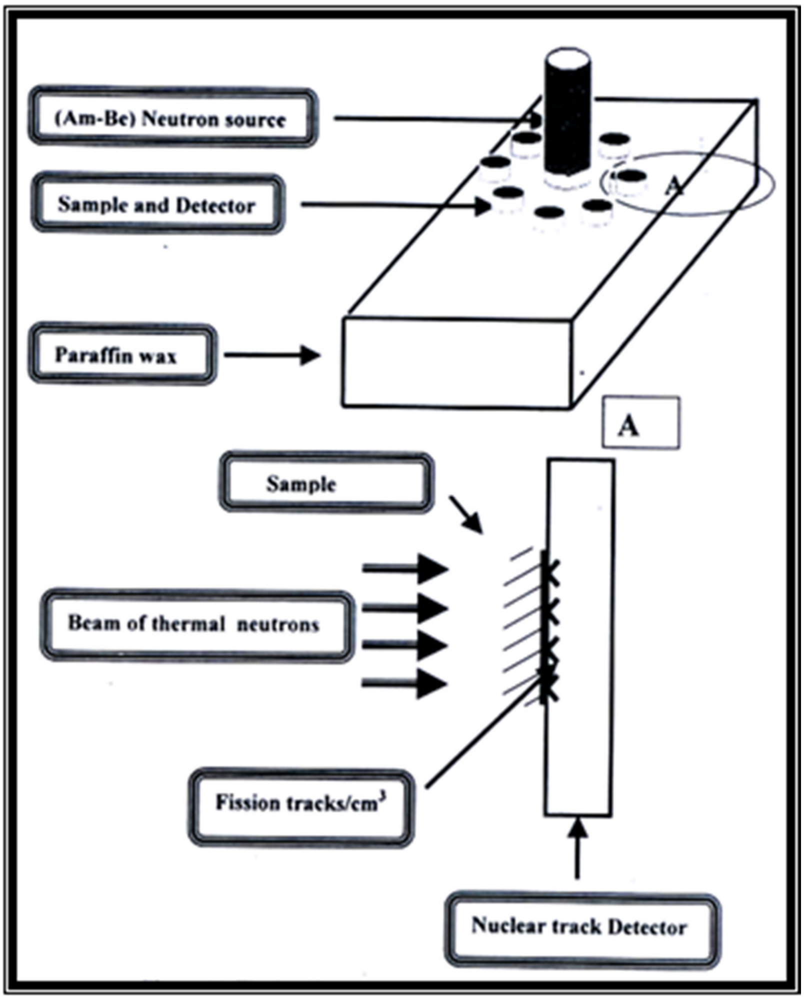


Figure 3. Soil samples and detector irradiation in front of the thermal neutron source

2-Chemical etching and microscopic scanning

After the irradiation time 7 days [Lindsay 1991] the CR-39 detectors were removed and etched in a 6.25 N aqueous solution of NaOH maintained at 70 C° for 6 hr ,which was the normal employed etching time [Singh *et al* 2001]. The detectors were rinsed with distilled water and dried in air. The tracks recorded in CR-39 detectors were counted by using optical microscope at a magnification of 400 X . The density of the tracks ρ in the detectors was calculated according to the following relation.

$$\rho x = \frac{N ave}{A} \qquad (2)$$

where ρ is the Track density (Track/mm^2), N is the a average of total tracks and A is the area of field view

2.2 Calibration Curve for soil sample

For the calibration curve plot between standard of different Boron solutions of known concentrations from 2ppm to 1ppm has been prepared to calibration our studying and track density by using neutron induced radiography which is based on the principle of solid state nuclear detectors SSNTDst CR-39. The Boron concentrations were measured by comparison between track densities register on the detectors of the samples and that of the standard samples from the Regression equation: y=2276.2+352.72*X , R^2 =0.97353. A linear calibration as shown in Fig. 4 was observed, followed by the calculation of the slope factor. The results are experimented in (mg B/l).

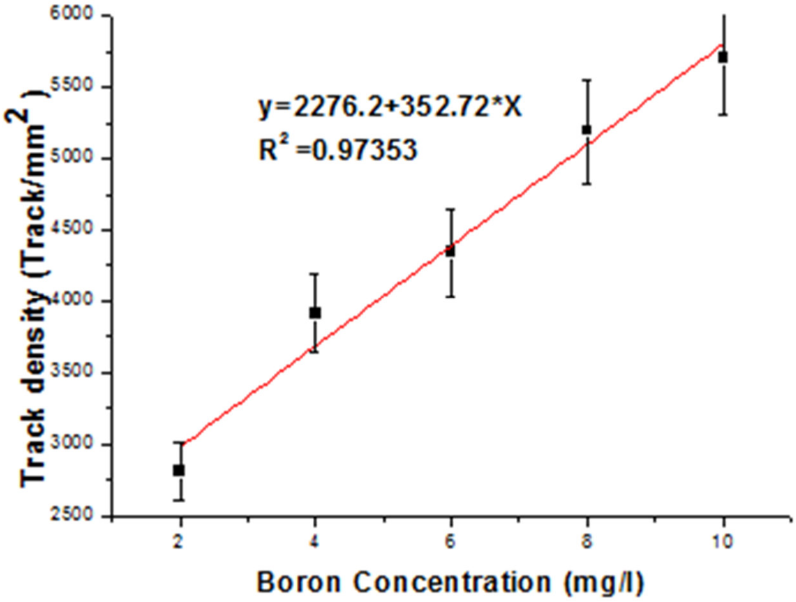


Figure 4. The relation between track density and Boron concentration (ppm) for standard Boron samples

3. Result and Discussion

Table 1 present the tracks density, Boron concentration samples that measured by *CR* –39 detector. The water samples of the rivers collected from fifteen locations distributed in different sites in Al-zobair, Al-mdiana, Abu-alkhesibe districts in Basra governorate. Fig.5 show the relation ship between Boron concentration and number of the location of the soils sample.

Table 1. Boron Concentration in the water in Abu -Al-Khaseeb rivers using SSNTDS method

Location No.	Location	Tracks Density (Tracks/mm²)	Boron Concentrations (ppm)
S_1	Khoz River	3012	0.695
S_2	River Hababah/ Alspliat	3041	0.776
S_3	mogera River	3041	0.776
S_4	Bab Suleiman River	3122	1.007
S_5	Sehan/Alseba/shat Alarab	2901	0.379
S_6	AMhala River	3005	0.674
S_7	Abu Flus River	3005	0.674
S_8	Hamdan River	3008	0.682
S_9	Sarraji	3348	1.646
S_{10}	Shat Al-rab/Alkrna	2865	0.277
S_{11}	Shafi \ Euphrates	2971	0.577
S_{12}	Hoyer Ekab river/Al-hoyer/Al-mdiana	3420	1.849
S_{13}	Euphretas/between Al-chabiash and Mdiana	3241	1.343
S_{14}	Alknazeria/Almdiana	3220	1.282
S_{15}	Shat-Al-arab-tnoma	3020	0.715

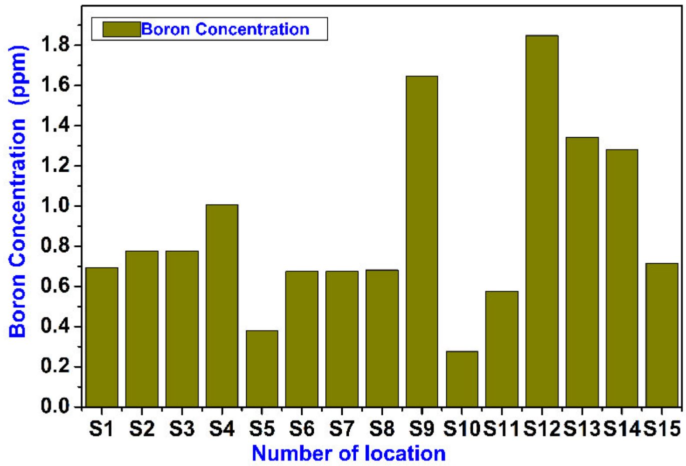


Figure 5. Boron concentrations in Al-zobair, Abu-khasib and Al-Mdiana soil as a function of number location

For the measurement of boron concentration level water, samples for the rivers table 1 and Fig.5, 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 15 samples categorized into 15 locations, from S1 to S15, shown in Fig.5. Boron content found maximum 1.849 ppm in Hoyer Ekab river/Al-hoyer/Al-mdiana belt and minimum 0.277ppm was recorded in Shat Al-rab/Alkrna belt. Out of the15 water samples of the rivers 5 samples recorded higher which are beginning from 1.007ppm to 1.646 ppm while the 7 water samples of the rivers are beginning from 0.6174 ppm to 0.776ppm than the prescribed WHO limit 0.5 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 [World Health Organization 2003 & Vadivel *et al.* 2012].The European Union established a value of 1.0 mg/L for boron in 1998 for the quality of water intended for human consumption [Council of the European 1998 & Neelesh *et al*. 2012]. New Zealand has established a drinking water standard for boron of 1.4 mg/L [New Zealand Ministry2000 & Abdul 2012]. 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 5mg/L. They will review this IMAC periodically as new data becomes available [Health 2003 & Ogbonna *et al*.].

4. Conclusion

Well soils are in many rural localities in rural areas and which were existent in the Basra Governorate Iraq. The analytical results of chemical soils analysis revealed the presence of Boron in the limit of New Zealand 1.4 ppm and IMAC 5 ppm, with a variation between 0.277 –1.849ppm. The values of Boron concentration are small and within the natural limits in most of the sample of the water samples of the rivers. The correlation factor, 97.35%, between the boron concentration of standard samples and Track density (track/m^2)of the samples in water samples of the rivers are very good correlation. Access to safe water of the rivers is essential to human well-being and is a key public health issue.

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