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 risk for human health may result from exposure to non-pathogenic toxic contaminants that are often globally ubiquitous in waters from which drinking water is derived to measure the Boron, $^{10}\text{B}$ 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 0.277 ppm 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, $^{10}\text{B}$ (19.8%) and $^{11}\text{B}$ (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$_3$BO$_3$) 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 anti-septics, 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 $^{10}\text{BNC}$-
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, 10B, 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 10B+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:

\[
10B + n \rightarrow [^7Li + ^4He + 2.79\text{MeV}] (\text{branching ratio } 6.1\%) \quad \Rightarrow \quad 7Li + ^4He + \gamma(0.48\text{MeV}) \quad (\text{branching ratio } 93.9\%)
\]

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 (\(^4\text{He}^+\)) 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.](image)

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. A nuclear reaction of type \(^{10}\text{B} (n, \alpha) ^{7}\text{Li}\) 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 °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 5 cm from the neutron source Am-Be, with flux of thermal neutron ($5 \times 10^3 \text{n cm}^{-2} \text{S}^{-1}$) as shown in Fig. 3 (Singh et al. 2001).

\[ \rho_{\text{ave}} \times N = \rho \frac{N_{\text{ave}}}{A} \]  

(2)

where $\rho$ is the Track density (Track/mm$^2$), $N$ is the 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 2 ppm to 1 ppm 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 SSNTD type 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: $y = 2276.2 + 352.72 \times X$, $R^2 = 0.97353$. 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/I).
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>
<thead>
<tr>
<th>Location No.</th>
<th>Location</th>
<th>Tracks Density (Tracks/mm²)</th>
<th>Boron Concentrations (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Khoz River</td>
<td>3012</td>
<td>0.695</td>
</tr>
<tr>
<td>S2</td>
<td>River Hababah/ Alspliat</td>
<td>3041</td>
<td>0.776</td>
</tr>
<tr>
<td>S3</td>
<td>mogera River</td>
<td>3041</td>
<td>0.776</td>
</tr>
<tr>
<td>S4</td>
<td>Bab Suleiman River</td>
<td>3122</td>
<td>1.007</td>
</tr>
<tr>
<td>S5</td>
<td>Sehan/Alseba/shat Alarab</td>
<td>2901</td>
<td>0.379</td>
</tr>
<tr>
<td>S6</td>
<td>AMhala River</td>
<td>3005</td>
<td>0.674</td>
</tr>
<tr>
<td>S7</td>
<td>Abu Flus River</td>
<td>3005</td>
<td>0.674</td>
</tr>
<tr>
<td>S8</td>
<td>Hamdan River</td>
<td>3008</td>
<td>0.682</td>
</tr>
<tr>
<td>S9</td>
<td>Sarraji</td>
<td>3348</td>
<td>1.646</td>
</tr>
<tr>
<td>S10</td>
<td>Shat Al-rab/Alkrna</td>
<td>2865</td>
<td>0.277</td>
</tr>
<tr>
<td>S11</td>
<td>Shafi \ Euphrates</td>
<td>2971</td>
<td>0.577</td>
</tr>
<tr>
<td>S12</td>
<td>Hoyer Ekab river/Al-hoyer/Al-mdiana</td>
<td>3420</td>
<td>1.849</td>
</tr>
<tr>
<td>S13</td>
<td>Euphretas/between Al-chabiash and Mdiana</td>
<td>3241</td>
<td>1.343</td>
</tr>
<tr>
<td>S14</td>
<td>Alknaizeria/Almdiana</td>
<td>3220</td>
<td>1.282</td>
</tr>
<tr>
<td>S15</td>
<td>Shat-Al-arab-tnoma</td>
<td>3020</td>
<td>0.715</td>
</tr>
</tbody>
</table>
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/Al krna 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 & Neelsh 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/m²)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.

References
Abdul, R.H. S., Master, A. A.,(2012), Advances in Applied Science Research, 3 , 563.
Lindsay, W.L. In: J. J. Mortvedt, etal.,(Eds), Micronutrients in Agriculture,2nd Edition, (Soil Science Society of
Advances in Physics Theories and Applications
ISSN 2224-719X (Paper) ISSN 2225-0638 (Online)
Vol.53, 2016

America, Madison, Wisconsin, USA, (1991), 89-144.
Neelesh, S., Mishra D. D., Mishra P. K. Advances in Applied Science Research, 2012, 3 ,335