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Estimation of Boron Concentration in Soil Samples in Al-Zubair, Abu-khasib and Al-mdiana districts of Basrah governorates using SSNTDs Techniques

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ABSTRACT

A technical method has been used to measure the boron concentration in soil samples in the Basra governorate by detecting alpha track density in CR-39 plastic detector. The measurements were performed by analyzing the soil samples collected from 39 location using SSNTDs method. The Boron concentrations which are obtained ranged from 0.512 ppm in Eastren star to 3.581 ppm in Alnagme in soils 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 soil quality standards by concerned authorities to maintain radioactive contamination-free drinking water supplies for the people. The study further reveals that 39 surface soil samples have boron below detection 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.

Keywords: Neutron Source, Boron, SSNTDs, Soils samples.

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,α) ^{7}Li 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 ionizations 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:

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

The reaction 0ccurs 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**.**

MATERIALS AND METHODS

In Basra governorate, the Samples from 39 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 70° 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.

1- Collection of soil samples

in this study thirty nine samples of soil distributed in in Basra governorate were taken from different locations. soil samples were brought to the laboratory cleaned from stones and any other impurities and dried in oven at 80 0C for few hours. The soil samples were crushed into a fine homogeneous powder using an electric mill , cleaned it using special seve(75 µm in diameter). 0.5 gm of soil samples were pressed into pellet of (1.5 mm) in thickness and (1 cm) in radius using a hydraulic machine [7].

2-Irrdiation of the samples

The pellets (soils samples) 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 (5×10^{3} $n.cm^{-2}\ S^{-1}$) as shown in Fig.1[8].

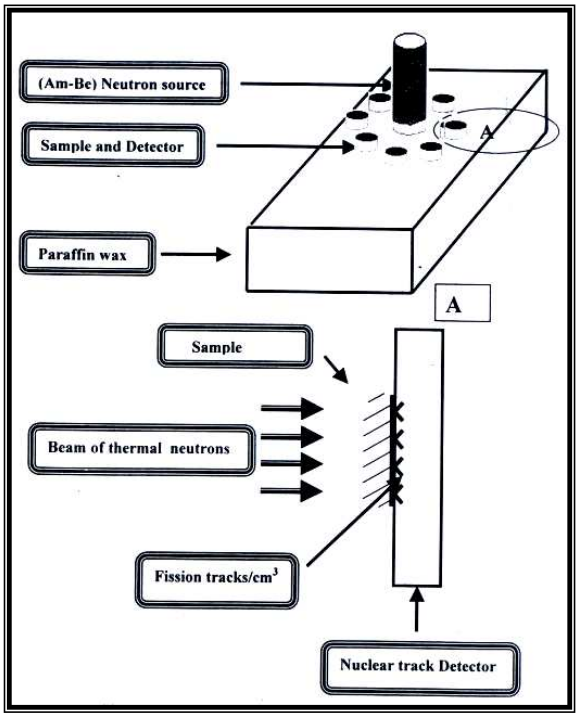

Fig.1 Shows the soil sample and detector irradiation in front of thermal neutron source

3-Chemical etching and microscopic scanning

After the irradiation time 7 days [8],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 [8].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 400X . The density of the tracks ρ in the detectors was calculated according to the following relation.

$$\rho x = \frac{N_{ave}}{A}$$

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

4- Calibration Curve for soil sample

For the calibration curve plot between standard of different Boron solutions of known concentrations from 2 ppm to 10 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 (SSNTDst) CR-39 . The Boron concentrations were measured by comparison between track densities registed 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.2 was observed, followed by the calculation of the slope factor. The results are experimented in (mg B/l).

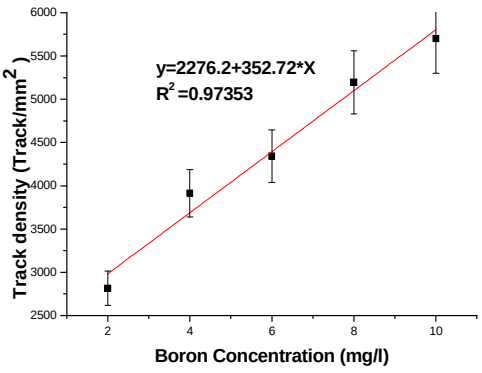

Fig. 2. The relation between track density and Boron concentration (ppm) for standard Boron samples

RESULTS AND DISCUSSION

Table 1 present the tracks density, Boron concentration samples that measured by *CR* – 39 detector. The soils samples collected from thirty nine location distributed in different sites in Al-zobair, Abu-khasib and Al-mdiana soil by SSNTDs districts in Basra governorate . Fig (3) show the relation ship between Boron concentration and number of the soil sample.

Table (1): Boron Concentration of Al-zobair, Abu-khasib and Al-mdiana soil by SSNTDs

Location No	Location	Density of Tracks (Tracks/mm²)	Boron Concentrations (ppm)
S_1	Eastern star/Al-zobair	3491	2.051
S_2	Allhis1	3162	1.120
S_3	Alhdama/Safwan-Amqusr street	3420	1.849
S_4	Allhis2	3440	1.930
S_5	Alamuelhat	3062	0.836
S_6	Alnagme	4008	3.518
S_7	The Eastern Star	2948	0.512
S_8	Southern Star/besides liquid gas plant	3620	2.416
S_9	Safwan 1	3280	1.452
S_{10}	Safwan2	2914.	1.809
S_{11}	Hamdan	3217	1.247
S_{12}	Albhadrai	2934	0.472
S_{13}	Mhegran	3144	1.067
S_{14}	Abu flus1	3391	1.768
S_{15}	Duaid	3391	1.768
S_{16}	Mhala	3120	0.998
S_{17}	Alsbelait	3520	2.132
S_{18}	Gekor	3441	1.910
S_{19}	Alsarage	3019	0.917
S_{20}	Babtweel	3019	0.917
S_{21}	Koz area	3384	1.646
S_{22}	Abu flus2 /neer water progect	3367	1.699
S_{23}	Bab sliaman	3084	0.897
S_{24}	Alekta/near Adu flus bridge	3220	1.282
S_{25}	Near Abu flues port	3505	2.092
S_{26}	Sehan	3112	0.978
S_{27}	Alabara	2514	0.674
S_{28}	talha/nahait Al_emam Alsadeq	3162	1.120
S_{29}	Almdiana bowndary	2780	1.428
S_{30}	Alfathai/Almdiana	2857	1.768
S_{31}	Qurna	3112	0.978
S_{32}	Riverbank Ezz1	3577	2.295
S_{33}	Almdiana	3291	1.484
S_{34}	Al_shafe	2734	2.740
S_{35}	Aldair	2605	2.375
S_{36}	Algalal	3712	2.679
S_{37}	Cliff Qurna	3597	2.315
S_{38}	Almaber	4005	3.510
S_{39}	Al-shafe	3491	2.015

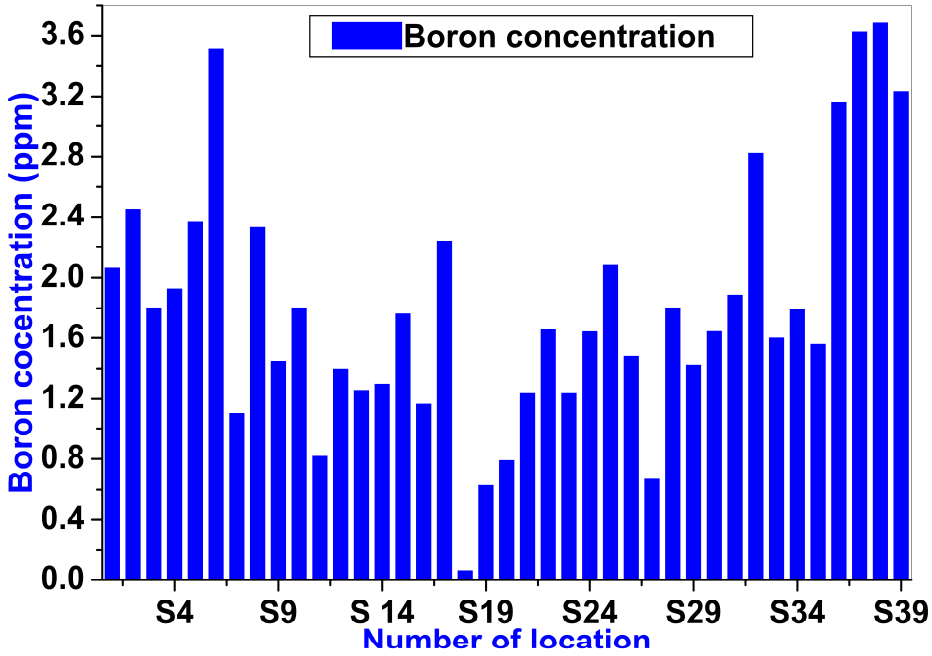

Fig.3: Boron concentration in Al-zobair, Abu-khasib and Al-mdiana soil as a function of the number of the sample by using SSNTDs

For the measurement of boron concentration level soils, table 1, and Fig..3. reflect the fact that, there was some less than level of Boron concentration in this soil samples less than from the U.S Environmental Protection Agency (EPA). The results for these 39 samples categorized into 39 locations, in Al-zobair, Abu-khasib and Al-mdiana region from S1 to S39, shown in Fig. 3 .Boron content found maximum (3.518 ppm) in Alnagme and minimum (0.512 ppm) was recorded in Eastern star belt. Out of the 39 soil samples 11 samples recorded higher which are beginning from 2.05 ppm to 3.518 ppm while the 21 soil samples are beginning from 1.108 ppm to 1.930 ppm while the 5 samples soils are beginning from 0.472 ppm to 0.824 ppm than the prescribed than the prescribed EPA limit (30 ppm). The maximum contaminant level (MCL) of boron was determined to be about 30 µg/L by U.S Environmental Protection Agency (EPA)[14].it is important to reliably monitor Boron concentrations in environmental samples. However, due to the relatively low sensitivity of these techniques for Boron, a large number of samples and long measurement times are generally required to obtain reliable results.

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 Low EPA (30 ppm), with a variation between (0.067-3.688) ppm .
• The values of Boron concentration are small and within the natural limits in most of the sample of the surface soils.
• The correlation factor, 97.3%, between boron of absorbance of standard and the absorbance of samples in soils samples are very good correlation.
• Access to safe soil is essential to human well-being and is a key public health issue.

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