Measurement of Alpha Emitters Concentration at Ground Level in Different Places in the Dhaka City Using Solid State Nuclear Track Detector

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Abstract: The presence of alpha emitters like uranium, thorium and their daughtep in human body is very harmful to the normal tissues because of its high attenuation power. These alpha emitters may enter the human body through food cycle, drinking, inhalation etc. Exposure to energetic heavy nuclear particle in the home and work place is one of the main risks of ionizing radiation causing millions of deaths from lung cancer each year globally. Other than lung cancer, renal effect, neurological effects, reproductive effect, hematological effects and various forms of cancer are observed form natural radiation exposure. For measuring this natural radioactivity solid state nuclear track detector (SSNTD) technique has been used. Alpha emitter concentration at ground level measured in 20 different places in Dhaka city is reported here.

Key words: attenuation power, alpha emitters, radiation exposure, radioactivity.

Introduction

The alpha emitting radioactive substances are harmful to tissues of human being because of their high attenuation power[1]. The alpha emitters like uranium, thorium and their daughters are consumed in trace amounts by living species through food chain and from environment [2, 3]. Natural uranium contains three isotopes with an isotopic abundance of ^{238}U: 99.2745%±0.0015%; ^{235}U: 0.72% ±0.001% and ^{234}U: 0.0055% ±0.0005%[9]. These alpha emitting radioactive substances enter into the human body mainly through ingestion of food, water and inhalation of air. Only 2-5 percent presence of ingested alpha emitters is absorbed in the gastrointestinal tract, the rest is eliminated from the body. The absorbed alpha emitters are carried through the bloodstream and will be filtered by the kidney and excreted in the urine in 24 hours. As a result nephritis in the primary chemically induced effect of alpha emitting radioactive substances is observed in human.

The danger of alpha emitter exposure in dwelling houses was discovered in 1984 by Stanley Watras [8]. He found the source was astonishingly high levels of Radon in his basement. The risk associated with living in his house were estimated to be equivalent of smoking 135 packs of cigarettes every day[1,2]. Depending on how houses are built and ventilated alpha emitters especially radon may be accumulated in the basement and dwellings. The European Union recommends that the action should be

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taken starting from concentrations of 400Bq/m^3 for old houses and 200Bq/m^3 for new ones. National Council for Radiation Protection (NCRP) recommends action for any house with a concentration higher than 8pCi/L (300 Bq/m^3). The united State Environmental Protection Agency recommends action for any house with a concentration higher than 148 Bq/m^3 (given as 4 pCi/L). Nearly one in 15 homes in the U. S. has a high level of indoor radon according to their statistics. The U. S. Environmental Protection Agency (EPA) recommends all homes be tested for radon. Since 1985, millions of homes have been tested for radon in the U. S. By adding a crawl space under the ground floor, which is subject to forced ventilation the radon level in the house can be lowered [3]. In Bangladesh, the statistic in this case not satisfactory. There is no recommended permissible level for alpha emitting radioisotopes like radon. A few research works have been done in this field [7]. So, the aim of this study is to establish a database for alpha emitters for Bangladesh especially for Dhaka city.

A suitable and less expensive method for determining alpha emitter concentration in ground level is essential for undertaking such survey. Alpha emitters usually presents in ground level at a very low concentration (part per billion, ppb). To develop a methodology for the assessment of alpha emitter concentration in ground level which would be cost effective i.e. cost per unit test should be reasonable, less time consuming, efficient and reliable technique, also a reasonable high precision technique and very simple in concentration and appropriate for the nationwide survey.

Solid State Nuclear Track Detector Technique (SSNTD) has been used in the present work and Acrylonitrate Butadiene Styrene (ABS) polymer has been used as Solid State Nuclear Track Detector because of some practical advantages such as simple in construction, low cost, sensitivity, resolution, reliability of their response, high homogeneity, isotropy, high optical transparencies, uniformity etc. Finally the goal of this work is to develop a protocol using these detectors for the assessment of alpha emitter concentration in ground level for different places of Dhaka in Bangladesh.

Methodology

Acrylonitrile butadiene styrene (ABS) is a common thermoplastic. It is a copolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5% to 30% butadiene and 40 to 60% styrene[4]. The chamber with detector configuration consisted of an open mouth insulating container of 8 cm in height and 7 cm in diameter. The middle portion of the chamber is covered with a semi permeable polyethylene membrane. The membrane slows down the normal diffusion of nobel gases into the chamber and thus discriminates in favor of radon against thoron. This configuration is generally used in the exploration to eliminate the thoron interference and water condensation. Also it prevents the entrance of radon daughter. This detector configuration was calibrated in laboratory and used for radon measurement.

The Acrylonitrile butadiene styrene (ABS) polymer film of 1cm x 1cm was hung from the bottom of the cap inside the chamber at 6 cm above the standard solution level. The containers were filled with 5 mL of standard solution. The detectors were exposed at 714.653 Bq/m^3 standardize radon activity obtained by standard radium nitrate solution. The containers were closed and were made airtight. As a result, the detectors are exposed only to alpha emitters especially radon. One side of each detector was covered so that only one side of the detector was exposed to radon. All of these exposures were done in airtight environment for thirty days free from any disturbance. After exposure all the detectors were taken out and washed with distilled water for several times. Then the detectors were dried in room temperature and marked. After exposure for desired period of time the detectors were etched in various etching solution at constant temperature of 60^o C for two hours and constant temperature of 70°C for four hours. To achieve a fixed temperature of 60^o C and 70°C, a constant temperature water bath was used [4]. The etching solution is 10% 3N NaOH.

The detectors were dropped in cold water after etching of precise hours and were held under the flow from top with the help of a forceps for two or three minutes. Finally the detectors were washed in distilled water, soaked by tissue paper, dried in air and kept wrapped in tissue paper for subsequent study under a microscope. Similar procedures of etching and identical etching conditions were adopted for all the detectors. Especial care was taken to keep the concentration of the solution, the temperature and the period of time identical for each case. After etching the detectors were scanned under an optical microscope. Figure 1 shows tracks from alpha particle for ABS polymer. Counting charts were prepared in which there were blocks recorded with number of counts. The count of each field of view was recorded and after completion of scanning of a detector the counts were added. The total count divided by the number of blocks gave the average number of alpha track etch pits per area of the field of view. Using the actual area of field of view the number of tracks per cm^2 was calculated [4, 5, 6].

The mathematical expression of track density could be given by [9]:

$$\rho_T = \frac{\sum_L^n N_i}{\sum n \times A}$$

Where, ρ_T = Track density or tracks per cm^2, $\sum_L^n N_i$ = Total number of tracks, $\sum n$ = Total number of fields counted and A = Area of one field.

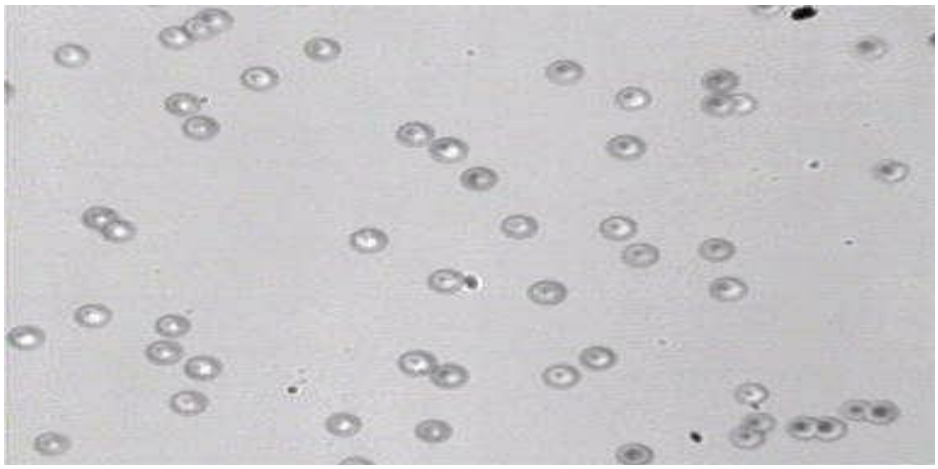

Fig. 1: *Tracks from alpha particle for ABS polymer*

In total 40 cup with detector configuration were placed in ground at 20 different places in Dhaka city. These detectors were allowed to expose for a 30 day period of time. Exposure for a long time is necessary to obtain relatively good amount of tracks. All of these detectors were allowed to expose at ground floor for better track formation. After the exposure of 30 day period of time detectors were etched with conventional 10% 6M NaOH etching solution. After that the tracks were counted in similar way and radon activity was determined by the calibration curves.

Results and Discussion

The highest average alpha emitter's concentration found in present study is 122.7±10.7 Bq/ m^3 at sampling place 6 and the lowest average alpha emitter's concentration is found 28.8±2.6 Bq/m^3 at sampling place 19. The average alpha emitter's concentration from different sampling places of Dhaka city are given in table below and comparison of different results are shown in figure 2. The tracks were counted and alpha emitter concentration was calculated from the calibration curves[9]. Solid state nuclear track detector technique was used for indoor alpha emitter especially radon analysis and 20 different places in Dhaka city were studied. The range of alpha emitter concentration was found from 28.8±2.6 to 122.7±10.7 Bq/m^3. The highest alpha emitter concentration were obtained is 122.7±10.7 Bq/m^3 from sampling place 6. This area is considered as old town and there ventilation system is very poor. This type of alpha emitter activity is hazardous and may cause lung cancer. Sampling places 3, 10, 11, 13, 14 and 15 shows alpha emitter activities 81.1±7.4, 81.9±7.3, 89.4±8.4, 86.4±8.3, 76.8±7.1 and 92.2±8.6 Bq/m^3 respectively. These levels of radioactive alpha emitter are a little higher than the safety range and may prove hazardous in the long run. The other places show alpha emitter activity at 28.9±2.6 to 68.9±6.5 Bq/m^3 which is an acceptable range and below danger zone. Present study shows seven sampling places out of twenty have alpha emitter activity higher than the normal acceptable range. This range of concentration is due to the poor ventilation system inside the houses. To prevent the exposure of alpha emitter the ventilation system of houses should be improved[10].

Table 1: *Data for the measurement alpha emitter's concentration of at different places in Dhaka city.*

Total number of detectors.	Sampling place no.	Average Alpha emitters concentration Bq/ m^3
4	1	41.7±4.1
4	2	36.8±3.5
4	3	81.1±7.4
4	4	78.6±7.3
4	5	57.4±4.9
4	6	122.7±10.7
4	7	39.1±4.1
4	8	33.7±3.3
4	9	42.9±4.6
4	10	81.9±7.3
4	11	89.1±8.4
4	12	54.2±5.3
4	13	86.4±8.1
4	14	76.8±7.1
4	15	92.1±8.6
4	16	64.2±5.7
4	17	33.2±2.9
4	18	68.9±6.5
4	19	28.8±2.6
4	20	66.9±3.4

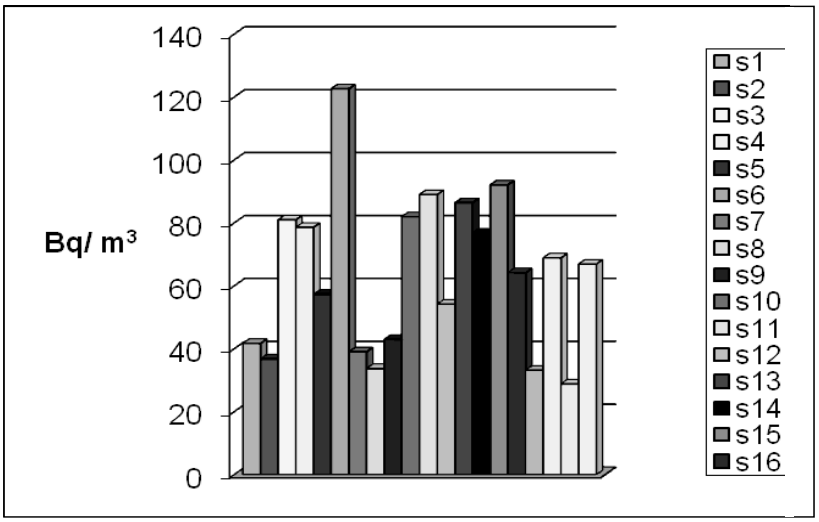

Fig. 2: *Bar diagram for the concentration of alpha emitter's using Acrylonitrate Butadine Styrene (ABS) polymer.*

Conclusion

The concentration of alpha emitters in some common places of Dhaka in Bangladesh has been measured using Acrylonitrate Butadine Styrene (ABS) polymer as solid state nuclear track detector. If these emitters remain in the air near to ground, it is more harmful to human because of inhalation. There is no standard level in this case for Bangladesh and people are also ignorant of the effect of radiation. But it is necessary to maintain a maximum permissible level of radiation in ground level. This result will be helpful in setting the actual limit of alpha emitters in Bangladesh urban environment. Further extensive measurements are needed in this regard.

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