The estimation of polonium contents in soil and plant samples in Udaipur, Rajasthan can be done through a process called radiochemical analysis.

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Abstract

The study was performed using alpha counting system at College of Science, Mohanlal Sukhadia University Udaipur, Rajasthan. Through the study, the observed ^{210}Po activity in plant and soil sample from different locations in Bhoio Ki Pancholi area ranges from 2.45-173.50 Bq kg^{-1} on dry weight basis. The daily and annual intake of ^{210}Po through water was also estimated and the mean value of 0.72 and 263.61 Bq, respectively, were observed. It is observed that the effective doses through water were higher than the World Health Organization recommended dose of 0.05 mSv/year.

The polonium contents in soil samples are in the range of 2.45-173.50 Bq kg^{-1} on dry weight basis. In soil samples minimum polonium contents was observed in samples no. BS I-17S. Maximum polonium contents (173.50 Bq kg^{-1}) were observed in sample no. BS II-4S. This soil sample was collected from the farmer's field in which it was growing *Triticum aestivum*.

At site BS I, *Jatropha curcas* showed the maximum polonium concentration (22.67 Bq/kg) (sample no. BS I-7P). Certain other plants with high concentrations of polonium were *Azadirachta indica, Tabernaemontana divaricata* & *Lantana camara*. Minimum polonium concentration was observed in *Calotropis procera* (0.36 Bq/kg).

In plant samples polonium contents was observed in the range of 0.36-25.94 Bq kg^{-1}. The plants of site BS II were also found to concentrate quite high polonium concentration ranging 1.91-25.94 Bq kg^{-1}. Maximum polonium contents (25.94) was observed in sample no. BS II-16P . Keywords Activity - Daily - Dose - Intake - Polonium -

Introduction

Polonium-210 (which has a physical half-life time of 138 days) is a member of the natural uranium-238 series and one of the relatively long-lived radionuclides of radon decay products. It is an alpha-emitting radionuclide and is present in trace amounts in most plants and foodstuffs as well as in human tissues (Batarekh and Teherani, 1987). The polonium isotopes are among the most radiotoxic nuclides to human beings. The concentrations of210Po in cigarette tobacco are in the range of 2.8–37 Bq/kg and vary with the cigarette brand, probably due to the different varieties of tobacco used and to different manufacturing procedures (Skwarzec et al.,2001b). The results obtained by Radford and Hunt (1964) indicate that210Po in cigarettes is volatilized at the temperatures characteristic for burning cigarettes and inhaled into the lung along with the cigarette smoke (mainstream smoke). It might effectively be a factor in the increased incidence of lung cancer among cigarettes smokers (Radford and Hunt, 1964).

Since then, other investigators have studied both the sources and behavior of 210Po and 210Pb in relation to smoking, and the biological effects of these on lung tissues and other organs (Batarekh and Teherani, 1987; Black and Brethauer, 1968; Boltzman and Ilcewicz, 1966; Cohen, 1979a,b; Fletcher, 1994; Godoy et al., 1992; Karali et al., 1996; Martell, 1974; Mussealo-Rauhammaa andJaakkola, 1985; Nada et al., 1999; Rajewskey and Stahlhofen, 1966; Shabana et al.,2000; Sinh and Nilekani, 1976; Tso et al., 1964; Tso et al., 1966; Watson, 1985). Tso et al. (1966) reported that the principal source of210Pb and thus also of210Po in tobacco is the soil and the contribution of polonium from atmosphere onto the tobacco plant to the total activity in the plant is minor compared to the polonium absorbed from the soil via the roots (Tso et al., 1966).

In contrast Skwarzec et al.(2001b) indicated that the atmospheric deposition is the main source of 210Po in the tobacco leaves. It is known to be absorbed to sub-micron-sized particles present in the smoke. Lead-210 is not sublimated at this temperature, but is rather a component of the resulting smoke and ash (Watson, 1985).

Lead is inhaled with the particulate fraction of mainstream smoke and acts as long-term source of210Po exposure. Both radionuclides contribute to cancer risk due to their deposition in the tissue of thelungs (Fletcher, 1994; Karali et al., 1996; Martell, 1974; Watson, 1985).

About 6.5–22% of the 210Po contained in cigarettes was found in the mainstream smoke (Mussealo-Rauhammaa and Jaakkola, 1985; Radford and Hunt, 1964). This work is a part of the national program to estimate the radioactivity contents of consumer products.

Material and Methods

The Study Area

Udaipur, the `abode of udai', meaning `City of Sunrise' is situated at 24^0 35' N latitudes and 73^0 41' E longitudes at a height of 582 meters above M.S.L. The eastern and north eastern portion of the district is hilly with long continuous ridges, as well as many detached hills, the whole physiography presenting a tangled wilderness of shallow valleys with an immense network of narrow `nallas' and fairly deep gorges. Geographically, the area deserves to be a basin, being girdled by low hills with few natural gaps along its borders. The basin is dominated by Aravali geological formation combined with rocks in its northern and southern parts. There are series of lakes along the western frontage.

Sample Collection and Preparation

Sampling for the following was carried out:

a. **Soil** – Soil samples have been collected from the areas near and far off from the place where mining activity was carried out. The areas were marked with the help of a portable GM counter. Samples from nearby farmer's fields have also been collected. Soil sampling was carried out for surface as well as sub surface (10-15 cm depth).

b. **Plants** – Following types of plants have been collected:

   i. Crop plants growing in the nearby and far off areas

   ii. Vegetables growing in the nearby and far off areas

   iii. Wild plants growing in the nearby and far off areas

Preparation of samples for analysis:

The plant samples were dried at 80ºC for 48 hours and powdered in a grinder, numbered and analysed for Gross alpha activity Po.

(D) Estimation of Gross alpha activity

Alpha counts:

The plant material was pulverized in a mixer grinder. 25 mg of the pulverized sample was taken in a planchet. A solution of ethyl acetate and colloidin was prepared in the ratio of 1:1. The plant sample kept in a planchet was fixed with the help of 4-5 drops of the mixture of the above solution. It was kept for a period of 20-30 minutes till completely dry. The planchet was kept in the alpha counter for a period of 9000 seconds and counts were noted. Each sample was replicated thrice and their counts were noted 3 times each for 9000 seconds.

The instrument was standardized daily with the help of a standard and background counts were also noted. The results have been calculated in Bq Kg^{-1} on dry weight basis.

Estimation of polonium in plant and soil samples

10 g of the plant samples were wet digested in nitric acid and hydrogen peroxide in the ratio of 1:1. The residue was then evaporated 2-3 times with 1:1 HCl till almost dryness to convert all nitrates to chlorides. It was then leached with 200 ml of 0.5N HCl and the final volume of the digestant was made up to 600 ml.

This volume was used for electrochemical deposition of polonium. 200 mg of ascorbic acid is added in the digestant to prevent the interference of iron and kept on a magnetic stirrer at 60° C for 6 hours. A clean and polished silver disc is placed inside. The silver disc is required to be alpha counted for its background counts on both the sides separately. Deposition is done for 6 hours. Po-210 gets plated on both the sides of the silver disc, which is then removed, washed well with water, dried and alpha counted on both the sides. Activity is then evaluated by applying % counter efficiency as given below:

$$\mathbf{A = (C/T_1 - B/T_2) \times 100/E \times 1/V}$$

Where A is the activity of the sample (Bq/L or Bq/ Kg fresh weight basis)

C is the sample + background counts (both sides together)

B is the background counts (both sides together)

T_1 is sample counting time in seconds

T_2 is background counting time in seconds

E is efficiency of the counter (%)

V is volume of water in litre or quantity of biological sample in Kg.

RESULTS

Bhoion Ki Pancholi Site (BS):

The polonium contents in soil samples are in the range of 2.45-173.50 Bq kg^{-1} on dry weight basis.

Maximum polonium contents (173.50 Bq kg^{-1}) were observed in sample no. BS II-4S. This soil sample was collected from the farmer's field in which it was growing *Triticum aestivum*.

At site BS I, *Jatropha curcas* showed the maximum polonium concentration (22.67 Bq/kg) (sample no. BS I-7P). Certain other plants with high concentrations of polonium were *Azadirachta indica, Tabernaemontana divaricata* & *Lantana camara*.

Discussion

Uranium in local soil mainly arises as a result of weathering of rocks, mining activities and use of phosphatic fertilizers in agriculture. In turn, it leaches out and mixes with water and get distributed in the local environment (Eisenbud, 1987).

Among the parameters involved in the probable contamination of human food chain by uranium tailings pile, migration of radionuclides and conventional toxins through subsoil seepage assumes significance. Processing of uranium ore leaves behind a large volume of low specific activity waste which is retained in the tailings pond. The chemical additives in the milling process account for the contribution of conventional toxins such as manganese, sulphate, chloride, etc.

Uranium content in average soils is in the range of 1-4 mg kg^{-1} and thorium contents in the range of 2-12 mg kg^{-1}. Contents of U and Th in minerals soils increase with clay content, due to adsorption at the surface of clay minerals and to the higher U and thorium contents of minerals in the clay fraction relative to contents in coarser soil constituents.

Rumble and Bjugstad (1986) determined uranium and radium concentration in plants growing on uranium mill tailings in South Dakota. The U concentrations in mill tailings averaged 13.3µg g^{-1} compared to 5.1µg g^{-1} in soils from control sites. U concentration in plants from tailings averaged 3.6 µg g^{-1}, but only 3.4 µg g^{-1} from control sites.

Lakshmanan and Venkateswarlu (1988) studied uptake of U by potatoes, *Raphanus sativus*, *Lagenaria leucantha*, *Solanum melongena* and *Abelmoschus esculentus* in pots by spiking soil and irrigation water with uranium. Increase in U was observed with increased U in water but not soil. However, the concentration factor for uptake of U by vegetables decreased with increase of U in the water. In rice, concentration in the grain was significantly less than in the husk, which was significantly less than in straw.

Koul *et al*. (1983) while studying the uptake of uranium in the plant *Cyclanthera pedata* also found uranium accumulation in the order of root, stem, leaf and flower.

Tutin *et al.* (1980) studied the vegetation covering the Crucea mining waste (Romania) which is characterized by coniferous forest species, consisting of *Abies alba, Picea exclesa* and *Larix decidna* and deciduous tree such as *Carpinus betulus, Acer negundo* and *Fraxinus excelsior*. The undergrowth consists of shrubs, such as *Vaccinium myrtillus* and *Rubus idaeus* and different forest species of spontaneous flora, such as *Dryopteris filix-mas, Lipidium draba, Holoshoenus vulgaris, Urtica dioica, Xanthium spinosum, Festuca rubra, Agrostis tenuis, Vaccinium myrtillus* and *Nardus stricta*.

Rubus idaeus, Abies alba, Festuca rubra, Agrostis tenuis, Nardus stricta, Lipidium draba, Urtica dioica, Xanthium spinosum showed that different capabilities of uranium assimilation and uranium are not uniformly distributed among plant tissues. The fir *A. alba* was found to have higher uptake of uranium (1300 ppm) than any other vegetation in the roots and twigs. *R. idaeus* and *V. myrtillus,* shrubs with edible fruits, showed medium to high uranium concentration (60 ppm) while *U. dioica, H. vulgaris and X. spinosum* have low (10 ppm) or no uranium retaining capacities. The roots of *F. rubra, A. tenius* and *N. stricta* and the twigs of *V. myrtillus* concentrated uranium as much as 3 times, the roots of *L. draba* concentrated uranium as much as 1.7 times, and roots of *V. myrtillus* had the highest concentration, as much as 6 times the uranium content in soil. Bramble (*X. spinosum*) had a poor uranium-retaining capacity, commonly lower than the uranium concentration in soil.

Ham *et al.* (1998) showed that soil adhesion made only a small contribution to the activity concentrations observed in the edible parts of crops. Sheppard *et al.* (1989) studied the effects of soil type on crops grown in lysimeters artificially contaminated with naturally-occurring radionuclides. This study demonstrated that soil type could have an effect on observed CRs. The study showed that values for sands were higher than those for finer textured soils, for which sorption of radionuclides would be greater.

Hill (1960) suggested that the routes of uptake of Pb^{210} and Po^{210} in the terrestrial system are through the aerial parts of the plants but that neither Unat nor Ra^{226} is accumulated to any great extent by terrestrial herbivores in areas of high natural radioactivity. Specific components of the environment namely sediments, algae, lichen and grass are the major sources for the body burden of specific radionuclides in each food chain.

Bondietti *et al.* (1976) suggested that the environmental mobility of naturally occurring radioactive Th may be useful in forecasting the long-term environmental fate of Pu and relative order of uptake is U> Pu> Th. Complexation with synthetic or natural chelating agents in soil may enhance Pu uptake by plants (Ballou *et al*., 1978; Lipton and Goldin, 1976). According to Romney *et al.* (1970) Pu uptake by plants increase with time.

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