



Estimation of Polonium Contents in Soil and Plants

Brijesh Pathak

Department of Botany, University College Dhilwan Tapa Constituent College of Punjabi University Patiala
Corresponding author: brijesh1pathak@gmail.com

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.

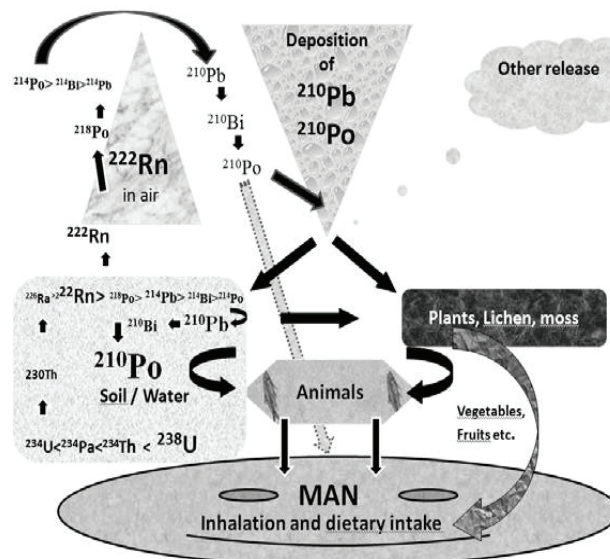
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INTRODUCTION

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 of ^{210}Po 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 that ^{210}Po 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 ^{210}Po and ^{210}Pb 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-Rauhamaa and Jaakkola, 1985; Nada et al., 1999; Rajewsky 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 of ^{210}Pb and thus also of ^{210}Po 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 ^{210}Po 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 of ^{210}Po exposure. Both radionuclides contribute to cancer risk due to their deposition in the tissue of the lungs (Fletcher, 1994; Karali et al., 1996; Martell, 1974; Watson, 1985). About 6.5–22% of the ^{210}Po 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 METHOD

Udaipur, the 'abode of udai', meaning 'City of Sunrise' is situated at $24^{\circ} 35'$ N latitudes and $73^{\circ} 41'$ 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:

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).

Plants

Following types of plants have been collected:

- Crop plants growing in the nearby and far off areas.
- Vegetables growing in the nearby and far off areas.
- Wild plants growing in the nearby and far off areas.

Preparation of Samples For Analysis:

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

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:

$$A = (C/T1 - B/T2) \times 100/E \times 1/V$$

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)
T1 is sample counting time in seconds

T2 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.

RESULT AND DISCUSSION

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. In soil samples minimum polonium contents was observed in samples no. BS I-17S. Maximum polonium contents (173.50Bq 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 .

Conclusions

These preliminary results suggested that polonium uptake by plants the main source of radionuclides was the soil rather than irrigation water. Nevertheless, irrigation with water containing higher polonium concentrations may contribute to enhance radionuclide uptake by the plants tested. Therefore, agriculture in soils containing high radionuclide concentrations from past uranium mining and milling activities, and the use of contaminated water for crop irrigation may increase radionuclide concentrations in agriculture products. Leafy vegetables (lettuce) accumulate much more radium and polonium than potatoes. A significant fraction of polonium accumulated in potatoes was associated with the skin and peeling would remove them, contributing to decrease radionuclide intake by humans.

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Declaration: *We also declare that all ethical guidelines have been followed during this work and there is no conflict of interest among authors.*

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