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# A Case Study of Natural Radioactivity in Soils of Punjab, India

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## Abstract

A study has been carried out to analyse the distribution of radioactive elements U, Th and $^{40}$K in the soil of some areas of Punjab State, India. The samples collected from different parts of the state were analysed using gamma spectrometry technique. The concentration of $^{226}$Ra in the state varies from a minimum value of 18.6 Bq/kg to a maximum value of 68.9 Bq/kg. Similarly $^{232}$Th concentration varies from a minimum of 10.6 Bq/kg to a maximum of 94.2 Bq/kg. The activity concentration of $^{40}$K varies from 48.8 Bq/kg to160.1 Bq/kg. No significant correlation was observed between indoor radon/thoron levels and $^{226}$Ra/$^{232}$Th contents of the soil adjacent to the dwellings. Annual effective dose received by population in these areas is also reported.

## Introduction

The exposure of human populations to ionizing radiations is a major health hazard. The largest source of these ionizing radiations is the natural radioactivity present in human environment. The environmental radioactivity has become a major concern for mankind. The main components of natural radioactivity in human environment are the gaseous elements, radon($^{222}$Rn) and thoron ($^{220}$Rn). These gases along with their daughters contribute more than 50% of the total radiation dose received by humans from all natural sources (UNSCEAR, 1993). The exposure to radon/thoron and their daughters can give rise to many health hazards. Radon/thoron have been characterized as a causative agent of lung cancer (Sevc et. al., 1976; Edling et al., 1986; Pershagen et al., 1994). The presence of these radioactive gases in environment is attributed to the presence of their parent elements, i.e., uranium and thorium in earth's crust. Analysis of distribution of uranium, thorium and potsssium-40 in the soil is very important for investigating the contribution of these elements to environmental radioactivity. A study was carried out to investigate the distribution of these elements in the soil of some areas in

Punjab state and to study the correlation, if any, between the distribution of these elements in the soil and indoor activity of radon/thoron in those areas.

**Geology of the area**

The study area can be divided into three major parts on the basis of the geology.

The first part is south eastern belt comprising districts of Patiala, Moga, Mansa, Sangrur and Bathinda. The area forms a part of Indo-Gangetic alluvial plane and is more or less flat. All of the are is covered by Indo-Gangetic alluvium which consists of sandy clay, gravel, pebble and kankar. The lithology of the area is not uniform. The district is poor as regards mineral wealth. Kankar and Saltpetre are two of the minerals found. The second part consists of districts of Amritsar and Gurdaspur. The area has low lying rugged hills of outer Himalaya and a large span of Indo-Gangetic alluvial tract. The area is characterized by grey to light, grey micaceous, fine to medium grained sandstone interbedded with reddish brown clay. Foundry sand deposits are reported from a small area. The third part includes the district of Hoshiarpur. The rock formations in the area include river terraces, gravel beds, alluvial fans and calc-tufa beds of recent origin. Glass sand and calc-tufa are the only minerals found in the district.

**Experimental technique**

**Sample collection and preparation**

Soil samples were collected from the areas in which indoor radon/thoron survey was conducted (Virk & Sharma, 1999; 2000). To collect the soil sample, the surface at the site of collection was cleared of any vegetation by removing top layer of about 1 cm. Then the samples were collected from a depth of about 12-15 cm and stored in plastic bags. The samples were dried in the oven at 100º C for about 1 hr. and sieved through 150 µm mesh and stored in standard plastic containers for one month before counting.

**Measurement of natural radioactivity**

Gamma-spectrometry technique has been used in this study. This technique is based on the measurement of natural radiation using scintillation counter. It is reported that 98.5% of the radiological effects of the elements of $^{238}U$ series are produced by $^{226}Ra$ and its daughter products and the contributions of $^{238}U$ and its predecessors can be ignored (Londhe and Rao, 1988). Hence $^{226}Ra$ has been measured in soil samples instead of $^{238}U$.

Sodium iodide crystal activated with thallium [NaI(Tl)] has been used as a scintillator. The present work was carried out at Defence Research Laboratory (DRL), Jodhpur. The gamma spectrometry system used 5"× 4" NaI(Tl) flat detector. The system was already calibrated for $^{226}Ra$, $^{232}Th$ and $^{40}K$ using standard sources and procedures.

The gamma lines used for counting were 1.46 MeV for $^{40}K$, 1.76 MeV for $^{226}Ra(^{214}Bi)$ and 2.62 MeV for $^{232}Th(^{208}Tl)$. The samples were counted for 200 mins. The counts obtained in photo peak regions of three radio-nuclides $^{40}K$, $^{226}Ra(^{214}Bi)$ and $^{232}Th(^{208}Tl)$ were noted.

The net counts due to each radio element are converted to concentration levels in Bq/kg using the standard source parameter as per the following equation:

$$A = P/\eta w$$

Where A is the activity concentration (Bq/kg), P is the net photo peak counts per second, η is the photo peak efficiency of the detector and w is the weight of the sample (Kumar et al., 1990).

To compare the specific radio activities of samples from different areas, radium equivalent activity was also calculated using the formula

$Ra_{eq} = A_{Ra} + (A_{Th} \times 1.43) + (A_K \times 0.077)$; where $A_{Ra}$, $A_{Th}$ and $A_K$ are the activity concentrations of $^{226}Ra$, $^{232}Th$ and $^{40}K$, respectively, in Bq/kg.

The gamma radiation absorbed dose rate in air was calculated using the formula

$D = (A_{Ra} \times 0.461) + (A_{Th} \times 0.623) + (A_K \times 0.0414)$, where D is in nGy/h.

Annual effective dose equivalent was calculated using a conversion factor of 0.7 Sv/Gy.

**Results and discussion**

The results of measurement of natural radio-nuclides ($^{226}Ra$, $^{232}Th$ and $^{40}K$) in the soils of Punjab are summarised in the table 1. The concentration of $^{226}Ra$ in the state varies from a minimum value of 18.6 Bq/kg in Bathinda district to a maximum value of 68.9 Bq/kg in Amritsar district. The $^{232}Th$ concentration varies form a minimum value of 10.6 Bq/kg for Patiala district to a maximum of 94.2 Bq/kg for Amritsar district. In one of the samples from Moga district, the $^{232}Th$ activity was found to be below the lower detection limit of the system. The activity concentration of $^{40}K$ varies from 48.8 Bq/kg for Moga district to 160.1 Bq/kg for Amritsar district. Comparing these values with the data for other parts of the world, the activity concentrations of $^{226}Ra$ and $^{40}K$ are lower than the values reported while the activity concentration of $^{232}Th$ is comparable with the world wide data (Mollah et al., 1986; Stranden & Strand, 1988; Steinhausler & Lettner, 1992; Beiza et al., 1992).

The study of correlation between the concentrations of $^{226}Ra$ and $^{40}K$ and $^{232}Th$ and $^{40}K$ shows reasonably good correlations for both cases. The correlation coefficient between the concentration of $^{226}Ra$ and $^{40}K$ comes out to be 0.80 while that between the concentration of $^{232}Th$ and $^{40}K$ comes out to 0.84. However, for any conclusive evidence for correlations between these quantities, a large number of samples need to be studied. The study of correlation behaviour between the $^{226}Ra$ and $^{232}Th$ in soil and indoor radon and thoron concentrations, respectively, in the dwellings adjacent to the place from where the soil sample is collected does not show any good correlation between these quantities. The correlation coefficient for indoor radon and $^{226}Ra$ in soil comes out to be –0.23 while the correlation coefficient between the room-averaged thoron concentration and $^{232}Th$ in soil comes out to be 0.31. However, both these values of correlation coefficients are less than the significant value of 0.58 for the present data set, so these are neglected and it is assumed that there is no correlation between these quantities. The reason for this is that indoor radon/thoron concentrations also depend upon a number of factors other than the strength of source of these gases in soil, such as nature of soil, i.e. its porosity and permeability, ventilation rate in the dwelling, building materials used and the habits of inhabitants, besides the seasonal factors. So the effect of $^{226}Ra$ and $^{232}Th$ in soil is masked by other factors and hence no significant correlation is obtained.

Comparing the radium equivalent activities of different districts of Punjab, the value of radium equivalent activity was found to be highest for Amritsar district with two samples from this district reporting the values of 200 Bq/kg and 215.5 Bq/kg, while the lowest value of 38.4 Bq/kg was for one sample from Moga district in which concentration of $^{232}Th$ was found to be less than the lower detection limit of the system. The values of radium equivalent activity in all districts are less than the acceptable safe limit of 370 Bq/Kg (OECD, 1979). The values of absorbed dose rate vary from a minimum value of 18 nGy/h to a maximum value of 96.8 nGy/h with an average value of 56.4 nGy/h. The values of annual effective dose vary from 0.09 mSv to 0.48 mSv with an average value of 0.28 mSv. International Commission on Radiological Protection recommends an annual effective dose limit of 1 mSv for general public (ICRP, 1993). All the values of annual effective doses reported here are less than the safe limit of ICRP.

**Table 1. Natural radioactivity levels in the soils of Punjab State**

| S. No. | Location (District) | Concentration (Bq/kg) $^{226}Ra$ | $^{232}Th$ | $^{40}K$ | $Ra_{eq}$ activity (Bq/kg) | Absorbed dose rate nGy/h | Annual Effective Dose (mSv) |
|---|---|---|---|---|---|---|---|
| 1. | Patiala | 34.7 | 10.6 | 59.6 | 54.4 | 25.1 | 0.12 |
| 2. | Bathinda | 18.6 | 36.3 | 68.0 | 75.7 | 34.0 | 0.17 |
| 3. | Bathinda | 23.4 | 41.7 | 81.4 | 89.3 | 40.1 | 0.20 |
| 4. | Sangrur | 46.8 | 79.5 | 133.0 | 170.7 | 76.6 | 0.38 |
| 5. | Sangrur | 28.8 | 30.1 | 79.1 | 77.9 | 35.3 | 0.17 |
| 6. | Moga | 34.6 | BDL* | 48.8 | 38.4 | 18.0 | 0.09 |
| 7. | Moga | 45.9 | 11.6 | 95.1 | 69.8 | 32.3 | 0.16 |
| 8. | Hoshiarpur | 49.1 | 68.1 | 86.7 | 153.2 | 68.7 | 0.34 |
| 9. | Amritsar | 68.9 | 94.2 | 154.1 | 215.5 | 96.8 | 0.48 |
| 10. | Amritsar | 68.7 | 83.2 | 160.1 | 200.0 | 90.1 | 0.44 |
| 11. | Gurdaspur | 59.0 | 73.9 | 104.6 | 172.7 | 77.6 | 0.38 |
| 12. | Gurdaspur | 48.5 | 86.0 | 150.0 | 183.0 | 82.2 | 0.40 |
|  | Average | 43.9 | 55.9 | 101.7 | 125.1 | 56.4 | 0.28 |

- BDL – Below detection Limit

**Figure 1. Correlation between $^{226}$Ra and $^{40}$K concentrations in soil**

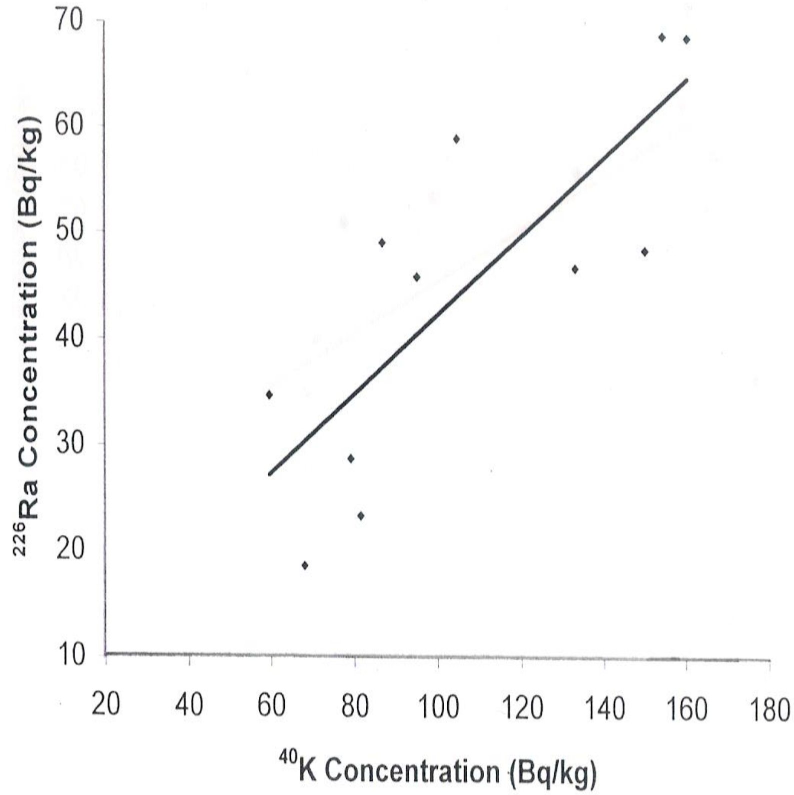


**Figure 2. Correlation between $^{232}$Th and $^{40}$K concentrations in soil**

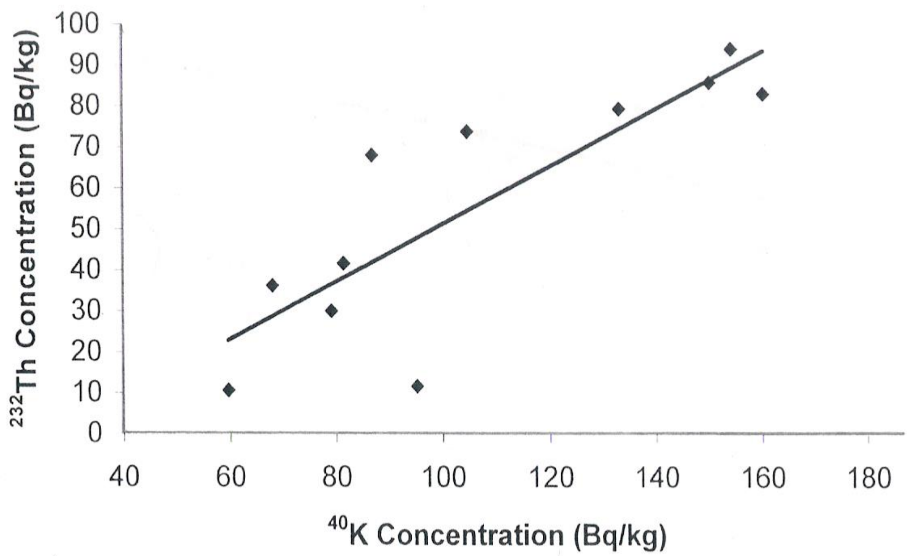


**Figure 3. Correlation between indoor radon concentration and $^{226}$Ra in soil**

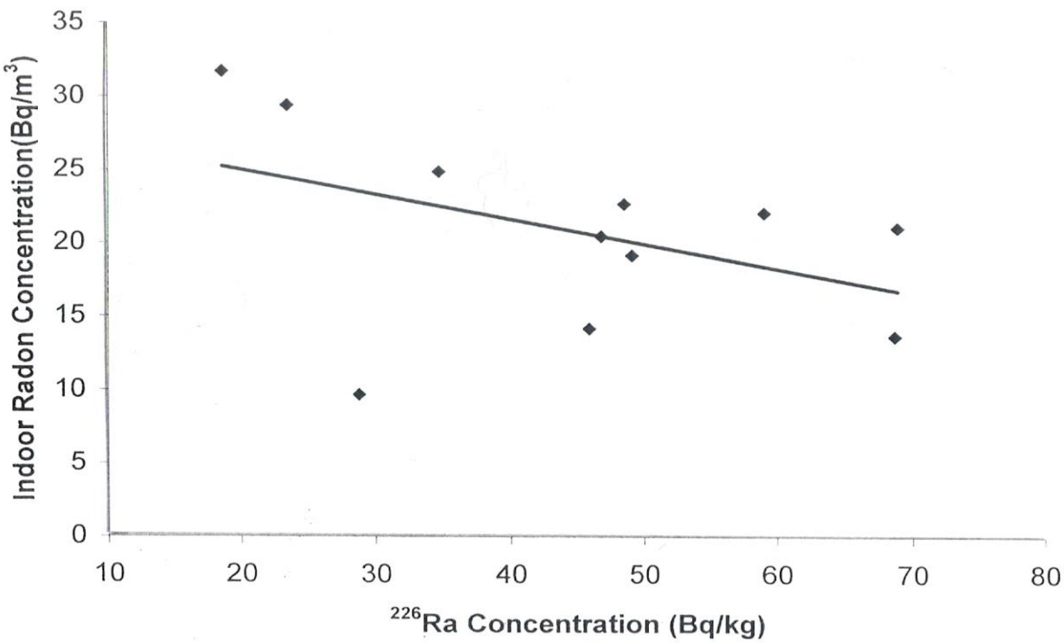
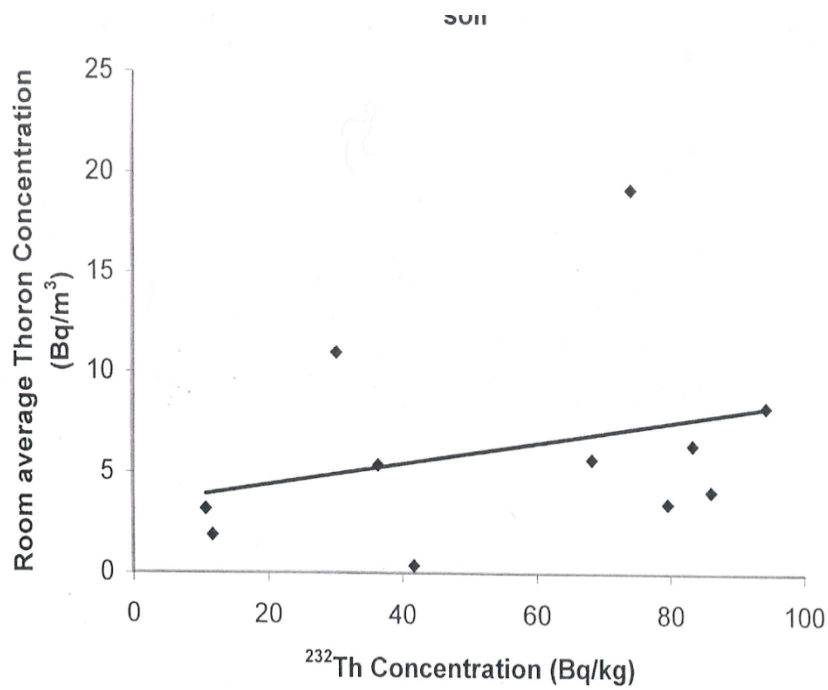


**Figure 4. Correlation between room averaged thoron concentration and $^{232}Th$ in soil**



## References

Beiza, A., Rio del M., Miro, C. and Paniagua, J.M., 1992. Natural radioactivity in soils of the province of Caceres (Spain). Radiat. Prot. Dosim., 45(1-4), 261-263.

Edling, C. and Axelson, O., 1984. A possible cause of lung cancer. Scand. J. Work Environ. Health, 10, 25-34.

ICRP (International Commission on Radiological Protection), 1993. ICRP Publication 65, Annals of the ICRP 23(2), Pergamon Press, Oxford.

Kumar, S., Gopalani, D., Bhatti, S.S., Ramaseshu, P. and Nagaratnam, A., 1990. Measurement of background radioactivity in Western Rajasthan. Ind. J. Phys., 64(A) (3), 225.

Londhe, V.S. and Rao, S.R., 1988. Study of distribution of some natural radionuclides on processing of rock phosphates. Bull. Radiat. Prot., 11(3-4), 181-186.

Mollah, A.S., Ahmed, G.U., Husain, S.R. and Rahman, M.M., 1986. The natural radioactivity of some building materials used in Bangladesh. Health Phys., 50(6), 849-851.

OECD (Organization for Economic Cooperation and Development), 1979. Exposure to radiation from the natural radioactivity in building materials. Report by a Group of Experts of the OECD Nuclear Energy Agency, OECD, Paris, France.

Sevc, J., Kuns, E. and Placek, V., 1976. Lung cancer in uranium miners and long term exposure to radon. Health Phys., 54, 27-46.

Steinhausler, F. and Lettner, H., 1992. Radiometric survey in Namibia. Radiat. Prot. Dosim., 45(1-4), 553-555.

Stranden, E. and Strand, T., 1988. Radon in an alum shale rich Norwegian area. Radiat. Prot. Dosim., 24(1-4), 367-370.

UNSCEAR, 1993. Exposure from natural sources of radiation. Annex. A. U. N. Sci. Comm. on the Eff. of A. Rad. A/AC.82/R 652.

Virk, H. S. and Sharma, Navjeet, 1999. Indoor levels of radon/thoron in some dwellings of Punjab and Himachal Pradesh, India. IRPA regional congress on Radiation Protection in Central Europe, Budapest, 23-27 August, (CD ROM).

Virk, H. S. and Sharma, Navjeet, 2000. Indoor radon levels and inhalation doses to population in Punjab. Curr. Sci. 78(12), 1418-1420.