Current Trends in Technology and Science
ISSN: 2279-0535. Volume: VI, Issue: V

Studies on the distribution of 210Po and ^{210}Pb in surface soil samples in and around Thirthahalli Taluk, Karnataka, India

Shilpa G. M
Designation:Research. Scholar, Organization:Research & Development Centre, Bharathiar University, Coimbatore, Tamil Nadu, EmailID:gmshilpa.82@gmail.com
B. N Anandaram
Designation: Professor, Organization, Dept. of Physics, J.N.N. College of Engineering, Shivamogga, Karnataka, India, Email ID: bnaram@jnnce.ac.in
Mohankumari T. L
Designation: Associate Professor, Organization, Dept. of Physics, Sir M.V. Science College, Bhadravathi, Karnataka, India, Email ID: mohankumari.tl@gmail.com

Abstract—*a systematic study on the concentration of ^{210}Po and ^{210}Pb in soil samples in and around Thirthahalli taluk has been carried out in 25 various locations. Standard sample collection procedure and radio chemical method has been employed in this study. The ^{210}Po concentration was ranging from 4.8 ± 1.5 Bq/Kg to 41 ± 3.3 Bq/Kg and that of ^{210}Pb lies between 5.9 ± 0.8 Bq/Kg to 71 ± 5.3 Bq/Kg. The ^{210}Po to ^{210}Pb ratio in this study is less than 1 indicating the presence of only supported ^{210}Po in this region. All these results are presented in this paper.*

Keyword—^{210}Po, ^{210}Pb, radiochemical separation ZnS (Ag) alpha counting system, Soil, and Thirthahalli taluk.

1. Introduction

Man is continuously exposed to natural background radiation, contributed by cosmic rays and terrestrial environmental radioactivity. The worldwide average natural dose to humans is estimated as 2.4mSv [15]. The occurrence of ^{210}Po and ^{210}Pb in soil is mainly due to the successive disintegration of ^{238}U. ^{210}Po has a half-life of 138.4 days and is an alpha emitter. The main source of ^{210}Po in the environment is ^{222}Rn, which emanates from earth's crust and ultimately decays to the nuclides ^{210}Pb and ^{210}Bi. This radionuclide's attach themselves to aerosol particles and return to the earth by atmospheric precipitation [2], [5], [11], and [16]. Hence the ^{210}Po and ^{210}Pb are widely present in the environmental matrices and contributing about 8% of the natural radiation exposure to human [15]. The ^{210}Po has attracted considerable attention due to its unique transportation behavior and high radio toxicity, which effect soft tissue, organs and human body and ^{210}Pb also has radiological significance since the metabolic properties of this nuclide controls the amount of daughters ^{210}Bi and ^{210}Po in man. Due to the alpha activity of ^{210}Po, it produces greater biological effect than ^{210}Pb, the beta emitter. The equivalent dose resulting from a single disintegration of ^{210}Po is 1000 times greater than the decay of ^{210}Pb. Hence it is grouped under highly toxic radioisotopes. The total amount of ^{210}Po in the earth's crust is approximately 2.3X 10^{-14}% of the total weight. From the geophysical point of view, polonium is very important because of the substantial decay energy involved and the corresponding contribution to the heat balance of the earth's crust [13].

In view of this, a systematic study has been carried out to know the activity of ^{210}Po and ^{210}Pb in soil through which the radionuclides enter the food chain [16] in the Thirthahalli region which is first of its kind in this part of the country.

Study Area

Thirthahalli is the taluk headquarters of Shimoga district, Karnataka state, located in the southern part of India. It lies between 13°14' N latitude and 75°14'E longitude with an average elevation of 602m above mean sea level. It is characterized by the Malnad region having thick forest and rich vegetation and has an average rain fall of about 3397mm [1]. The geological features indicate Migmatites and gneisses as the major deposition in this study area, where Quartz and chlorite schist forms the second major deposit found in east and north eastern part, and Metabasalt formation in south western part of this area in figure 1.

2. Materials and Methods

Sample collection and Preparation

The surface soil samples were collected from undisturbed locations situated in and around Thirthahalli taluk. At each location, about 5-7 spots were chosen for grab sampling by marking a square of 15cm ×15cm, and from all these spots, the surface soil was collected at a depth of 0-5cm. The soil was thoroughly mixed, stones and gravels are removed. About 3kg of the resulting composite soil samples was stored in a polyethylene bag and brought to laboratory. The samples were allowed to dry overnight in an oven

at a temperature of 90°C, and then cooled; the dried sample was then sieved through 100 µm sieve [2], [6], [8]. ^{210}Po is volatile in nature. Hence processing of the samples at high temperature will lead to loss of Polonium. So, wet ashing of soil sample was carried at a temperature of 90°C for the radiochemical separation of ^{210}Po. About 20g of dried soil was taken in a 500ml beaker to which 100ml of 8N nitric acid was added and kept for digestion on a hot plate. This results in leaching of ^{210}Po present in the sample into the solution. The sample solution was evaporated to near dryness. After about 4 to 5 repeated digestions, the sample was treated with about 50ml of 1:1 mixture of nitric acid and hydrogen peroxide and evaporated to near dryness repeatedly for 5 to 6 times in order to remove the organic matter present in it. The resulting residue is then treated with 100ml of 8N HCl and then evaporated to near dryness. This process is repeated 4 to 5 times to convert the sample completely into HCl medium. Finally, the residue is treated with 200 ml of 0.5N HCl. This solution is taken for spontaneous deposition of ^{210}Po on a silver planchet using a magnetic stirrer; the stirring speed was maintained between 200 to 300 rpm. About 80 mg of ascorbic acid was added to reduce ferric ions into ferrous ions to avoid possible interference during ^{210}Po deposition. Temperature of the solution was maintained to near 80°C. A bright polished background counted silver disc was suspended inside this solution to enable deposition of ^{210}Po on the disc. The system is kept for 5 to 6 hours so that all the ^{210}Po in the sample solution gets transferred to the disc. After the deposition, the disc was washed with distilled water, dried and alpha counted using a ZnS (Ag) alpha counting system [2], [6], [8]. The specific activity of ^{210}Po in the soil was estimated using the relation

$$A = (s \pm SD)\frac{100 \times 100 \times 1000}{\varepsilon \times E_p \times W} Bq/Kg$$

s is net counts per sec

ε is efficiency of the alpha counter (%)

$E_p$is plating efficiency (%)

W is Mass of the sample taken for analysis

SD is standard deviation,

$SD = (C_s/T_s^2 + C_b/T_b^2)^{1/2}$

C_s and C_b are the sample counts and background counts respectively

T_s and T_b are the counting time for sample and background respectively.

The plating efficiency of the ^{210}Po was determined through ^{210}Po standard solution and was found to be 95%.

The specific activity of ^{210}Pb in soil sample was estimated through back calculation method. In this method the sample solution after extracting ^{210}Po, was kept for a period of 6 to 8 months to allow the growth of ^{210}Po from ^{210}Pb [7]. The sample solution was then subjected to spontaneous deposition to know the ^{210}Po activity, from which the ^{210}Pb was estimated by using the buildup factor for ^{210}Po from ^{210}Pb during the sample storage period. This is one of the easiest methods but requires the complete removal of ^{210}Po from the sample solution during first plating. This was ensured by replanting ^{210}Po on silver planchet, soon after the first plating. The counts thus obtained were insignificant which confirms the complete removal of ^{210}Po from the sample during the first plating itself.

3. Results and Discussion

The specific activity of ^{210}Po and ^{210}Pb in surface soil samples collected from 25 different locations in and around Thirthahalli taluk is presented in table 1.

Table 1. Activity of Po^{210} and Pb^{210} in Soil samples

Regional geology	Location	Specific Activity of Po^{210} and Pb^{210} in soil sample in Bq/kg		Po^{210}/Pb^{210}
		Po^{210}	Pb^{210}	
Granite	Kanagalkoppa	20.2±3.9	29.9±1.8	0.67
	Beguvalli	21.98±3.9	31.8±1.8	0.69
	Garaga	22.5±4.5	33±1.90	0.68
	Siddashwara hill	25.2±4.2	37.2±2	0.67
	Kuruvalli	23.3±3.7	31.4±1.7	0.76
	Thirthahalli hill	23.9±4.5	37.1±2.02	0.64
	Keegadi	41.±3.3	71±5.3	0.57
	Kelanarsi	15.7±2.4	20.3±3.45	0.77
Acid volcanics	Halaga	11.9±3.3	18.3±1.3	0.65
	Singanabidri	20.1±4.2	35.3±1.2	0.56
	Hegalathi	5.04±2.8	10.2±0.93	0.49
Migmatites	Kesthur	8.20±3.6	15.3±1.2	0.53
	Kavaledurga	7.9±2.6	15.8±1.3	0.49
	Thyrandur	5.04±2.3	10.3±1	0.49
	Kimmane	18.2±4.2	22.2±1.5	0.82
	Malalur	8.20±2.7	10.2±1.3	0.80
	Salur	6.31±2.8	9.4±0.9	0.67
	Nonbur	4.9±2.1	6±1.8	0.82
Metabasalt	Hosur	6.9±2.9	11±1	0.63
	Agumbe	8.20±3.1	15.4±1.4	0.53
	Bellihalli	5.6±2.3	9.5±0.9	0.59
Quartz and chlorite schist	Attigudde	11.2 ± 3.3	16.5±1.2	0.68
	Thudur	7.6±2.6	16.8±1.2	0.45
	Alase	14.5±3.6	22.1±1.5	0.65
	Kannagi	4.8±1.5	5.9±0.8	0.82

The activity of ^{210}Po lies between 4.8±1.5Bq/Kg to 41±3.3Bq/Kg and that of ^{210}Pb ranged from 5.9±0.8 Bq/Kg to 71± 5.3Bq/Kg. The wide range of variation in the activity of ^{210}Po and ^{210}Pb may be attributed to various factors like regional geology, atmospheric precipitation, soil porosity, grain size distribution etc. Similar to the reported values elsewhere with respect to other environs, the ^{210}Po to ^{210}Pb ratio varies from 0.45 to 0.82. The observed variation in the ratio with

respect to different locations may be attributed to the factors like atmospheric precipitation, soil particle size distribution etc. This ratio of less than unity indicates that, there is no direct precipitation of ^{210}Po to the earth surface and ^{210}Pb is the source for ^{210}Po in this environment. The graph of specific activity of ^{210}Po in soil and that of ^{210}Pb in soil shows good correlation of 0.964 in the present study.

Parameters	Specific activity of ^{210}Po in soil samples in Bq/Kg	Specific activity of ^{210}Pb in soil samples in Bq/Kg
Range	4.8-41	5.9-71
GM	11.5	18
GSD	1.8	1.8

Table 2. Comparison of^{210}Po activity measurements in soil with other environs

Activity of ^{210}Po (Bq/kg)		Region	References
Present study	Literature values		
4.8-41	4.7-43.9	Shimoga	[3]
	4.2-12.9	South India(Cauvery)	[4]
	0.49-13.95	Virajpet taluk	[11]
	7.6-37.3	Mysore	[13]
	8.14-219	Kalpakkam	[7]

Table 3. Comparison of ^{210}Pb activity in soil with other environs

Activity of ^{210}Pb(Bq/kg)		Region	References
Present study	Literature Values		
5.9-71	7.8-60.4	Shimoga	[3]
	2.6-12.8	South India (Cauvery)	[4]
	7.2-38.6	Mysore	[13]
	53.7-125.8	Top soil of Japan	[9]
	22.2-122.1	Black forest of Germany	[14]

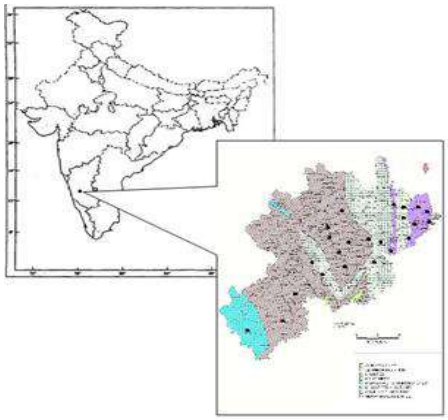

Fig.1 Geological map of Thirthahalli taluk showing the location of soil sampling.

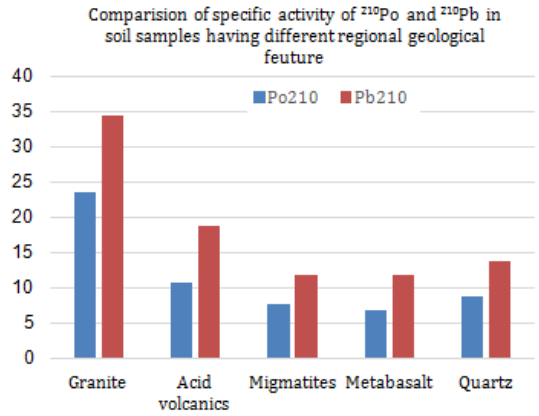

Fig.2 A plot of specific activity of ^{210}Po and ^{210}Pb in soil samples with respect to regional geology.

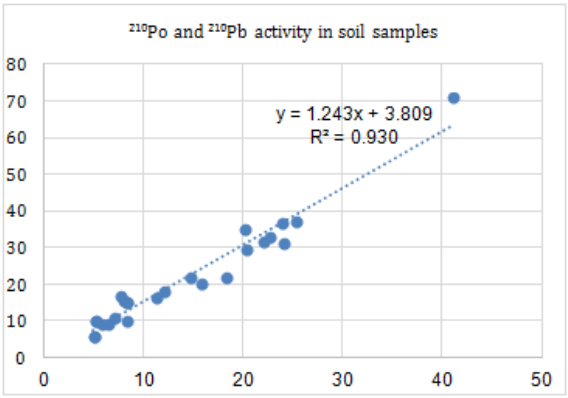

Fig.3 Correlation between^{210}Po and ^{210}Pb activity in soil samples.

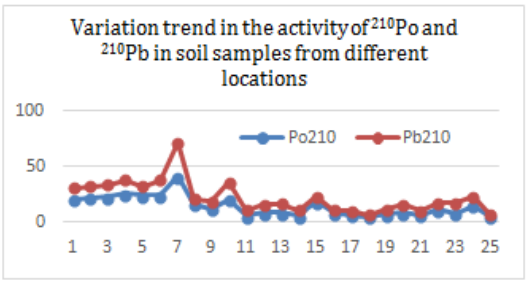

Fig.4 Variation trend in the activity of ^{210}Po and ^{210}Pb in soil samples from different locations.

4. Conclusion

The measured activity of ^{210}Po and ^{210}Pb in surface soil samples of Thirthahalli Taluk are comparable to those reported for other normal background environs. The locations having regional geology as granites showed relatively higher concentration. However, no exact correlation can be predicted with respect to ^{210}Po or ^{210}Pb concentrations in soil to the geology of the sampling location, since the samples taken for analysis were the surface soils. The ^{210}Po/^{210}Pb ratio is less than 1 indicating that ^{210}Pb is the source for ^{210}Po and no unsupported ^{210}Po is reported in the present study.

ACKNOWLEDGMENT

The authors wish to thank Vision Group on Science and Technology for the procurement of instruments, through which this research work is possible. Thanks are also due to the Principal, J N N College of Engineering, Shivamogga for the continuous support and encouragement throughout this work.

REFERENCE

[1]. "Shimoga district at a glance 2012-2013" A statistical view of Shimoga district, published by Shimoga.

[2]. B.N Anandaram "Study of environmental radioactivity in and around Shimoga". Ph.D. thesis. Mysore University, (1998).

[3]. B.N. Anandaram, S. Manjunatha, M.A.R. Iyengar, M. Raghvayya and P. Venkataramaiah "Studies on the distribution of ^{210}Po around Shimoga, India". Proceedings of 8th national symposium on environment, PP.167-168, (1999).

[4]. C.S. Kaliprasad and Y. Narayana "Speciation and behavior of ^{210}Po and ^{210}Pb in the riverine ecosystem of Cauvery, a major river of south India". Volume 58, Issue 4, PP.431-437, (2016).

[5]. D.N. Avadhani, H.M Mahesh, N. Karunakara, H.M. Somashekarappa, Y. Narayana and K. Siddappa "Distribution of ^{210}Po and ^{210}Pb in soil samples of Goa, South west coast of India" Journal of radiation protection environment, Volume 24, Issue 1 and 2, PP. 401-405, (2001).

[6]. EML Procedure manual, Edited by Herbert L, Volchok and Gail de planque, 26thedition, environmental laboratory, (1983).

[7]. Iyengar M.A.R., Rajan M.P., Ganapathy S and Kamath P.R. "Sources of natural radiation exposure in a low monazite environment". Natural radiation environment-III, proceedings of International symposium on natural radiation environment, Houston, PP.1090-1106, (1980).

[8]. Karunakara N, Hegde A.G, P.C Verma and Sunil Kumar S. "Measurement of radionuclide concentration in environmental samples" Lab manual published by Mangalore university, (2013).

[9]. Kiyoshi Kodaira, Mituko Kato, Misako Komamura, Atsuko Kawanuram Akio Yamamoto, Ryoichi Ebisawa, Masanobu Sakanoue and Kazuhisa Komura "Distribution of Lead-210 in Japanese soils and its relation to the distributions of Strontium-90, Cesium-137 and stable Lead", In: Natural radiation environment –III, Proceedings of the International symposium on natural radiation environment, Houston, PP.61-629, (1980).

[10]. M. Eisenbud "Environmental Radioactivity from natural, industrial and Military Sources, 3rd edition., Academic press Inc., California, (1987).

[11]. M.M. Prakash, C.S. Kaliprasad and Y. Narayana "Distribution of ^{210}Po in soils of Virajpet taluk, Coorg District, Karnataka". Journals of radiation research and applied sciences, Volume 10 Issue 1 PP.57-62, (2017).

[12]. Nagaiah "Studies on environmental radiations around Mysore", Ph.D. Thesis, Mysore University, (1996).

[13]. Parfenov. Yu. D "polonium-210 in the environment and in the human organism", Atomic energy review, Volume 12, PP.75-143, (1974).

[14]. Schuettelkopf H, Kiefer H "The Ra-226, Pb-210 and Po-210 contamination of the black forest", In: Natural radiation environment Proceedings of 2ndSpec. Symposium, Bombay (Edited by Vohra K G, Mishra U.C, Pillai K C and Sadashivan S, Wiley Eastern Ltd., New Delhi, India, PP.1994-1999, (1982).

[15]. UNSCEAR "United Nations Scientific Committee on the Effects of Atomic Radiation" Sources, effects and risk of ionizing radiation. Report to the General Assembly. New York, USA. (2000).

[16]. Vaaramaa K, Lasie A, Dina S and Jukka L "Distribution of Pb210 and Po210 in Boreal forest soil" In: Science of the Total Environment, 408(24), PP.6165-6171, (2010).

AUTHOR'S PROFILE

Mrs Shilpa G M, obtained her master degree M. Sc. in Physics from Kuvempu University in 2005 and completed her M. Phil in 2008 at Alagappa University. She has experiences of 8 years of teaching and currently working as an Assistant Professor of Physics at Government First Grade College Shikaripura, Shivamogga district. She is a research scholar at Barathiyar University, Coimbatore, Tamil Nadu under the guidance of Dr.B.N.Anandaram,Professor & Head, Department of Physics JNN College of Shivamogga.

Dr B N Anandaram, Obtained his Ph. D degree in 1999 in Physics from Mysore University. He has over 24 years of teaching experience and 8 years of research experience. Currently he is holding the position of Professor and HOD of Physics in J N N College of Engineering, Shivamogga. He has published 19 research papers in various National and International journals and symposium proceedings. Environmental Radioactivity research laboratory has been set in J.N,N. College of Engineering under his leadership. Currently he is guiding for 3 research students in the field of Environmental Radioactivity and Radiation Physics. His area of interest includes Radiation Physics, Electronics and Solar energy and has keen interest in developing the

Science models. He has been recognized as resource person in Physics for more than 20 training programs both for high school and P U College teachers. He has served as member of BOE Kuvempu University, Visvesvaraya Technological University and Bangalore University.

Mrs Mohan Kumari T L received her master (M.Sc.,) degree in Physics from University of Bangalore in l984. She has an experience of 26 years of teaching and currently working as Associate Professor of physics in Sir M V Government Science College, Bhadravathi, Shimoge (dist). .Her area of research interest is radiation physics

.