Estimation of Activity Concentration of Uranium and Thorium Using Gross Alpha and Gross Beta in Agricultural Soils in Kanyakumari District

S.Sindhu*, M.Sheela Udhaya Roselin, G.Shanthi.

Department of Physics and Research Centre, Women's Christian College, Nagercoil, Tamil Nadu, India, 629001.

Abstract

Natural radioactivity originates from extraterrestrial sources. Radioactivity concentration is one of the main determinants of the natural background radiation. In this study the radioactivity concentrations of different agricultural soil samples were determined the gross alpha and gross beta activity concentrations were measured by using an alpha counter and low beta counter. The gross alpha and beta activity were ranged from 585.73Bq/kg to BDL and 2570.703Bq/kg to142.82Bq/kg .The gross alpha activity maximum at Arasamoodu Spinach soil (585.73Bq/kg) while it s minimum at Thotiyodu spinach soil (BDL) and The gross beta activity maximum at Arasamoodu Spinach agricultural farms (2570.703Bq/kg) while it s minimum at Arasamoodu Coconut agricultural farms (142.82Bq/kg). The Thorium and Uranium concentration were also calculated by using gross alpha and gross beta activities.

Key words: *gross alpha, gross beta, agricultural soils*

I. Introduction

Terrestrial radiation varies from place to place depending upon the variation of radionuclide concentration originates in soil. The largest proportion of human exposure to radiation comes from natural sources of external radiation including cosmic and terrestrial radiation and from inhalation or ingestion of natural radioactive nuclides. Existing in terrestrial materials, such as ^{40}K, ^{238}U, ^{232}Th radio nuclides are of great interest. Soil radionuclide activity concentration is one of the main determinants of the natural background radiation [1].When rocks are disintegrated through natural process ,radio nuclides are carried to soil by rain and flows,[2]. The high radiation levels are due to the presence of large quantities of naturally occurring radioactive minerals in the rocks, soils, water, etc., to some extent due to the cosmic ray latitude effect, and residual radioactivity from fallout of nuclear bomb explosions including nuclear reactor leaks. Significant natural radionuclide in soil which is directly relevant to the outdoor exposure is largely determined by the activity concentration in the source rock [3].The natural radioactivity of soil sample is usually determined from ^{226}Ra, ^{232}Th and ^{40}K .The concentrations of natural radioactivity is usually important for the purpose of establishing baseline data for future radiation impact assessment, radiation protection and exploration [4]. Natural background radiation comes from three primary sources: cosmic radiation , terrestrial sources ,and radon. The worldwide average background dose for a human being is about 2.4 mGy/Year. This exposure is mostly from cosmic radiation and natural isotopes in the Earth. The terrestrial radiation varies from place to place , which depends on geological environment, type of living accommodation and elevation above the sea level . Naturally occurring radioactive materials (NORM) are always having been part of our world since its exits. The main radioactive materials in NORM are long lived radio nuclides

such as ^{238}U, ^{235}U, ^{232}Th, and ^{40}K [5]. The main sources of phosphorus for fertilizers and the primary material for the production of phosphate products are products are phosphate rocks. Fertilizers are generally used in improving the properties of crops and in improving the properties of crops and in reclaiming land. Phosphate fertilizers contain elevated natural uranium and its decay products [6]. The concentrations of natural radioactivity is usually important for the purpose of establishing baseline data for future radiation impact assessment, radiation protection and exploration[7].Agricultural soils are of special concern because they expose a direct threat to human and environmental health .Monitoring of radioactivity in the environment is important for human and environmental protection and provides a baseline of environmental radioactivity levels.[8].(Potassium-40, uranium-238, and thorium-232 and their decay products are important natural elements that contribute to a large part of the radiation dose received by humans; thus far, approximately 60 abundantly distributed radionuclides have been identified. Radionuclides are encountered in terrestrial strata (soil or rocks) or lakes and water bodies (ocean, sea, or lakes) and can be easily accumulated into the food chain). Measurement of natural radioactivity in rocks and soils is very important to determine and monitor the amount of change of the natural background activity with time for environmental protection [9].

The objective of the present study is to measure the gross alpha and gross beta activity using the alpha scintillation counter and low beta counter respectively also. And to estimate the activity concentration of Thorium and Uranium from gross alpha and beta activity.

II. Study area:

The area for the investigation under this project work is the agricultural soils. All these areas come under Kanyakumari District.

III. Experimental Techniques

Zinc Sulphide Scintillation Detector

An alpha counting system comprises of an alpha probe and counting electronics system includes high voltage supply to probe, a preamplifier, an amplifier, timer and scalar. The counter model SP 647A was used for the measurement. The PMT and crystal are placed n a light tight steel housing. So as to have very low background and have an efficiency of about 31.07%. The standard source Am-241 was used for detector calibrations.

Low Beta Counter

The Counters consists of two or three G.M counters. The counters have a silver or gold foil window through which the beta particles travels and reach the gas chamber with isopropyl alcohol vapors and ionize the medium. The counter model BCS36A was used for this study. The standard source ^{40}K was used and the corresponding efficiency of the counter was about 38.16%.

About 60mg of the soil sample from each site was crushed into fine powder using agate motor and spread as a fine layer Aluminum planchet and its gross alpha activity was measured using alpha scintillation counter with ZnS (Ag) detector. Gross beta activity was measured using low beta counting system of 2.5cpm background (ECIL model/K2700B).

The soil samples were dried and then remove all attached sand and dust particles. About 60mg of the soil sample from each site was crushed into fine powder using agate motor and spread as a fine layer Aluminum planchet and its gross

alpha gross beta activity were measured using alpha and low beta counter respectively.

3.2. Estimation of Thorium and Uranium from gross alpha and gross beta activity

In monazite the concentration of Thorium (9%) and Uranium is (0.30%). The specific activity of Uranium is 3 times higher than that of the Thorium, the activity wise ratio of Th: U in monazite can be taken as 10:1. Further, disintegration of one atom of Thorium results in the emission of 6αs an 4βs and disintegration of one U atom results in the emission of 8αa and 6βs. the total number of disintegration from U nuclides also can be obtained by dividing the corresponding number of α ray by 8.[10]

4. Results and discussions

TABLE I: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS ALPHA ACTIVITY IN COCONUT TREE SOIL SAMPLE

Location	Gross Alpha Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Arasamoodu	212.99	32.27	2.42
Madichel	266.24	40..34	3.03
Paraicodu	319.49	48.41	3.63
Veeyanoor	212.99	32.27	2.42

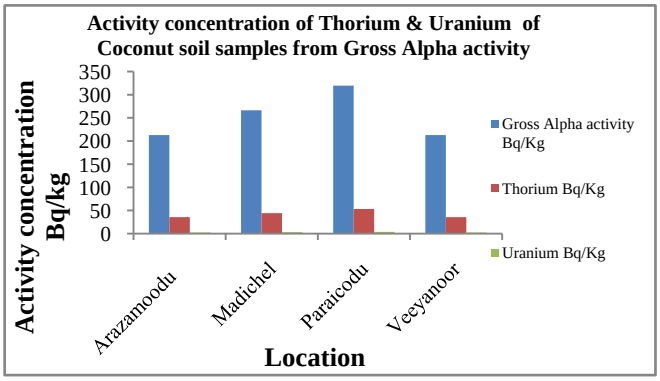

Fig.1

The gross alpha activity of the soil sample collected from near Coconut tree in Kanyakumari district is shown in Table 1. It shows that the gross alpha activity maximum in Paraicodu surface soil sample 319.49 Bq/kg and the minimum value of gross alpha activity is Arasamoodu, Veeyanoor, surface soil samples 212.99 Bq/kg.

TABLE II: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS ALPHA ACTIVITY IN BANANA TREE SOIL SAMPLES

Location	Gross Alpha Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Arasamoodu	212.99	32.27	2.42
Kumarakoil	53.25	8.06	0.605
Paraicodu	212.99	32.27	2.42
Veeyanoor	372.74	56.48	4.24

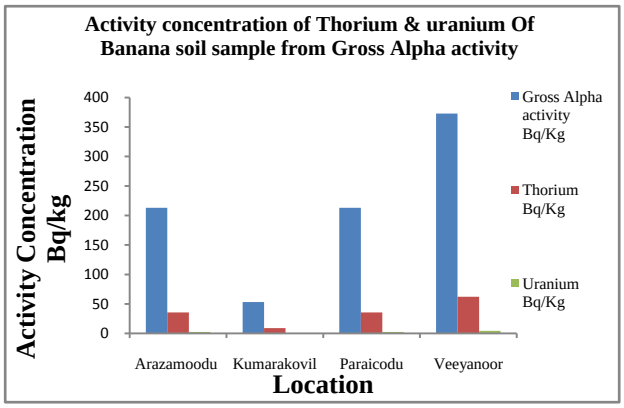

Fig.2

The gross alpha activity of the soil sample collected from near Banana tree in Kanyakumari district is shown in Table 2. It shows that the gross alpha activity maximum in Veeyanoor soil sample 372.73 Bq/kg and the minimum value of gross alpha activity is Kumarakoil, soil sample 53.25 Bq/kg.

TABLE III: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS ALPHA ACTIVITY IN SPINACH SOIL SAMPLES

Location	Gross Alpha Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	585.73	88.75	6.66
Arasamoodu	585.73	88.75	6.66
Veeyanoor	106.69	16.16	1.21
Thotiyodu	BDL	BDL	BDL

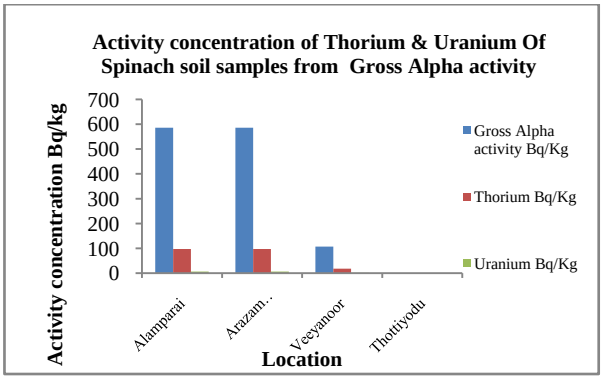

Fig.3

The gross alpha activity of the soil sample collected from spinach in Kanyakumari district is shown in Table 3. It shows that the gross alpha activity maximum in Alamparai, Arasamoodu soil samples 585.72 Bq/kg and the minimum value of gross alpha activity is Thotiyodu soil samples BDL.

Table IV: Activity concentration of Thorium and Uranium from Gross Alpha Activity in Tapioca (Tuber) soil sample

Location	Gross Alpha Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	212.99	32.27	2.42
Melapallam	266.24	40.39	3.03
Thotiyodu	266.24	40.39	3.03
Veeyanoor	266.24	40.39	3.03

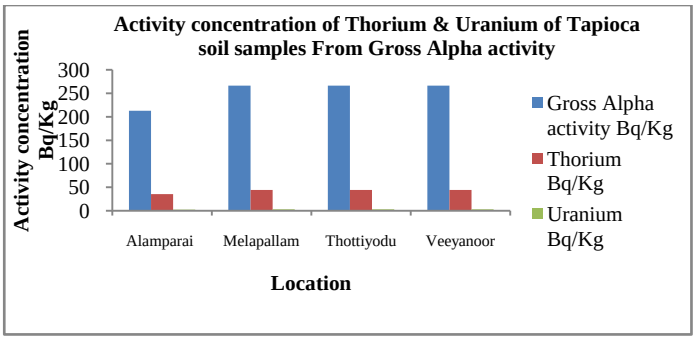

Fig.4

The gross alpha activity of the soil sample collected from near Tapioca soil in Kanyakumari district is shown in Table 4. It shows that the gross alpha activity is maximum in Melapallam, Thotiyodu, Veeyanoor, soil sample 266.24 Bq/kg and the minimum value of gross alpha activity is Alamparai soil sample 212.99 Bq/kg.

TABLE V: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS ALPHA ACTIVITY INDRUMSTICK TREE SOIL SAMPLES

Location	Gross Alpha Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	212.99	32.27	2.42
Kalluvilai	BDL	BDL	BDL
Thiruthuvapuram	159.74	26.62	1.81
Madichel	159.74	26.62	1.81

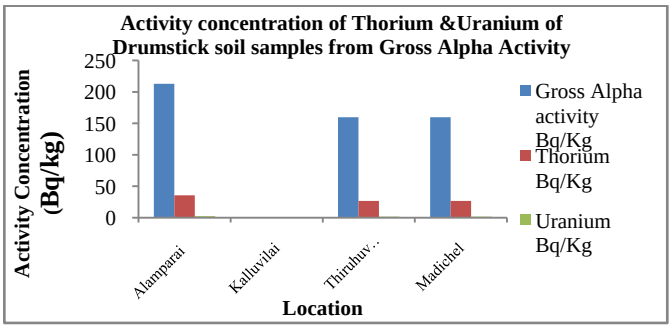

Fig.5

The gross alpha activity of the soil sample collected from near Drumstick plant in Kanyakumari district is shown in Table 5. It shows that the gross alpha activity maximum in Alamparai, soil sample 212.99 Bq/kg and the minimum value of gross alpha activity is Kalluvilai soil sample BDL.

TABLE VI: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS ALPHA ACTIVITY IN PAPAYA TREE SOIL SAMPLES

Location	Gross Alpha Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	266.24	40.34	3.03
Thiruthuvapuram	266.24	40.34	3.03
Madichel	266.24	40.34	3.03
Arasamoodu	479.23	72.61	5.45

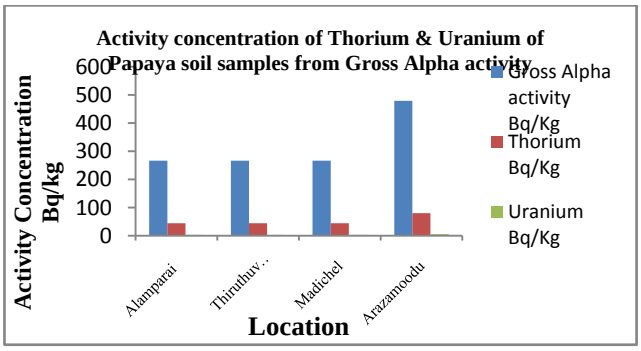

Fig.6

The gross alpha activity of the soil sample collected from near Papaya tree in Kanyakumari district is shown in Table 6. It shows that the gross alpha activity maximum in Arasamoodu soil sample 479.23 Bq/kg and the minimum value of gross alpha activity is Alamparai, Thiruthuvapuram, Madichel soil samples 266.24 Bq/kg.

TABLE VII: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS BETA ACTIVITY IN COCONUT TREE SOIL SAMPLES

Location	Gross Beta Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Arasamoodu	142.82	32.45	2.16
Madichel	2035.14	462.53	30.84
Paraicodu	1856.62	421.96	28.13
Veeyanoor	749.79	170.41	11.36

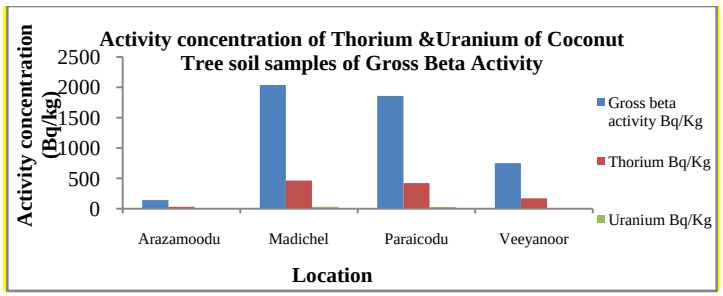

Fig .7

The gross beta activity of the soil sample collected from near Coconut tree in Kanyakumari district is shown in Table 7. It can be seen that the gross beta activity is maximum in Madichel soil with the value of 2035.14 Bq/kg and the gross beta activity is minimum 142.82 Bq/kg has been recorded in Arasamoodu soil. By comparing table1&7 the beta activity of the soil collected from the surface is higher than the alpha activity. The content of Uranium is very lower than that of the Thorium.

TABLE VIII: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS BETA ACTIVITY IN BANANA TREE SOIL

Location	Gross Beta Activity Bq/Kg	Thorium Bq/Kg	Uranium Bq/Kg
Arasamoodu	1999.43	454.42	30.29
Kumarakoil	499.86	113.60	7.57
Paraicodu	2035.37	462.58	30.84
Veeyanoor	999.72	227.21	15.15

SAMPLES

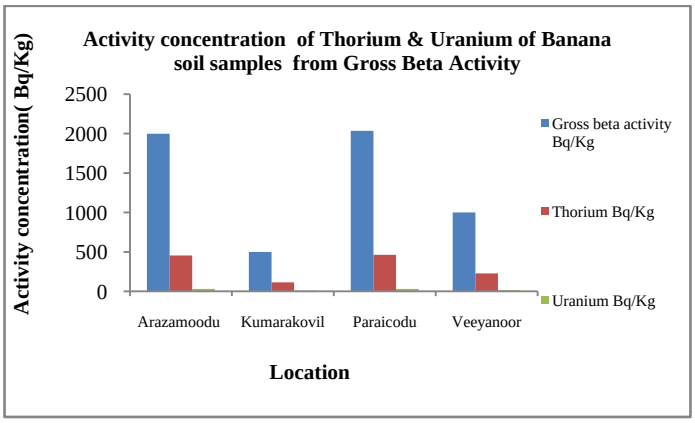

Fig.8

The gross beta activity of the soil sample collected from near Banana tree in Kanyakumari district is shown in Table 8. It can be seen that the gross beta activity is maximum in Paraicodu soil with the value of 2035.37 Bq/kg and the gross beta activity is minimum 499.86 Bq/kg has been recorded in Kumarakoil soil.

By comparing table2&8 the beta activity of the soil collected from the surface is higher than the alpha activity. The content of Uranium is very lower than that of the Thorium.

TABLE IX: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS BETA ACTIVITY INSPINACH SOIL SAMPLES

Location	Gross Beta Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	928.31	210.98	14.07
Melapallam	1856.62	421.96	28.13
Thotiyodu	1213.94	275.89	18.39
Veeyanoor	1213.94	275.89	18.39

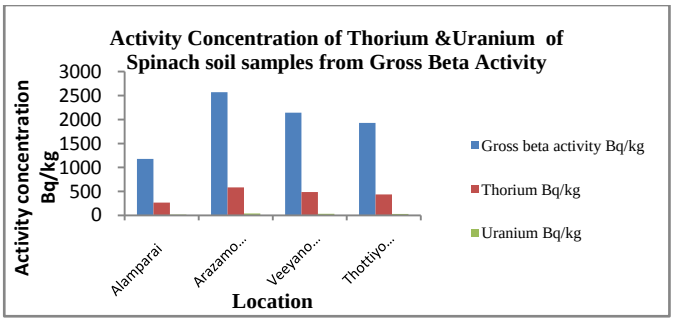

Fig.9

The gross beta activity of the soil sample collected from near Spinach in Kanyakumari district is shown in Table 9. It can be seen that the gross beta activity is maximum in Melapallam soil with the value of 1856.62 Bq/kg and the gross beta activity is minimum 928.31 Bq/kg has been recorded in Alamparai soil.

By comparing table3&9 the beta activity of the soil collected from the surface is higher than the alpha activity. The content of Uranium is very lower than that of the Thorium.

TABLE X: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS BETA ACTIVITY IN TAPIOCA SOIL SAMPLES

Location	Gross Beta Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	1178.24	267.78	17.85
Arasamoodu	2570.70	584.25	38.95
Veeyanoor	2142.25	486.88	32.46
Thotiyodu	1928.03	438.19	29.21

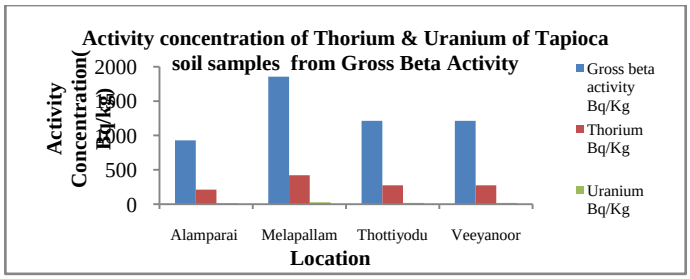

Fig.10

The gross beta activity of the soil sample collected from near Tapioca soil in Kanyakumari district is shown in Table 10. It can be seen that the gross beta activity maximum in Arasamoodu soil with the value of 2570.70 Bq/kg and the gross beta activity is minimum 1178.24 Bq/kg has been recorded in Alamparai soil.

By comparing table 4&10 the beta activity of the soil collected from the surface is higher than the alpha activity. The content of Uranium is very lower than that of the Thorium.

TABLE XI: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS BETA ACTIVITY IN DRUMSTICK TREE IN SOIL SAMPLES

Location	Gross Beta Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	1392.46	316.47	21.09
Kalluvilai	1532.28	348.25	23.22
Thiruthuvapuram	2142.25	486.88	32.46
Madichel	2534.99	576.13	38.41

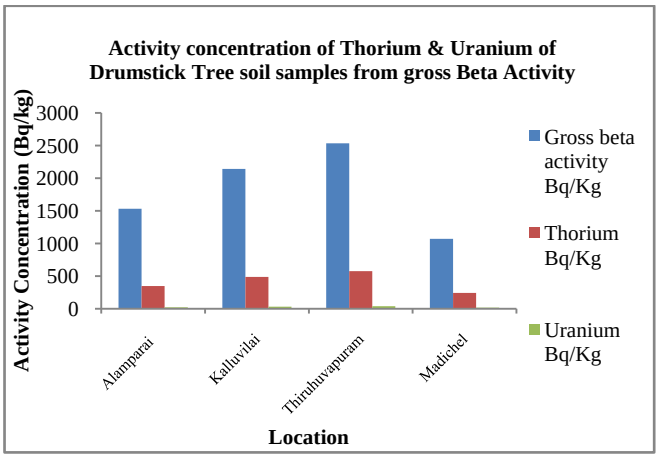

Fig. 11

The gross beta activity of the soil sample collected from near Drumstick tree soil in Kanyakumari district is shown in Table 11. It can be seen that the gross beta activity is maximum in Madichel soil with the value of 2534.99 Bq/kg and the gross beta activity is minimum 1392.46 Bq/kg has been recorded in Alamparai soil.

By comparing table 5&11 the beta activity of the soil collected from the surface is higher than the alpha activity. The content of Uranium is very lower than that of the Thorium.

TABLE XII: ACTIVITY CONCENTRATION OF THORIUM AND URANIUM FROM GROSS BETA ACTIVITY IN PAPAYA TREE SOIL SAMPLES

Location	Gross Beta Activity (Bq/kg)	Thorium (Bq/kg)	Uranium (Bq/kg)
Alamparai	1071.13	243.44	16.23
Thiruthuvapuram	1642.39	373.27	24.88
Madichel	2070.84	470.65	31.38
Arasamoodu	1963.73	446.30	29.75

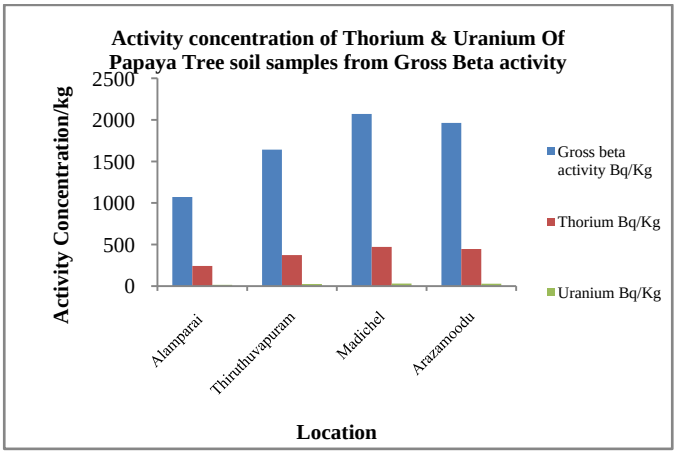

Fig.12

The gross beta activity of the soil sample collected from near papaya tree in Kanyakumari district is shown in Table 12. It can be seen that the gross beta activity is maximum in Madichel soil with the value of 2070.84 Bq/kg and the gross beta activity is minimum 1071.13 Bq/kg has been recorded in Alamparai soil.

By comparing table 6&12 the beta activity of the soil collected from the surface is higher than the alpha activity. The content of Uranium is very lower than that of the Thorium.

Conclusion

- The present study is to calculate the activity concentration of the radio nuclides such as Thorium, and Uranium in Agricultural soils in Kanyakumari District.
- From the gross alpha activity of the soil sample collected from agricultural places of Kanyakumari District. It can seen that the gross alpha activity near coconut tree soil samples were higher in Paraicodu (319.49 Bq/kg), and concentration is lower in Arazamoodu, Veeyanoor surface soil (212.99 Bq/kg). The gross beta activity of the soil sample is higher in Madichel (2035.14 Bq/kg) and lower in Arazamoodu (142.82 Bq/kg).
- The gross alpha activity of the near Banana tree soil samples were higher in Veeyanoor (372.74 Bq/kg) and lower in Kumarakoil (53.25 Bq/kg). The gross beta activity of the soil sample is higher in Paraicodu (2035.37 Bq/kg) and lower in Kumarakoil (499.86 Bq/kg).
- The gross alpha activity of the near Spinach soil samples is higher in Alampari, Arazamoodu (585.73 Bq/kg) and lower in Thottiyodu (BDL). The gross beta activity of the soil sample is higher in Arazamoodu (2570.70 Bq/kg) and lower in Alamparai (1178.24 Bq/kg).
- The gross alpha activity of near Tapioca soil samples is higher in Melapallam, Thottiyodu, and Veeyanoor (266.24 Bq/kg) and lower in Alamparai (212.99 Bq/kg). The beta activity of the soil sample is higher in (1856.62 Bq/kg) and lower in Alamparai (928.31 Bq/kg).
- The gross alpha activity of the near Drumstick tree soil samples were higher in Alamparai (212.99 Bq/kg) and lower in Kalluvilai (BDL). The gross beta activity of the Drumstick Tree soil sample is higher in Madichel (2534.99 Bq/kg) and lower in Alamparai (1392.46 Bq/kg).
- The gross alpha activity of the near Papaya tree soil samples were higher in Arasamoodu (479.23 Bq/kg) and lower in Alamparai, Thiruthuvapuram and Madichel (266.24 Bq/kg). The gross beta activity of the papaya soil sample is higher in Madichel (2070.84Bq/kg) and lower in Alamparai (1071.13 Bq/kg).

References:

[1] K.Al-Jundi,B.A.Al-Bataina,Y.Abu-Rukah,H.M.Shhadeh, Natural radioactivity concentrations in soil samples along the Amman Aqaba Highway, Jordan, Radiat. Meas. 36, 555-560. 2003.

[2] H.M.Taskin, P. Karavus, A. Ay, S. Touzogh, Hindiroglu, and G.Karaham, (2009), Radionuclide concentration in soil and lifetime cancer risk due to the gamma radioactivity in Kirklareli, Turkey. Journal of environmental radioactivity, 100, pp.49-53.2009.

[3] International symposium on areas of high natural radioactivity, in: T.L.Cullen. E. Penna Franca (Eds), Proceedings of the symposium published by Academica Brasileira de cienelas RJ, Procos da Calgdes, Brazil, June16-20, 1975, 1977.

[4] M.Sohrabi,Recent radiological study of high level natural radiation areas of Ramsar, In: Proceeding of international conference Ramsar,3(7) pp: 39-47,1990

[5] R.L.Kathren, NORM sources and their origins. Appl. Radiat. Isot. 49, 149-168.1988.

[6] M.Bolca, M.Sac,B.Cokuysal, T.Karalı, and E. Ekdal, Radioactivity in soils and various foodstuffs from the Gediz River Basin of Turkey. Radiat Meas. 42, 263-270. 2007.

[7] Laura Guidotti,Franca Carini,Riccardo Rossi,Marina Gatti,Roberto M.Cenci, Gian Maria Beone:Gamma Spectroscopic measurement of radioactivity in agricultural soil of the Lombardia region ,northern Italy.142(2015) 36-44.

[8] B. Skwarzec and L. Falkowski, "Accumulation of ^{210}Po in Baltic invertebrates," Journal of Environmental Radioactivity, vol. 8, no. 2, pp. 99–109, 1988.

[9] A.Najam Laith ,M. AL-Jomaily Firas ,M. ALFarhaEnas , Natural radioactivity levels of limestone rocks in northern Iraq using gamma spectroscopy and nuclear track detector, J Radioanal Nucl Chem . 289:709 - 715. 2011.

[10] A.TRamli, A.Wahab,M.A Hussein,A.A. Khalikwood, Enviromental 238 U and 232 Th concentration measurements in an area of high level natural background radiation at palong, Johor, Malaysia.J. Environ. Radioact.80.287-275.2005