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Evaluation of the Gross Alpha and Beta Radioactivity Concentration in Agriculture Soils of South India

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ABSTRACT:

A survey of the gross alpha and beta radionuclide activity in agricultural soil samples collected along the different plantations in the Kanya kumari district has been carried out. The samples were collected and analyzed for gross alpha and beta activity using a ZnS (Ag) and low beta counter. Background measurement was done to determine the background radioactivity. Radiological impacts of phosphate rocks mining and manufacture could be significant due to the elevated radio-activity contents of the naturally occurring radio-active materials (NORM) such as ^{238}U series, ^{232}Th series &^{40}K. Natural radio-activity is composed of the Cosmo genic& primordial radio nuclides. Soil not only consists of organic and inorganic compounds but also radionuclides. Radon is formed from the decay of radium which in turn is formed from uranium. The results obtained showed that the average gross alpha and beta activity of the agricultural soils ranged from 2045.32 Bq/kg - 54.44 Bq/kg and 13262.3 Bq/kg - 112.09 Bq/kg. The thorium and uranium concentration were also calculated using gross alpha and beta activities. The gross alpha activity is maximum at 2045.32 Bq/kg and minimum at 54.44 Bq/Kg. The gross beta activitiesare maximum at 13262.3 Bq/kg and minimum at 112.09 Bq/kg.

KEYWORDS: Gross alpha activity, Gross beta activity, Agriculture soils, Uranium, Thorium.

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INTRODUCTION:

Naturally occurring radioactive materials (NORM) are found almost everywhere.[1]Natural and manmade sources of ionizing radiation are present in the environment in which man lives; there is a continuous bombardment of man and his environment by these ionizing radiations. Naturally Occurring Radionuclide(NORM)of Thorium and Uranium are significant contribution of ingestion doseand are present in the biotic systems of soil, water and air. Measurement of natural radioactivity in soil is very important to determine the amount of change of the natural background activity with time as a result of a radioactivity release.[2]

A significant part of the total dose contribution in the form of natural sources comes from terrestrial gamma radionuclides. Only nuclides with half-lives comparable with the age of the earth or their corresponding decay products existing in terrestrial materials, such as ^{40}K, ^{238}U, ^{232}Th radionuclides are of great interest.[3] radioactive isotopes concentration in soil is an indicator of radio-active accumulation in the environment, which affects human, plants,and animals. The application phosphate fertilizers have substantially increased in the world.The source of radio-activity in soil other than those of natural oxygen are mainly due the extensive use of fertilizers rich in phosphate for agricultural purpose.[4]Radionuclides such as ^{40}K,^{238}U, ^{232}Th which are present in trace amounts in soil represent the major source of external exposure due to gamma radiation.

The concept of technologically enhanced natural radio-activity (TE NORM) was introduced in the mid-seventies. It represents the unintentional exposure to natural source of radiation which would not exist without the technological activity. Earlier studies have shown that the main sources of technologically enhanced natural radioactivity are coal fired power plants and artificial fertilizers applied in agriculture.

Coal fixed power plants have been neglected as a radiation source for a long time. They became important for investigation as a result of the advancement of the scientific knowledge of biological effect of radiation in international recommendation and standards. The basic problem of technologically enhanced natural radioactivity caused by coalfired power plant is the increase of the background gamma radiation level.Therefore, the local population is exposed to higher gamma radiation doses than in the absence of coalfired power plant.[5] More than 30 million metric tons of phosphate fertilizers are annually consumed worldwide, which increase crop production and land reclamation.[6] Nowadays, agricultural chemical fertilizers including phosphate fertilizers are an essential component of the agricultural activity that help to increase crop production and to improve the properties of the nutrient-deficient lands. Human activities such as adding fertilizers importing topsoil and the like can alter the surface activity.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 radioactivity levels.[7]

Soil and fertilizers consist of naturally occurring radionuclides with their daughter decay products. Relatively large concentrations of natural radionuclides present in the phosphate fertilizers contaminate the environment and agricultural lands during cultivation.Existing in terrestrial materials such as ^{40}K,^{238}U,^{232}Th radionuclides are of great interest. Soil radionuclide activity concentration is one of the main determinants of the natural background radiation.[8]

The present study aims are as follows to determine the Gross alpha and Beta activities and to determine the Uranium and Thorium concentration.

Sample Collection:

In order to measure the alpha and beta activity in environmental samples, the samples of agriculture soils were randomly collected from different locations of Kanyakumari district at different depths 0-10,10-30 and 30-50 cm with a probe. The samples (about 1 kg) were packed in polythene bags, sealed properly marked according to the location of sampling site, labeled sampleswere transported to the laboratory. The samples were uniformly mixed, sieved, air dried at temperature of 100^0C to 120^0C for an hour to remove the moisture content. The samples were sealed and kept for one month to attain secular equilibrium between the long lived parent nuclides and theirshort lived daughter radionuclides in the ^{40}K,^{238}U,^{232}Th decay series.

Sample Preparation:

The gross alpha activity in the samples is measured by using Alpha Probe SP647A radiation counting system has the efficiency of about 30.42%. The standard source ^{241}Am is used for detector calibrations. For gross beta activities is measured by using BCS36A and have the efficiency of about 38.42%. The Standard source potassium isused for corresponding detector calibrations.

The dried soil samples of about 60mg from each site was crushed into fine powder using agate motor and spread as a fine layer in aluminumplanchet and its gross alpha and beta activity was measured using the counter for a time period of about 1000s and preparation procedures followed as reported earlier.[9]The background of each detector study was determined by counting an empty planchet for 1000s using standard methods.[10]

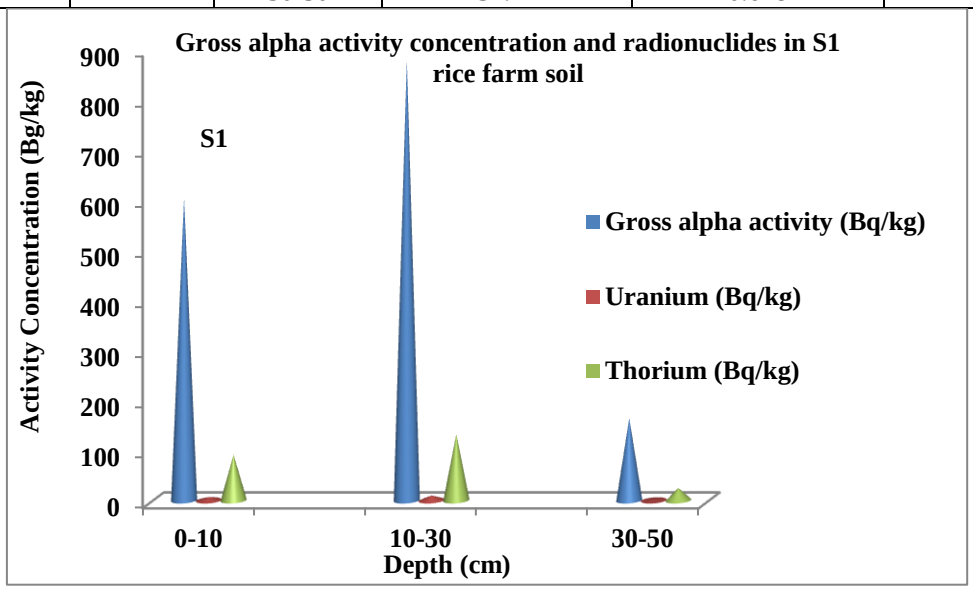
Study of Thorium and Uranium from gross alpha and gross beta activity

The concentration of Thorium is about 9% and uranium is of about 0.30% in the monazite. The specific activity of the uranium is three times higher that of the thorium, in the monazite the activity wise ratio is of about 10:1 (Thorium:Uranium). The disintegration of one thorium atom results in the emission of $6\alpha^s$ and $4\beta^s$. Similarly the disintegration of one U atom results in the emission of $8\alpha^s$ and $6\beta^s$. The total number of disintegration from U nuclides can also be obtained by dividing the corresponding number of x ray by 8.[11]

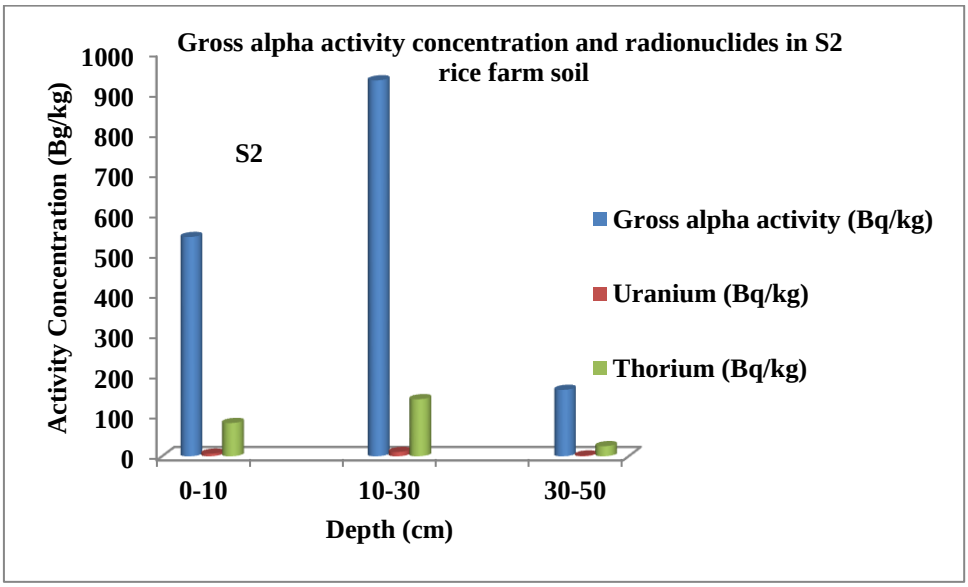
RESULTS AND DISCUSSION:

Table: 1Activity Concentration of Uranium and Thorium in Rice farm soil sample from Gross alpha activity

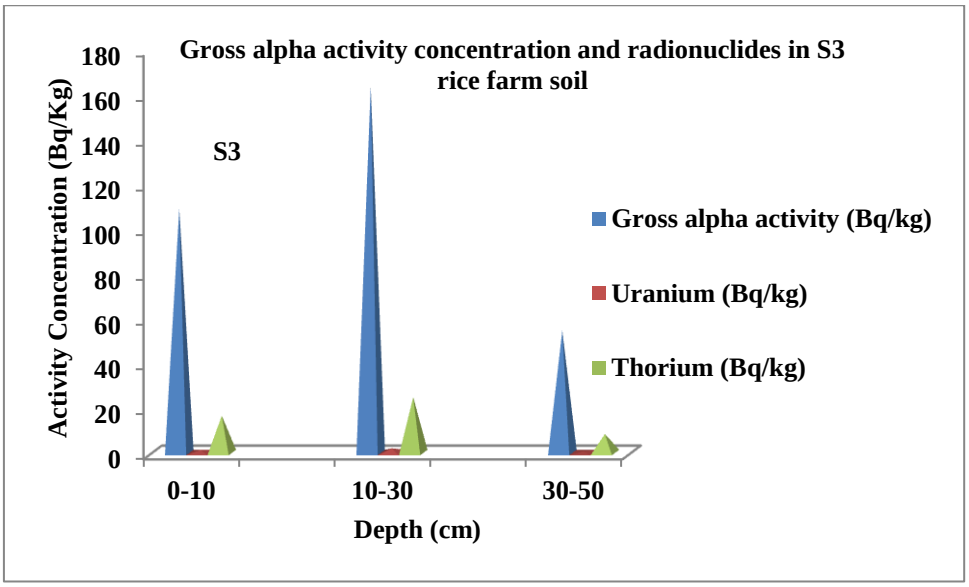
Location	Sample Id	Depth cm	Gross α activity (Bq/kg)	Uranium (Bq/kg)	Thorium (Bq/kg)
Vellimalai	S1	0-10	602.6	6.847	91.3
		10-30	876.6	9.96	132.81
		30-50	164.3	1.867	24.88
Tirunainarkurichy	S2	0-10	542.8	6.23	82.22
		10-30	931.3	10.58	141.1
		30-50	164.2	1.865	24.87
Saral	S3	0-10	108.89	1.237	16.49
		10-30	163.34	1.856	24.74
		30-50	54.44	0.618	8.248



Graph.1: Variation of activity of radionuclides with depth of S1 Rice farm soil



Graph.2: Variation of activity of radionuclides with depth of S2 Rice farm soil

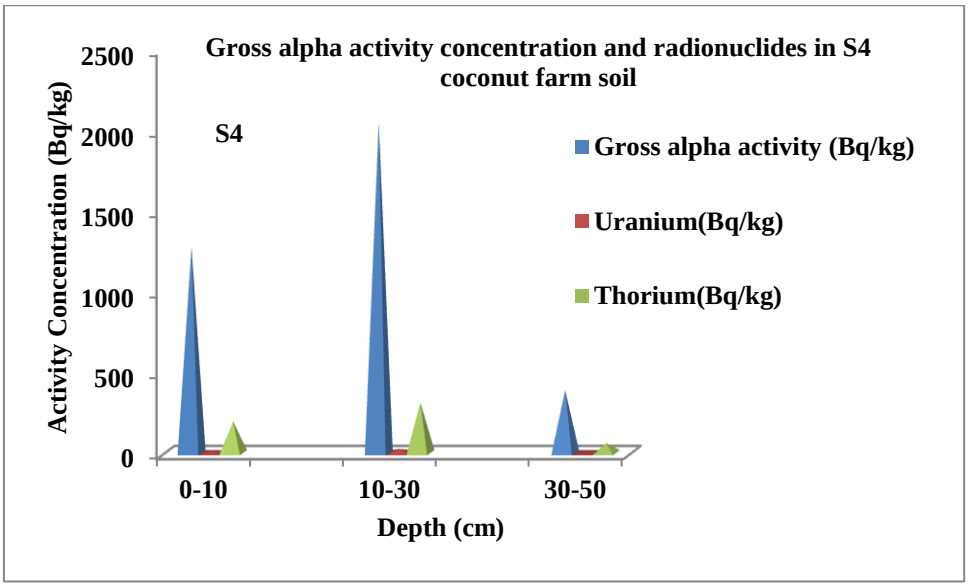


Graph.3: Variation of activity of radionuclides with depth of S3 Rice farm soil

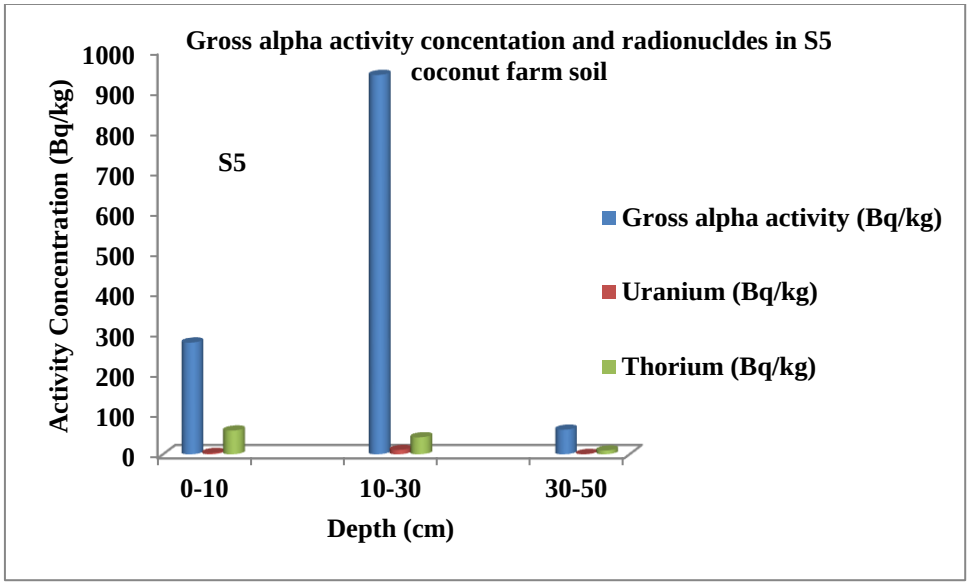
The table 1 represents the gross alpha activity of the soil sample in Kanyakumari district from the rice farm of different depths. It shows that the gross alpha activity is maximum in Tirunainarkurichy in the surface soil of depth 10-30 cm of about 931.3 Bq/kg and the minimum value in Saral of depth 30-50 cm of about 54.44 Bq/kg.

Table: 2 ActivityConcentration of Uranium and Thorium in Coconut soil sample from Gross alpha activity

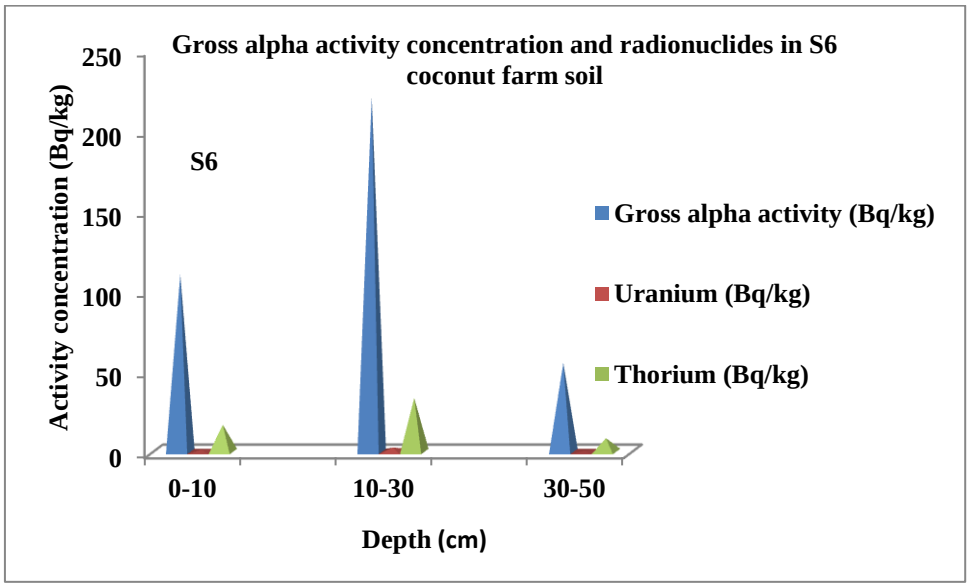
Location	Sample Id	Depth cm	Gross α activity (Bq/kg)	Uranium (Bq/kg)	Thorium (Bq/kg)
Mondaikadu	S4	0-10	1271.42	14.44	192.63
		10-30	2045.32	23.24	309.88
		30-50	386.95	4.397	58.62
Karingal	S5	0-10	276.3	3.139	58.62
		10-30	939.7	10.678	41.86
		30-50	60.80	0.690	9.212
Paraseri	S6	0-10	110.22	1.2525	16.7
		10-30	220.45	2.505	33.4
		30-50	55.11	0.626	8.35



Graph.4: Variation of activity of radionuclides with depth of S4 Coconut farm soil



Graph.5: Variation of activity of radionuclides with depth of S5 Coconut farm soil

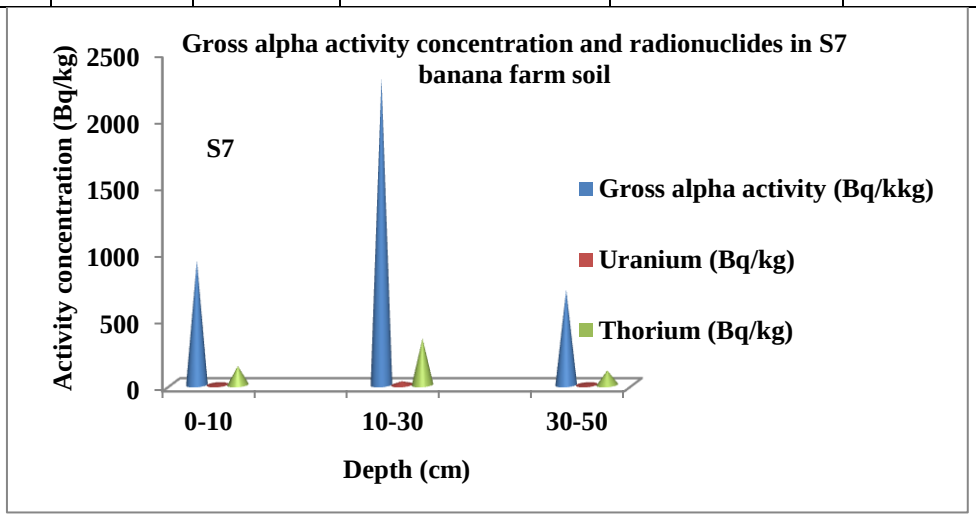


Graph.6: Variation of activity of radionuclides with depth of S6Coconut farm soil

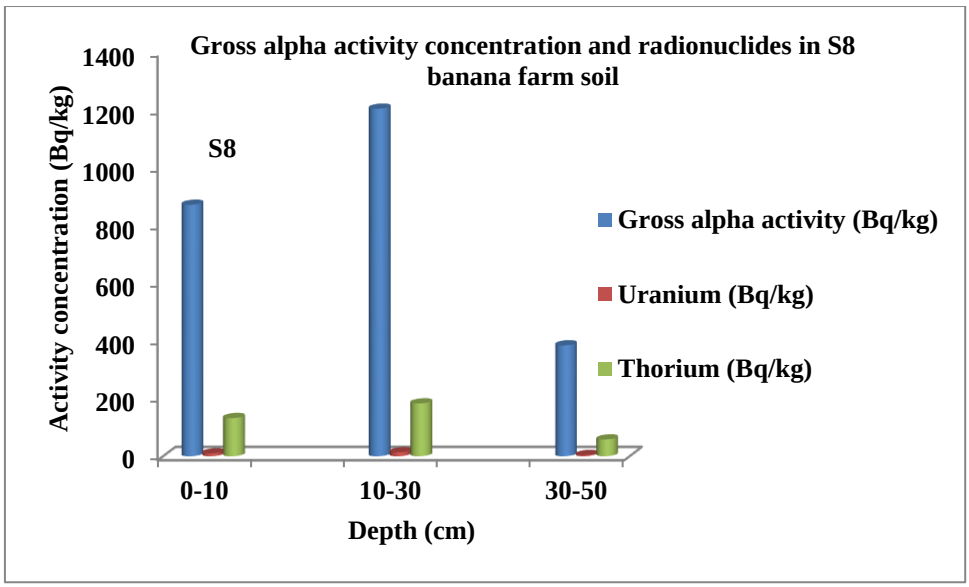
The table 2 represents the gross alpha activity of the soil sample in Kanyakumari district from the coconut tree of different depths. It shows that the gross alpha activity is maximum in Mondaikadu in the surface soil of depth 10-30 cm of about 2045.32 Bq/kg and the minimum value in Paraseri of depth 30-50 cm of about 55.11 Bq/kg.

Table: 3Activity Concentration of Uranium and Thorium in Banana tree soil sample from gross alpha activity

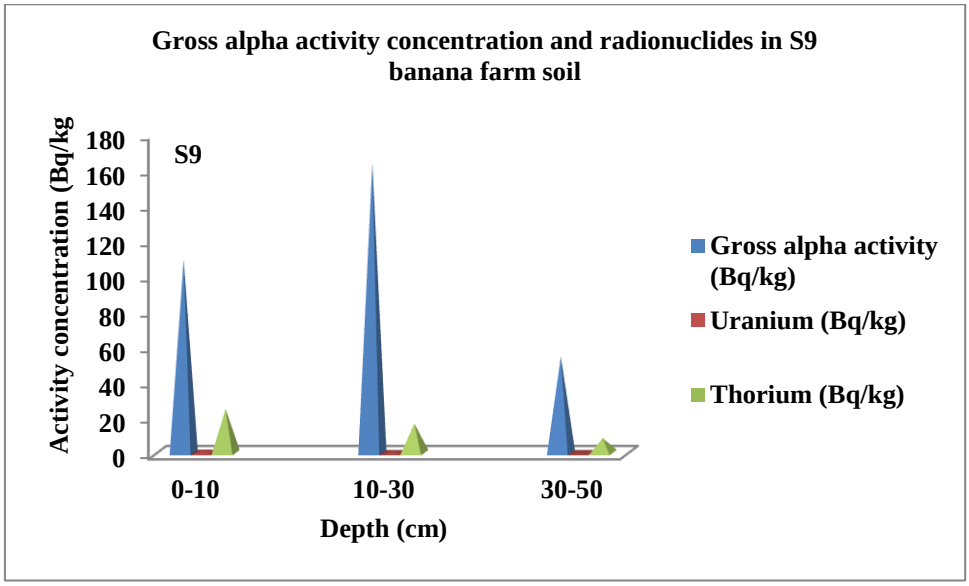
Location	Sample Id	Depth cm	Gross α activity (Bq/kg)	Uranium (Bq/kg)	Thorium (Bq/kg)
Chakkapattu	S7	0-10	931.39	10.5	141.11
		10-30	2301.1	26.1	348.65
		30-50	712.2	8.093	107.90
Paruthivilai	S8	0-10	871.45	9.902	132.03
		10-30	1205.3	13.69	182.62
		30-50	383.51	4.358	58.106
Asaripallam	S9	0-10	108.89	1.856	24.74
		10-30	163.34	1.237	16.498
		30-50	54.4	0.618	8.248



Graph.7: Variation of activity of radionuclides with depth of S7banana farm soil



Graph.8: Variation of activity of radionuclides with depth of S8 banana farm soil

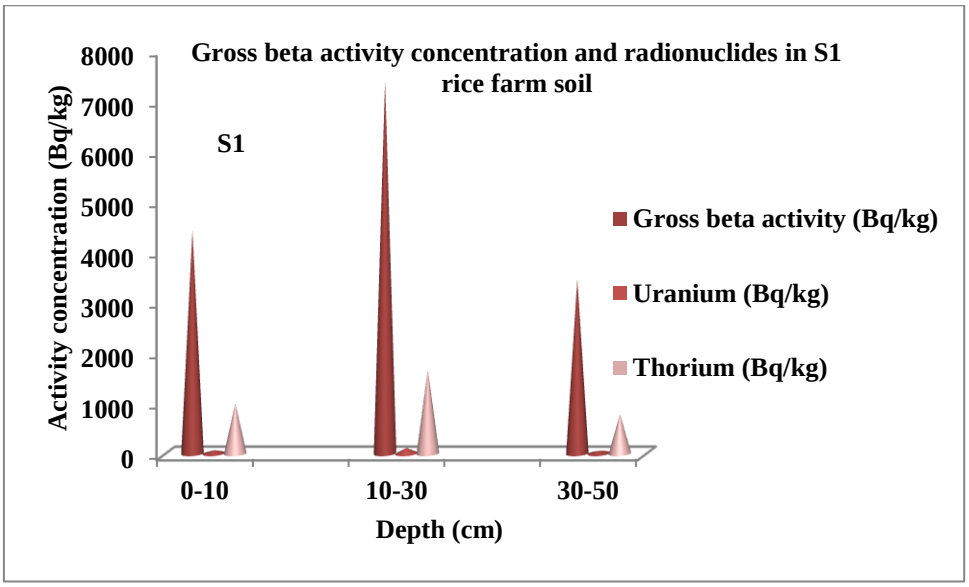


Graph.9: Variation of activity of radionuclides with depth of S8 banana farm soil

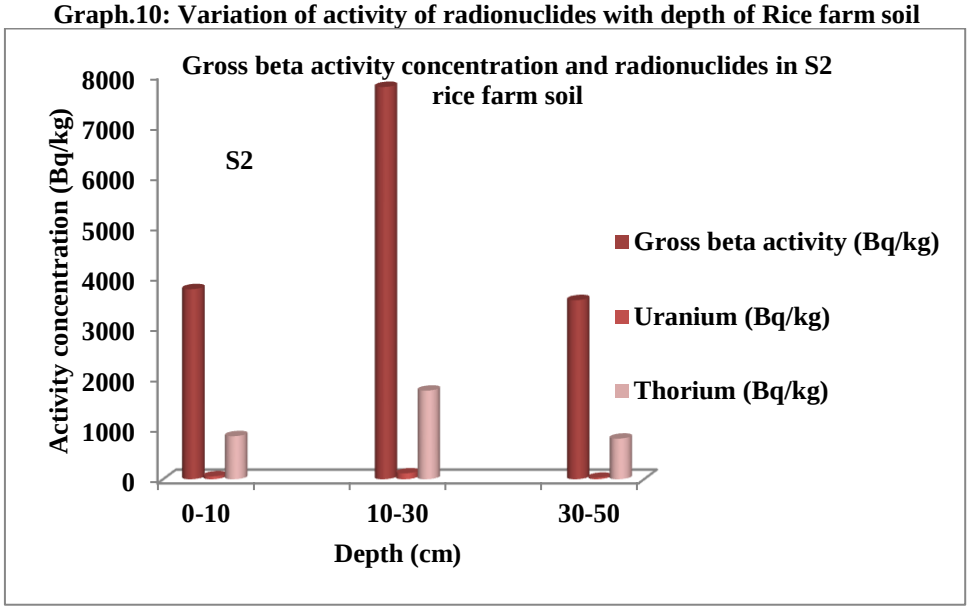
The table 3 represents the gross alpha activity of the soil sample in Kanyakumari district from the banana tree of different depths. It shows that the gross alpha activity is maximum in Chakkapattuin the surface soil of depth 10-30 cm of about 2301.1 Bq/kg and the minimum value in Asaripallam of depth 30-50 cm of about 54.4 Bq/kg.

Table: 4Activity Concentration of Uranium and Thorium in Rice farm soil sample from Gross beta activity

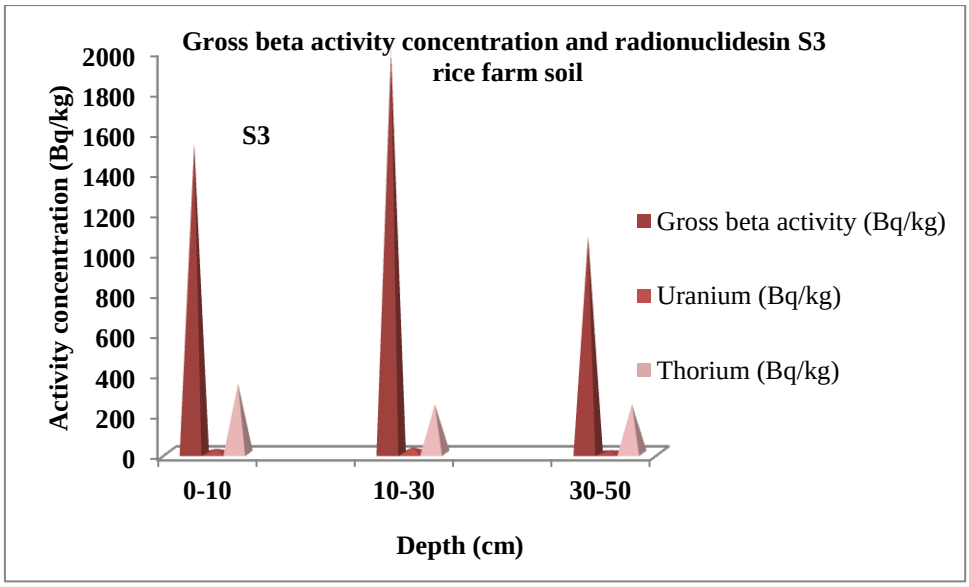
Location	Sample Id	Depth cm	Gross β activity (Bq/kg)	Uranium (Bq/kg)	Thorium (Bq/kg)
Vellimalai	S1	0-10	4424.57	67.05	1005.5
		10-30	7374.2	111.2	1675.9
		30-50	3470.25	52.57	788.6
Tirunainarkurichy	S2	0-10	3773.90	57.18	857.7
		10-30	7764.6	117.6	1764
		30-50	3557.0	29.3	808.4
Saral	S3	0-10	1535.9	23.27	349
		10-30	1992.5	30.18	245.2
		30-50	1079.2	16.35	245.2



Graph.10: Variation of activity of radionuclides with depth of Rice farm soil



Graph.11: Variation of activity of radionuclides with depth of Rice farm soil

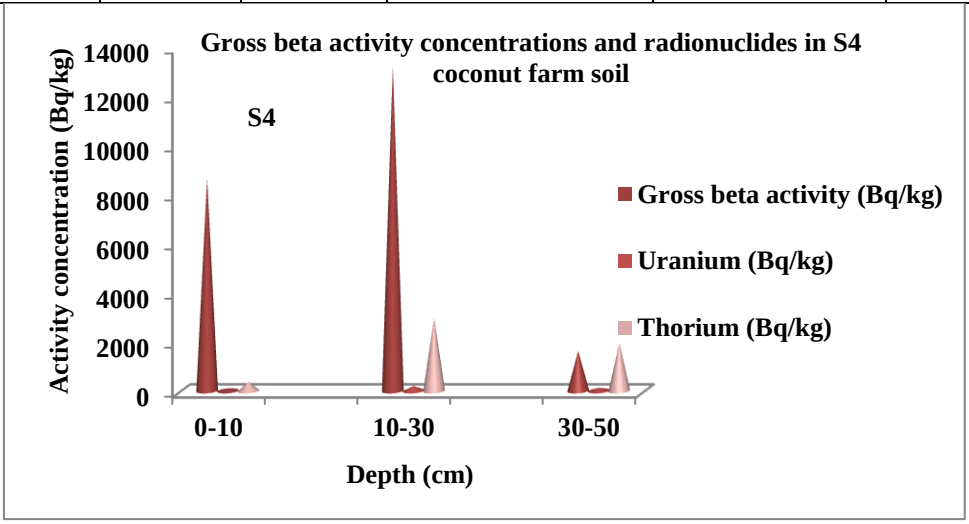


Graph.12: Variation of activity of radionuclides with depth of Rice farm soil

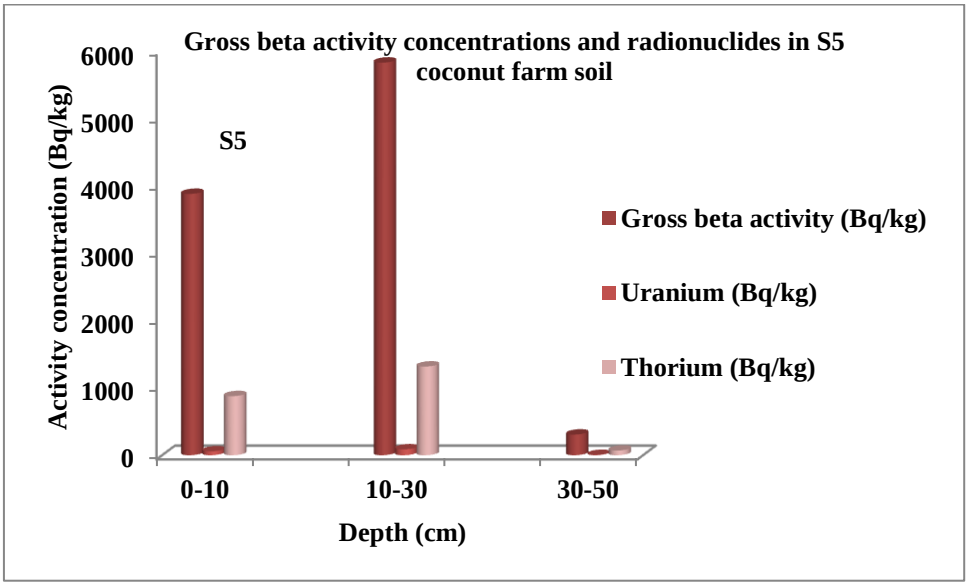
The table 4 represents the gross alpha activity of the soil sample in Kanyakumari district from the rice farm of different depths. It shows that the gross beta activity is maximum in Tirunainarkurichy in the surface soil of depth 10-30 cm of about 7764.6 Bq/kg and the minimum value in Saral of depth 30-50 cm of about 1079.2 Bq/kg.

Table:5Activity Concentration of Uranium and Thorium in Coconut soil sample from Gross beta activity

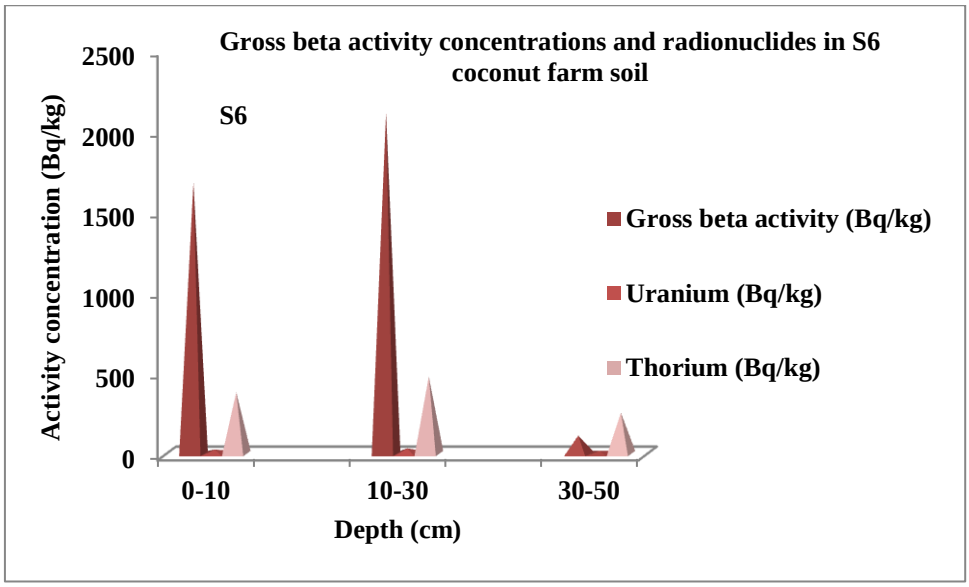
Location	Sample Id	Depth cm	Gross βactivity (Bq/kg)	Uranium (Bq/kg)	Thorium (Bq/kg)
Mondaikadu	S4	0-10	8700.7	24.95	374.36
		10-30	13262.3	200.94	3014.1
		30-50	1647.2	131.82	1977.4
Karingal	S5	0-10	3885.7	58.87	883.1
		10-30	5828.6	88.31	1324.6
		30-50	308.6	4.671	70.06
Paraseri	S6	0-10	1680.88	25.46	382
		10-30	2111.8	31.99	479.9
		30-50	112.059	16.97	254.67



Graph.13: Variation of activity of radionuclides with depth of coconut farm soil



Graph.14: Variation of activity of radionuclides with depth of coconut farm soil

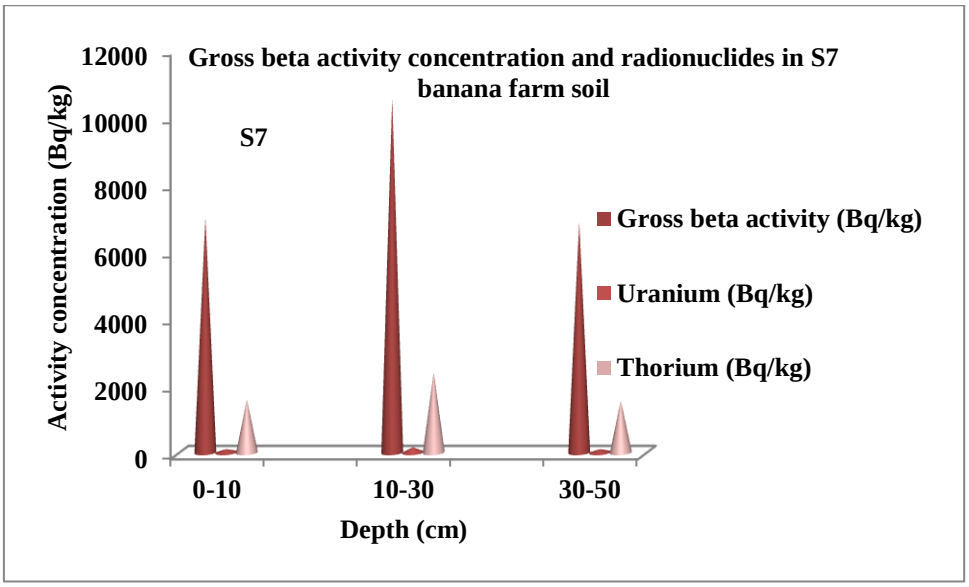


Graph.15: Variation of activity of radionuclides with depth of coconut farm soil

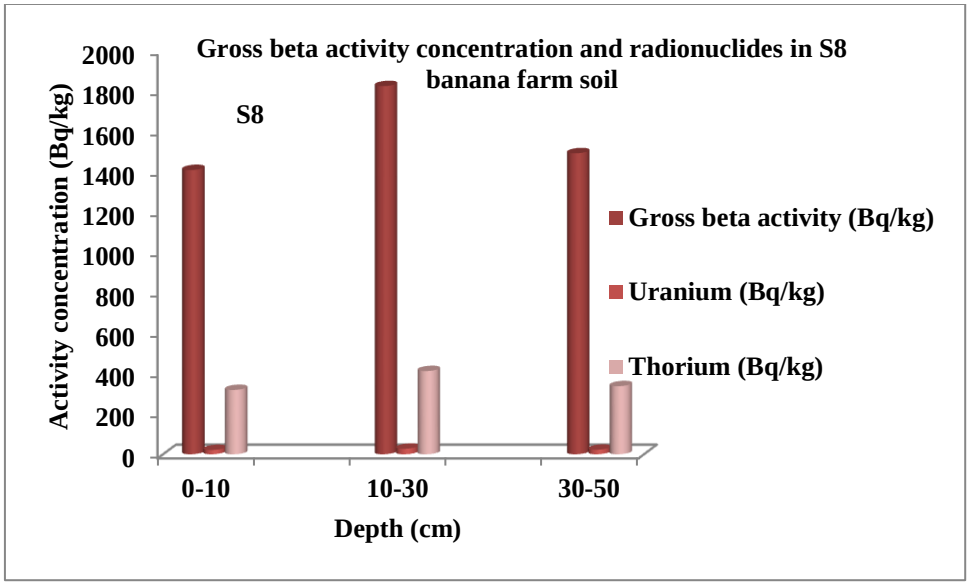
The table 5 represents the gross alpha activity of the soil sample in Kanyakumari district from the coconut tree of different depths. It shows that the gross betaactivity is maximum in Mondaikadu in the surface soil of depth 10-30 cm of about 13262.3 Bq/kg and the minimum value in Paraseri of depth 30-50 cm of about 112.059 Bq/kg.

Table: 6 Activity Concentration of Uranium and Thorium in Banana tree soil sample from Gross beta activity

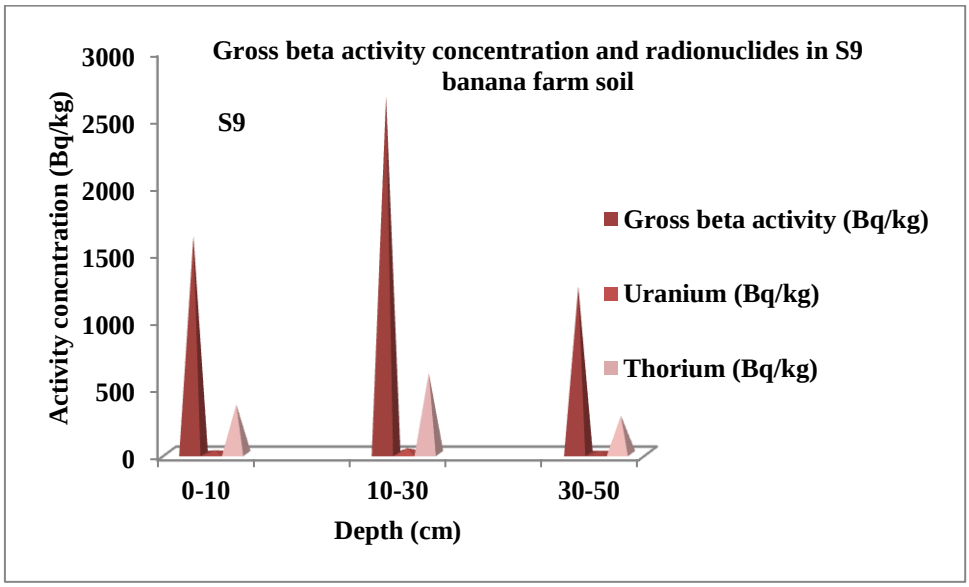
Location	Sample Id	Depth cm	Gross β activity (Bq/kg)	Uranium (Bq/kg)	Thorium (Bq/kg)
Chakkapattu	S7	0-10	6983.8	105.81	1587.2
		10-30	10540.9	159.71	2395.6
		30-50	6853.7	103.84	1557.6
Paruthivilai	S8	0-10	1411.3	21.38	320.95
		10-30	1826.4	27.67	415.09
		30-50	1494.3	22.64	339.6
Asaripallam	S9	0-10	1618.9	24.52	367.92
		10-30	2656.7	40.25	603.79
		30-50	1245.3	18.86	283



Graph.16: Variation of activity of radionuclides with depth of banana farm soil



Graph.17: Variation of activity of radionuclides with depth of banana farm soil



Graph.18: Variation of activity of radionuclides with depth of banana farm soil

The table 6 represents the gross alpha activity of the soil sample in Kanyakumari district from the banana tree of different depths. It shows that the gross beta activity is maximum in Chakkapattu in thesurface soil of depth 10-30 cm of about 10540.9 Bq/kg and the minimum value in Asaripallam of depth 30-50 cm of about 1245.3 Bq/kg. By comparing alpha and beta activity,the beta activity is higher than the alpha activity and the uranium content is lower than the thorium.

CONCLUSION:

The present study investigates the activity concentration of the radionuclides such as thorium and uranium in Agricultural soils in the Kanyakumari district.The gross alpha and beta activity measurement from the collected samples is achieved by using alpha and beta counting system. High uranium and thorium concentrations indicate high gross alpha and highest potassium content and use of fertilizers indicate high beta activities in the sample. A fertilizer largely used to improve soil fertility is seen to have enhanced the quantity of natural radionuclides in the soil and consequently through uptake are made available to the plants.The gross alpha and beta activity in the surveyed sampleare varied from location to location. The variation may be due to the heterogeneity of radionuclide deposited and greatly influenced by the water transportation,depends on the type of the soil and mean activity in the environment.In the middle layer the activity increases due to the extent of fertilizers applied to the agriculture land area soils. The alpha and beta activity are decreasing when the depth increases due to the fertilization in the soil.

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