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Study of gross alpha and gross beta activity concentration in sediment and soil samples of three southern districts of Tamil Nadu

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ABSTRACT

Human can be exposed to the radiation emitting from different radioactive sources depending upon their activities and surroundings. Human activities have contributed to the increased concentration of some radionuclides in the environment. A survey of the gross alpha and gross beta activity in soil samples collected along the three southern districts of TamilNadu has been carried out. Determination of the gross alpha and gross beta activity concentration are done by using ZnS (Ag) and low beta counter. The gross alpha activity varies from 162.3 Bq/kg to 3679.6 Bq/kg near the sea and ranges from 107.5 Bq/kg to 1774.1 Bq/kg 150 m away from the sea. The gross alpha activity in the sub-urban area varies from 53.67 Bq/kg to 644.12 Bq/kg. The gross beta activity concentration in the soil ranges from 388.8 Bq/kg to 40111.1 Bq/kg in the coastal region (near the sea) and ranges from 669.06 Bq/kg to13278.4 Bq/kg (150 m away from the sea). While the gross beta activity concentration in the sub-urban area varies from 1103.05 Bq/kg to 4202.12 Bq/kg. The obtained values shows soil from the sampled locations may pose some long time health hazards to the public. Statistical analysis are also performed between the soil samples.

Key words : Gross alpha, Gross beta, natural radioactivity, sediment, soil

Introduction

Naturally occurring radiation can be found all around us. Radiation can be found in soils, air, water, and in us. We encounter it every day through the food we eat, the water we drink, and the air we breathe also in building materials and items we commonly use. Human beings have been continuously exposed to ionizing and non-ionizing radiation. Both ionizing and non-ionizing radiation are harmful to organisms which result in changes to the natural environment. Radioactivity in nature comes from two main sources, terrestrial and cosmic. First there is the radiation in the soils and rocks, called primordial or terrestrial. Then there is radiation that comes from space, called cosmic or cosmogenic. Another source of exposure in the environment is the artificial source that are released from human activists such as radioactive fallout from past nuclear weapon testing and nuclear activities of nuclear research. The radiation that we are exposed come from two sources, that which occur naturally and that which is due to the activities of man. Natural environmental radioactivity arises mainly from primordial radionuclides, such as ^{40}K and the nuclides from the ^{232}Th and ^{238}U series and their decay products. The decay of naturally occurring radionuclides in soil produces exposures to humans. The radioactivity measurement is significant to assess the radiation impact on environment, population exposed to radiation. The worldwide average background dose to humans is about 2.4 mSv/year [1]. The dose from these sources varies in different parts of the world. The concentration of natural radioactivity and the associated external exposure vary depend on the geological and geographical conditions in the soils of each region in the world [2]. Irradiation of the human body from external sources is mainly by gamma radiation from radionuclides of the ^{235}U, ^{238}U and ^{232}Th decay series and from ^{40}K. These radionuclides may be present in the body and irradiate various organs with alpha and beta particles as well as gamma rays. Alpha radiation travels a very short distance through air. The nucleus is initially in an unstable energy state. An internal change takes place in the unstable nucleus and an alpha particle is ejected leaving a decay product. The atom has then lost two protons along with two neutrons. Alpha-emitting materials can be harmful to humans if the materials are inhaled, swallowed, or absorbed through open wounds. A fast-moving electron or positron that is emitted from a nucleus during the radioactive process known as beta decay. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles may be stopped by thin sheets of metal or plastic. Beta particles travel with an initial speed of about 180 million m/s. A medium energy beta particle will travel about one meter in air but only about one millimeter through body tissue. Potassium-40 and carbon-14 are weak beta emitters that are found naturally in our bodies. Some decay products of radon emit beta particles. Beta emitters that eject energetic particles can pose a significant health concern. The radiation hazard from beta particle is

greatest if they are ingested. Naturally occurring radionuclides are the largest contributors to radiation doses received by human beings. Measurements of natural radioactivity in soil have been performed throughout the world [3-8]. The soil radioactivity is usually important to establish baseline data for futuristic purpose of radiation assessment and protection. The present work investigates the gross alpha and gross beta activity concentration in soil samples collected from different locations of south east region of Tamilnadu.

Experimental

Sample collection

The samples are collected from the three southern districts of Tamil Nadu (Kanyakumari, Tirunelveli, and Tuticorin). The locations surveyed in the present work are shown in map. The study area lie between latitudes $8^{o}29'$ to $8^{o}48'$ N and longitude $78^{o}11'$ to $78^{o}29'$ E. A total of 30 soil samples are collected from the both low and high background radiation areas which is from various distance (near the sea, 150 m away from the sea, sub-urban area). The samples are collected at a depth of 10 cm from every site. The samples are crushed to a fine powder, dried until the moisture of the soil is removed completely and are properly sealed, coded according to the location. Three different sizes of sieve are used for sieving the samples which are 0.250 mm, 0.063 mm and 0.025 mm respectively. The samples are kept in room temperature for a month to reach secular equilibrium between ^{226}Ra and its daughters.

Sample preparation

The measurement of the gross alpha and gross beta activity in the samples is carried out by using Alpha Probe AP185 radiation counting system and Beta Counting System BCS 36A, Electronics Corporation of India Limited. In order to measure the concentration of gross alpha and gross beta activity

in the collected samples, each soil sample weighing 0.06 gm is taken and powdered with the help of agate motor and uniformly spread on the aluminium planchet. The sample is counted for a time period of 1000 s. The net counts obtained are found out by subtracting the background count from the sample counts and thus the gross beta activity can be calculated. As mentioned above, similar procedure is applied to determine the background count.

Results and discussions

Table [1-3] shows the summary of results of the gross alpha and gross beta activity of the selected soil samples near the sea of sieve size 0.250 mm, 0.063 mm and 0.025 mm. The gross alpha and beta radioactivity concentration of the collected soil samples 150 m away from the sea are presented in table [4-6]. Soil samples are analyzed for gross alpha and gross beta activity. As shown in the table 1, the alpha activity concentration varies from 216.4 Bq/kg to 3679.6 Bq/kg and beta activity concentration ranges from 388.8 Bq/kg to 40111.1 Bq/kg near the sea of sieve size 0.250 mm. In table 2, the alpha activity concentration varies from 270.5 Bq/kg to 3517.3 Bq/kg and beta activity concentration varies from 1777.7 Bq/kg to 24166.6 Bq/kg in the coastal region (neat the sea) of sieve size 0.063 mm. According to table 3, the maximum alpha and beta activity is observed in Ko1 of sieve size 0.025 mm. As seen in table 4, the sample Pml5 shows maximum alpha and beta activity of 1774.1 Bq/kg and 12512.8 Bq/kg (150 m away from the sea) of sieve size 0.250 mm. In table 5, the alpha activity is higher in Pml5 where the gross beta activity is higher in Uv5 of sieve size 0.063 mm. Table 6 shows that the sample Uv5 shows maximum alpha activity and the sample Pml5 shows maximum beta activity in the coastal region of sieve size 0.025 mm. In table 7, the sample Ti shows higher alpha and beta activity in the sub-urban area of sieve size 0.250 mm. In tables 8 and 9, the maximum alpha and beta activity is observed in sample Ku and Ni in the sub-urban area of sieve size 0.063 mm and Ni sample shows higher alpha and beta activity concentration of sieve size 0.025 mm compared with other region. The maximum alpha activity is due to the presence of uranium and radium isotopes in the corresponding region. The elevation of the gross beta activity of the study are could be attributed to the highest potassium content present in the sample. Table [10-15] shows ANOVA result of soil samples in coastal region and sub-urban area of sieve size 0.250 mm, 0.063 mm and 0.025 mm respectively. The correlation analysis has been carried out to determine the mutual relationship and the strength of association between the samples of various sieve size. Strong correlation is observed between the samples of sieve size 0.250 mm and 0.025 mm in the coastal region ($r = 0.97$). Negative correlation is found between the sample sieve size 0.250 mm and 0.025 mm ($r = -0.12$). The results are then evaluated by a one-way analysis of variance. Statistical significance is assessed at the $p<0.05$ probability level. This means the results do not differ significantly. Figure [1-9] shows the gross alpha and beta activity concentration for the soil samples of sieve size 0.250 mm, 0.063 mm and 0.025 mm near the sea, 150 m away from the sea and in the sub-urban area.

Conclusion

The results of this investigation for the soil samples along the south eastern coast of Tamil Nadu are summarized in Table [1-15]. The gross alpha and beta activity measurements for the collected samples is achieved by using alpha and beta counting system. The maximum gross alpha and beta activity is observed in Ko1 sample in the coastal region of sieve size 0.250 mm. The higher alpha activity concentration in the soil sample is due to the presence of high radioactive content in the sample. Ku sample in the sub-urban area shows maximum alpha activity of sieve size 0.025 mm. Ni soil sample of sieve size 0.063 mm exhibit higher beta activity compared with other region in the sub-urban area. The alpha and beta activity concentration shows large variations in all the locations. According to the results obtained in this study, it can be concluded the maximum alpha activity is due to the existence of uranium and radium isotopes in the sample and maximum beta activity is due to the highest potassium content

present in the sample. The positive correlation coefficient is observed between the sample sieve size 0.250 mm and 0.025 mm in the coastal region.

Table 1. The gross alpha and gross beta activity in the soil samples near the sea for sieve size 0.250 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Ko1	3679.6	40111.1
Le1	1515.1	7388.8
Uv1	1190.4	7444.4
Pe1	1569.2	12722.2
Ma1	595.2	1388.8
Aa1	216.4	388.8
Th1	378.7	2944.2
Ve1	216.4	1722.2
Pml1	703.4	3944.4
Mtm1	270.5	2166.6

Table 2. The gross alpha and gross beta activity in the soil samples near the sea for sieve size 0.063 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Ko1	3517.3	24166.6
Le1	2435.0	16777.7
Uv1	1731.6	18777.7
Pe1	1893.9	13555.5
Ma1	270.5	1777.7
Aa1	270.5	2277.7
Th1	1785.7	12388.8
Ve1	378.7	3055.5
Pml1	1569.2	6555.5
Mtm1	378.7	2611.1

Table 3. The gross alpha and gross beta activity in the soil samples near the sea for sieve size 0.025 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Ko1	3354.9	30888.8
Le1	1461.0	8555.5
Uv1	1352.8	10833.3
Pe1	2759.7	14833.3
Ma1	162.3	1333.3
Aa1	162.3	1055.5
Th1	703.4	5722.2
Ve1	487.0	1500.0
Pml1	1298.7	6000.0
Mtm1	270.5	3111.1

Table 4. The gross alpha and gross beta activity in the soil samples 150 m the sea for sieve size 0.250 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Ko5	537.6	1749.8
Le5	860.2	5352.5
Uv5	1344.4	5301.0
Pe5	376.3	669.06
Ma5	967.7	4992.2
Aa5	483.8	1384.6
Th5	215.0	2769.2
Ve5	430.1	2358.9
Pml5	1774.1	12512.8
Mtm5	268.8	1333.3

Table 5. The gross alpha and gross beta activity in the soil samples 150 m the sea for sieve size 0.063 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Ko5	591.3	2779.2
Le5	752.6	6381.8
Uv5	1397.8	13278.4
Pe5	215.0	2624.8
Ma5	752.6	10910.9
Aa5	709.6	6666.6
Th5	537.6	2871.7
Ve5	967.7	7948.7
Pml5	1505.3	7846.1
Mtm5	322.5	1897.4

Table 6. The gross alpha and gross beta activity in the soil samples 150 m the sea for sieve size 0.025 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Ko5	430.1	2882.1
Le5	268.8	3602.6
Uv5	967.7	7205.3
Pe5	107.5	1286.6
Ma5	645.1	4014.4
Aa5	268.8	3846.1
Th5	430.1	3589.7
Ve5	537.6	3282.0
Pml5	860.2	7897.4
Mtm5	376.3	1179.4

Table 7. The gross alpha and gross beta activity in the soil samples in the sub-urban area for sieve size 0.250 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Vm	268.38	2468.74
Ku	322.06	2416.22

Vr	429.41	2206.11
Ni	268.38	2153.58
Mu	375.73	2836.43
Pi	375.73	1943.48
Vlu	214.70	2521.27
Vam	53.67	1103.05
Mlm	322.06	1680.84
Ti	483.09	3046.53

Table 8. The gross alpha and gross beta activity in the soil samples in the sub-urban area for sieve size 0.063 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Vm	268.38	2783.90
Ku	590.44	1996.00
Vr	322.06	2468.74
Ni	268.38	4202.12
Mu	483.09	1365.68
Pi	375.73	2258.64
Vlu	161.03	1733.37
Vam	322.06	1838.42
Mlm	214.70	2311.16
Ti	375.73	2678.85

Table 9. The gross alpha and gross beta activity in the soil samples in the sub-urban area for sieve size 0.025 mm

Sampling Location	α(Bq/kg)	β(Bq/kg)
Vm	536.76	2573.79
Ku	644.12	3519.27
Vr	322.06	3256.64
Ni	161.03	2153.58
Mu	161.03	1575.79
Pi	322.06	2468.74
Vlu	322.06	2048.53
Vam	107.35	2573.79
Mlm	161.03	1628.32
Ti	483.09	2101.06

Table 10. ANOVA result of gross alpha activity for soil samples near the sea

Source	SS	df	MS	F	p-value	F-critical
Between groups	763893	2	381946.5	0.3236	0.7262	3.3541
Within groups	31860512.12	27	1180018.96			
Total	32624405	29				

Table 11. ANOVA result of gross alpha activity for soil samples150 m from the sea

Source	SS	df	MS	F	p-value	F-critical
Between groups	467316.72	2	233658.36	1.3836	0.2678	3.3541
Within groups	4559437.49	27	168868.05			
Total	5026754	29				

Table 12. ANOVA result of gross alpha activity for soil samples in the sub-urban area

Source	SS	df	MS	F	p-value	F-critical
Between groups	3649.811	2	1824.905	0.085639	0.918174	3.354131
Within groups	575348.9	27	21309.22			
Total	578998.7	29				

Table 13. ANOVA result of gross beta activity for soil samples near the sea

Source	SS	df	MS	F	p-value	F-critical
Between groups	27096744	2	13548372	0.1406	0.8693	3.3541
Within groups	2.6E+09	27	96304788			
Total	2.63E+09	29				

Table 14. ANOVA result of gross beta activity for soil samples150 m from the sea

Source	SS	df	MS	F	p-value	F-critical
Between groups	40354235	2	20177117	1.9045	0.1683	3.3541
Within groups	2.86E+08	27	10593958			
Total	3.26E+08	29				

Table 15. ANOVA result of gross beta activity for soil samples in the sub-urban area

Source	SS	df	MS	F	p-value	F-critical
Between groups	132616.1	2	66308.06	0.1497	0.8616	3.3541
Within groups	11954647	27	442764.7			
Total	12087263	29				

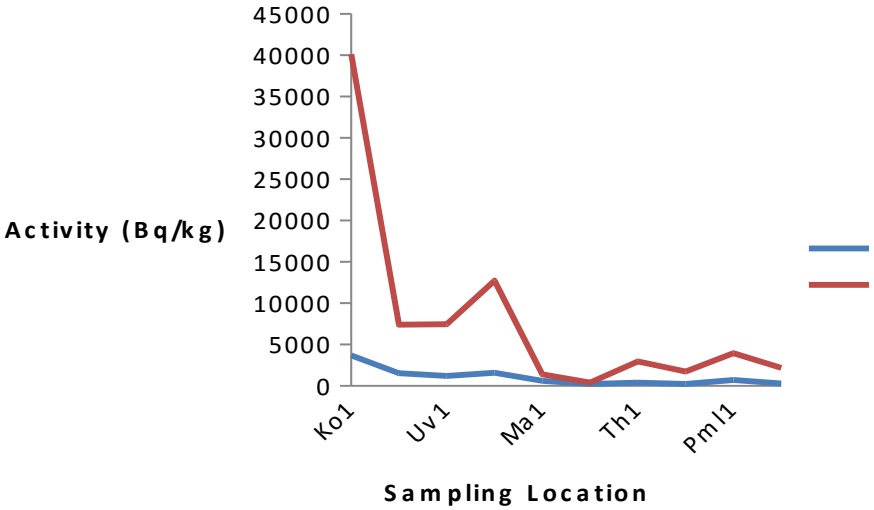

Fig 1. The gross alpha and beta activity concentration of soil samples near the sea of sieve size 0.250 mm

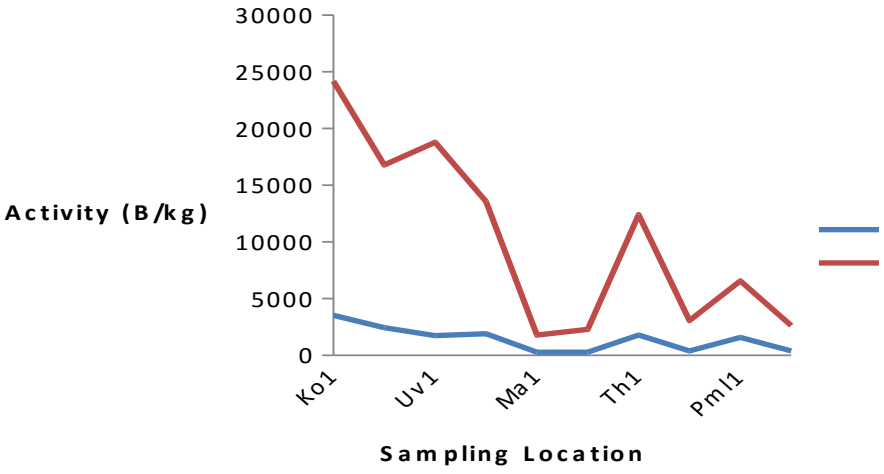

Fig 2. The gross alpha and beta activity concentration of soil samples near the sea of sieve size 0.063 mm

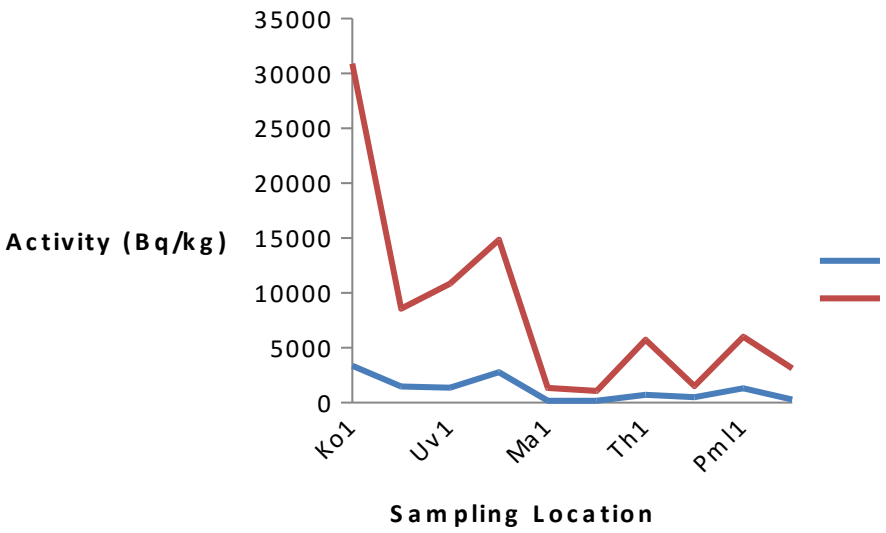

Fig 3. The gross alpha and beta activity concentration of soil samples near the sea of sieve size 0.025 mm

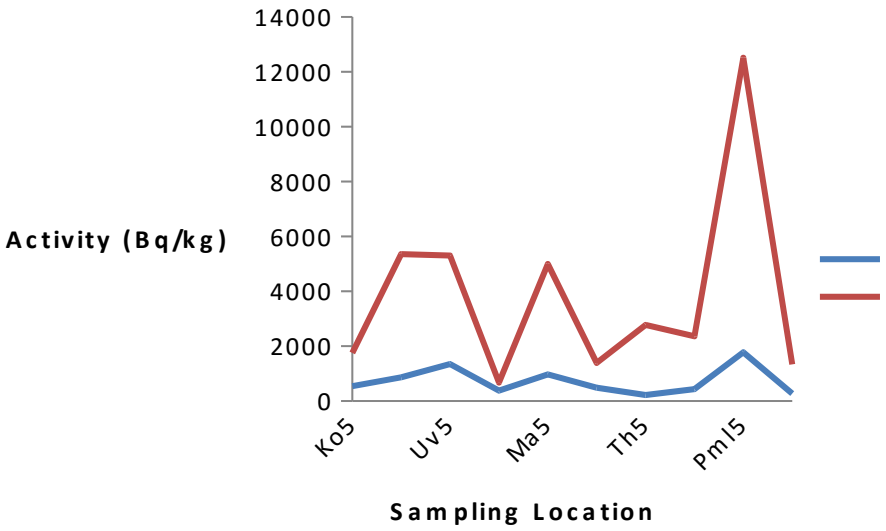

Fig 4. The gross alpha and beta activity concentration of soil samples 150 m away from the sea of sieve size 0.250 mm

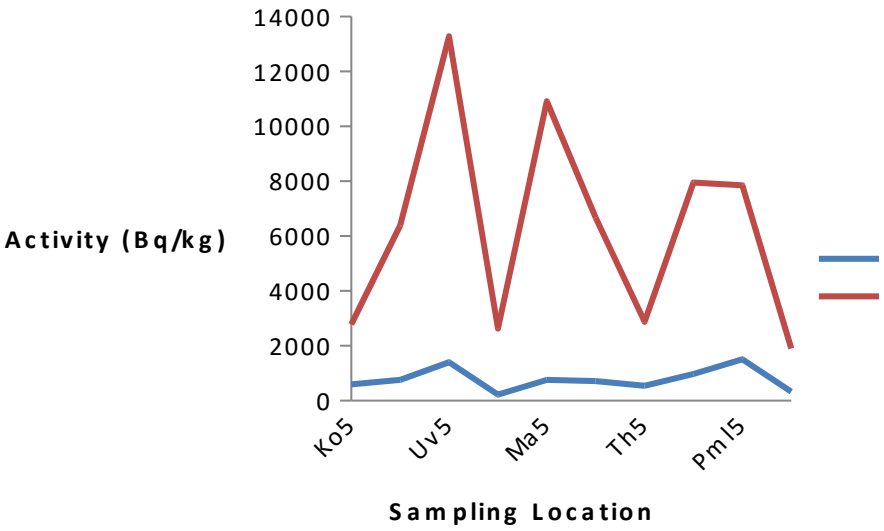

Fig 5. The gross alpha and beta activity concentration of soil samples 150 m away from the sea of sieve size 0.063 mm

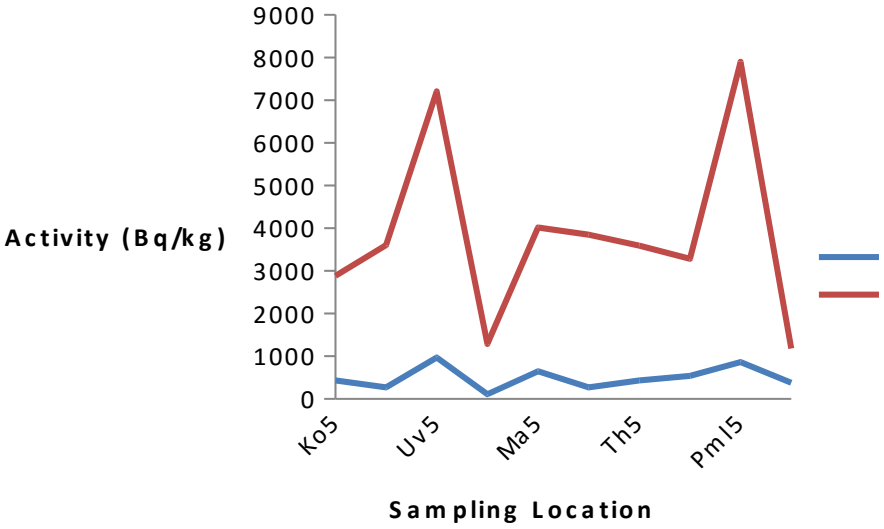

Fig 6. The gross alpha and beta activity concentration of soil samples 150 m away from the sea of sieve size 0.025 mm

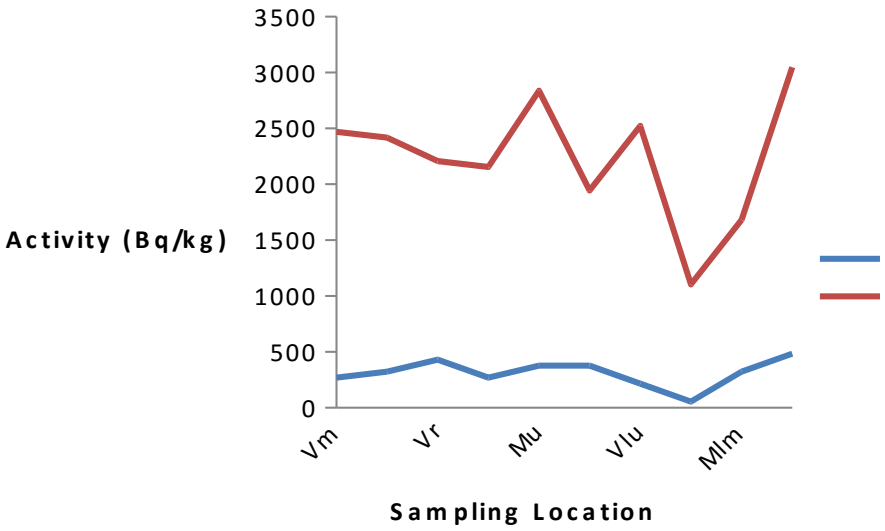

Fig 7. The gross alpha and beta activity concentration of soil samples in the sub-urban area of sieve size 0.250 mm

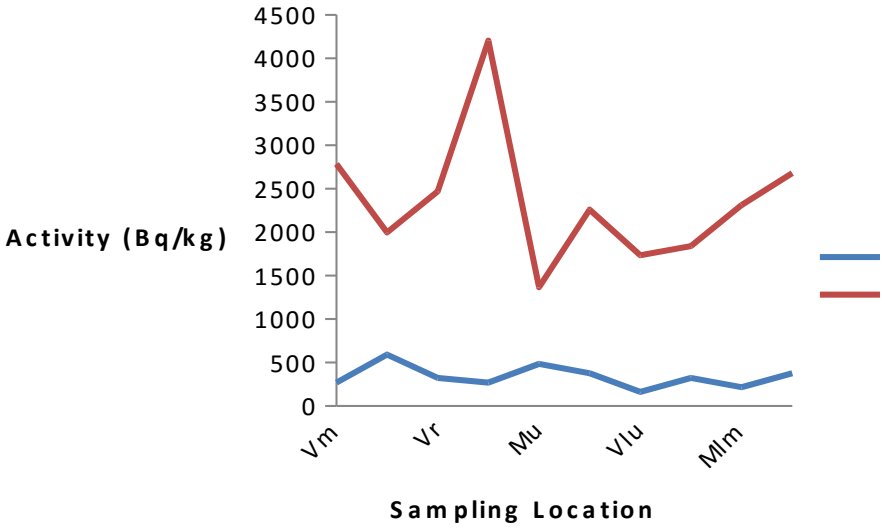

Fig 8. The gross alpha and beta activity concentration of soil samples in the sub-urban area of sieve size 0.063 mm

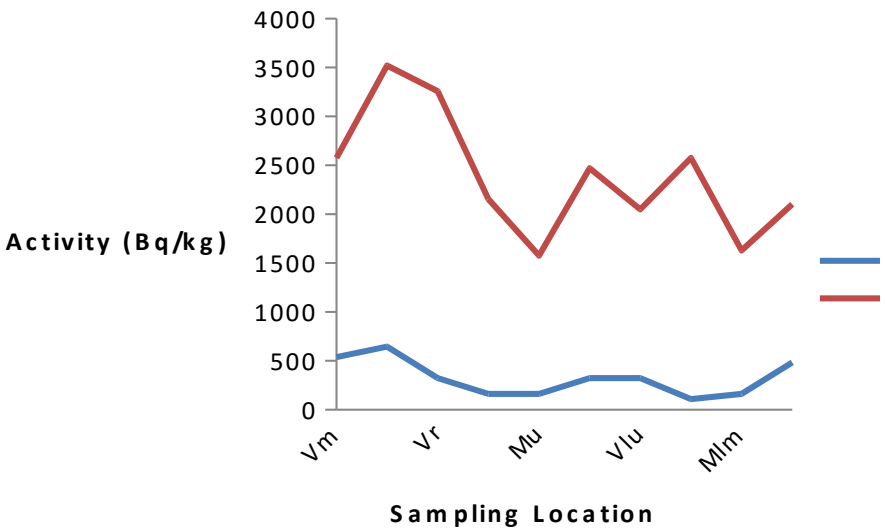

Fig 9. The gross alpha and beta activity concentration of soil samples in the sub-urban area of sieve size 0.250 mm

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