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ACTIVITY CONCENTRATION AND ASSOCIATED RADIATION DOSE IN MACHINJONI DUMPSITE IN TRANS-NZOIA COUNTY, KENYA.

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Abstract: The activity concentration in Machinjoni dumpsite has been investigated. Activity concentration was measured using a 76 mm x76 mm NaI (Tl) detector using gamma ray spectrometry technique and various radiological parameters calculated to quantify the level of radiological hazardousness posed by the dumpsite on those interacting with the dumpsite. The mean activity concentration of ^{238}U, ^{232}Th and ^{40}K in the dumpsite were 16 ± 0.83 $BqKg^{-1}$, 68 ± 3.4 BqKg-1 and 60 ± 3 BqKg-1 respectively. ^{232}Th exceeded the permissible limit of 45 $BqKg^{-1}$ while ^{238}U and ^{40}K were within permissible limits. The radiological hazard calculated in this study was absorbed dose rate. The calculated values of absorbed dose rate ranged from 29 ± 1.45 to 140 ± 7.03 $nGyhr^{-1}$ with a mean of 51 ± 2.56 nGh^{-1} and were lower than the world mean value of 84 $nGhr^{-1}$. From the values it can be seen that there is significant radiation it parts of the dumpsite even though the mean values were all below permissible world values.

I.INTRODUCTION

Natural radioactivity contributes significantly towards the total radiation exposure which humans receive [1]. This is due to presence of primordial radionuclides in the environment (soil and water). These primordial radionuclides have long half-lives and contribute heavily to the background radiation [2].Therefore, for most individuals, exposure to natural background radiation is the most significant part of their total exposure to radiation [3]. However, a relatively small amount of radiation in the environment comes from artificial sources including medical irradiating devices like x-ray machines, nuclear power plants and nuclear medicine (radiopharmaceuticals) [4].

Exposure to radiations by humans depends on the radioactivity pathways from a source located outside the human body or inside the human body [5]. In these modern times, the risk of radioactivity has been escalated further due to the numerous applications of radioactive materials in various industrial processes. This has led to generation of radioactive wastes which find their way in dumpsites.

Lack of proper waste management practices of dumpsites coupled by high poverty prevalence levels has made people exposed to wastes in towns and cities. This because most dumpsites are not fenced and are located very close to informal settlements in towns and cities. Therefore the transfer of radionuclides in the environment is inevitable. The transfer coefficients of radionuclides depend on movement of radionuclide from one compartment to another such as the movements of radionuclides in the body to build-up the dose is by inhalation and ingestion [5].

Most of the poor populations in urban centers make livelihoods from dumps by collecting, reusing and selling objects which can be recycled. Thus they are susceptible to the detrimental effects of gamma radiation emanating from the wastes unknowingly. Consuming food stuffs from the dumpsite is a huge health and radiological risk. Similarly consuming animal products fed on dumpsites increases risk. This is because food contamination includes food crops and animal products as a consequence of terrestrial intake. Exposed plant parts are also possible means of transfer of radionuclides to human by eating directly or through animal products such as meat, milk, or eggs [5].

Rapid population growth, urbanization, industrial growth and economic development have led to the generation of significant quantities of solid wastes, which are causing serious environmental degradation. These wastes have diverse nature and have various health effects. Moreover wastes are dumped without proper physical isolation of hazardous materials [6]. Since even low concentrations of the radioactive isotopes of radium can create a health hazard by accumulating in the lungs, circulating in the blood-stream and deposited in bone and teeth [7], it is important keep the process of keep the monitoring process of food and environment continuous and unbroken since elevated radiation levels recorded can be used to plan future improvements to minimize the risk and avert diseases [8].

MATERIALS AND METHODS

Materials

A digger and spade, GPS machine, plastic bags, sodium iodide detector.

Sample preparation and analysis

Sample preparation

Samples were collected by random method to achieve statistical sensitivity [9]. At each sampling point three samples were collected and mixed to produce a composite quality assurance. A digger and spade were used in collecting soil samples. Twenty soil and ten water samples were collected. Five soil samples were collected from the nearby farms to quantify the extend of spread of the pollutants. During collection, care was taken not to mix the samples and avoid contamination. In each site, vegetation and debris were removed to expose soil and collected at a depth of about 20 to 23 cm. Each soil sample was carried in a plastic container and sun dried in a dry weather separately for 30 days to attain constant mass. The dried samples were individually pulverized using a motor and pestle manually and sieved through a 200 µm steel mesh for homogeneity without contamination through mixing. Each sample was placed in a 200 ml plastic Marinelli beaker, sealed, labeled and stored for 30 days to allow ^{238}U, ^{232}Th to reach secular equilibrium with their radioactive daughters before measurement [10]

Figure 1: Machinjoni dumpsite

Sample analysis

Samples were taken to the Laboratory where weighing was done and activity concentration was measured using a 76 mm x76 mm NaI (Tl) detector. The activity concentration was used to calculate other radiological parameters.

Activity concentration

The activity concentration of ^{226}Ra was determined by the 1764KeV γ-line of ^{214}Bi, activity concentration of ^{40}K determined by a single 1460 KeV γ-line and the 2614 KeV γ-line of ^{208}Ti was used to determine concentration of ^{234}Th. Activity of each radionuclide was determined using net area under photo peaks using equation (1.0)

$$A_C = \frac{C_n}{\varepsilon_{yM_sI_y}} \quad (1.0)$$

Where, A_c is the activity concentration of radionuclide in the sample given in BqKg^{-1}, C_n- is net count per second of sample under the corresponding peak, ε_y is efficiency of detector at specific γ-ray energy, M_s is mass of sample (Kg) and I_y is intensity of gamma ray at particular energy being counted.

Calculation of radiological hazard

From the activity concentration, the following radiological parameters were calculated to quantify the level of radiations emitted in the dumpsite: Absorbed Dose Rate calculated according to the equations 2.

Absorbed Dose Rate

The absorbed dose rate, D (nGy/h) in air at 1 m above ground level because of 226Ra, 232Th, 40K, radionuclides in soil samples at each site was calculated using equation (3) [11], where A_{Ra}, A_{Th}, and A_K, are the activity concentration of uranium, thorium and potassium radionuclides respectively. Absorbed dose rate is used to assess potential for biochemical changes in specific tissues due to interaction with ionizing radiations.

$$D(nGyh^{-1}) = 0.416A_{Ra} + 0.623A_{Th} + 0.0414A_k \quad \ldots\ldots\ldots\ldots\ldots (2)$$

RESULTS

Activity concentration

Activity concentration of Uranium-238, Thorium-232 and Potassium-40 in soil samples from Machinjoni dumpsite in Trans-Nzoia County have been measured and calculated by equation (1). There was elevated activity concentration due to Uranium-238 in samples D6, D7, D8, D9, and D17 .Sample D3 exceeded the permissible limit. Similarly, samples D1, D3, D5, D6, D7, D8, D9, D10, D12, D14, D15, D16, D17, D18, D19 and D20 had elevated activity concentration due to thorium-232 which exceeded the permissible limit of 45 Bq/Kg (UNSCEAR, 2000). This would be attributed to dumping of construction wastes which contain granite, sandstone and quartzite which have been reported in this county [13]. The activity concentration of thorium-232 and uranium-238 in the dumpsite is not minimal .However, the activity concentration due to potassium-40 in all samples were below the permissible value of 420 Bq/Kg as seen from table (1) hence no significant radiological threat due this radionuclide in Machinjoni dumpsite. The minimum activity concentrations of ^{238}U, ^{232}Th and ^{40}K were 5.9±0.29 BqKg^{-1}, 38.19 BqKg^{-1} and 25± 1.28 BqKg^{-1} while maximum values were 41±2.05 BqKg-^{1},192± 9.61 BqKg^{-1} and 131± 6.57 BqKg^{-1} respectively. The mean activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the dumpsite are 16±0.83 BqKg^{-1}, 68±3.4 BqKg-1 and 60±3 BqKg-1 respectively as shown in table (1.0).

Table 1: Showing the radiological parameters and their corresponding mean values compared to permissible world values.

ID	**ACTIVITY CONCENTRATION (Bq/Kg)**			**ABSORBED DOSE RATE (nGy/h)**
	U-234	**Th-232**	**K-40**	
D1	13±0.67	65±3.25	25±1.28	46±2.33
D2	8±0.41	38±1.9	52±26	29±1.45
D3	41±2.05	192±9.61	131±6.57	140±7.03
D4	12±0.64	40±2	74±3.73	33±1.66
D5	17±071	45±2.25	25±1.29	34±1.74
D6	27±1.39	64±3.3	55±2.76	53±2.69
D7	22±1.11	84±4.24	77±3.85	64±3.23
D8	28±1.41	84±4.21	85±4.29	67±3.37
D9	22±1.1	65±3.28	66±3.34	52±2.63
D10	14±0.71	82±4.11	66±3.34	59±2.95
D11	11±0.58	38±1.9	45±2.26	30±1.51
D12	9±0.47	45±2.28	44±2.24	33±1.68
D13	8±0.44	44±2.22	60±3.01	33±1.67
D14	23±1.18	84±4.22	97±4.88	66±3.3
D15	14±0.73	67±3.36	64±3.21	50±2.5

D16	6±0.33	58±2.91	38±.9	39±1.99
D17	21±1.06	92±4.62	50±2.52	67±3.39
D18	14±0.76	55±2.77	63±3.19	42±2.14
D19	13±0.65	68±3.43	29±1.49	48±2.44
D20	5±0.29	43±2.18	47±2.37	31±1.55
MEAN	**16±0.83**	**68±3.4**	**60±3**	**51±2.56**
WORLD MEAN	**33**	**45**	**420**	**84**

The calculated values for various activity concentrations and absorbed dose rates (ADR) are presented in the table(1)
The activity concentration for the three primordial radionuclides values are plotted on fig (1) below.

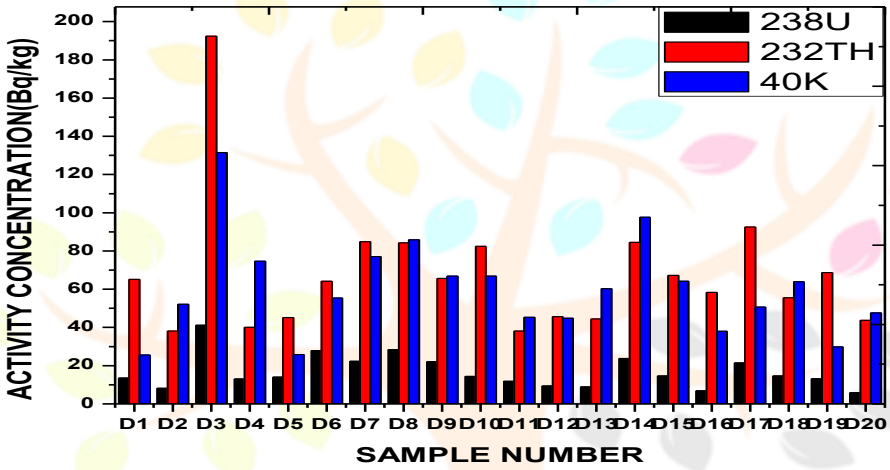

Figure 1. Activity concentration of the samples.

Sample D3 had elevated activity concentration of the three primordial radionuclides .However the concentration of the radionuclides varied generally showing uneven distribution in the dumpsite due to dumping practices and other activities such as turning of wastes to facilitate decomposition. Generally, the activity concentrations of different radionuclides in Machinjoni dumpsite showed that $^{238}U<^{40}K<^{232}Th$ in most of the sampling sites Thus thorium was the most abundant radionuclide in the dumpsite

Absorbed dose rate

From table 1, it the absorbed values ranged from 29±1.45 nGy/h to 140±7.03 nGy/h. This highest value was almost double the permissible value of 84 nGy/h. Similarly several other samples such as D7, D14 and D17 exhibited elevated values which were in close range to the permissible limit. This point to pollution of the dumpsite with radionuclide .The distribution of radionuclide is not uniform due to various dumping activities which involves turning of the wastes to allow the decay process. Nevertheless the average value of the absorbed dose rate from fig1 of 51±2.56 nGy/h and was below the permissible value. The elevated values of radiological parameters in specific samples may be attributed to dumping and deposition of industrial matter in the soil such as fertilizer, building materials [14]. The absorbed dose rates are shown in fig 2.

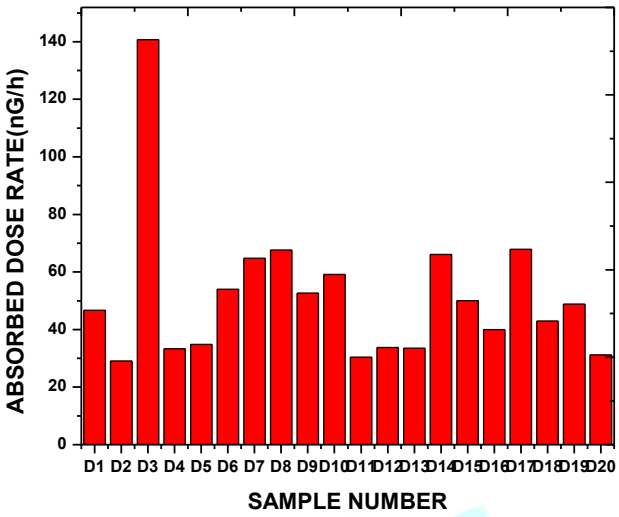

Figure 2. Absorbed dose rates distribution in the soil samples.

CONCLUSION

Assessment of hazard levels due natural radioactivity in municipal dumpsite of Machinjoni in Trans-Nzoia County, Kenya has been carried out. Absorbed Dose Rate has been calculated in this study from the activity concentration. From the results obtained, the mean activity concentrations for potassium-40 and uranium-238 were below permissible value of 420 Bq/Kg and 33 Bq/Kg respectively. However the mean activity concentration of thorium-232 was higher than the permissible value. Thus the exposure to gamma radiation to the users of the dumpsite is not generally low since some sites showed elevated values of activity concentration.

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