Distribution of Gamma-Emitting Radionuclides in the Soils of the Neudamm Campus of the University of Namibia, Windhoek, Namibia

J. A. Oyedele*, E. Taapopi and S. Shimboyo
Department of Physics, University of Namibia
340 Mandume Ndemufayo Avenue, Private Bag 13301, Pioneerspark, Windhoek, Namibia

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Abstract

The concentrations of naturally occurring radionuclides ^{40}K, ^{232}Th and ^{238}U in soil samples taken from the Neudamm campus of the University of Namibia, Windhoek, Namibia have been determined and used to calculate a mean annual effective dose for the campus. The concentrations were measured using a sensitive gamma-ray spectroscopic system consisting of a high purity germanium detector and associated equipment. ^{40}K was found to have the highest specific concentration varying between 229.1 $\pm$ 13.5 Bq kg^{-1} and 499.0$\pm$ 16.5 Bq kg^{-1} with a mean value of 364.5 $\pm$ 79.3 Bq kg^{-1} while the concentration of ^{232}Th varies between 10.4 $\pm$ 2.8 Bq kg^{-1} and 38.5 $\pm$ 3.8 Bq kg^{-1} with a mean value of 28.0 $\pm$ 9.2 Bq kg^{-1} and the concentration of ^{238}U varies between 11.7$\pm$ 1.3 Bq kg^{-1} and 24.7 $\pm$ 2.1 Bq kg^{-1} with a mean value of 18.5 $\pm$ 4.8 Bq kg^{-1}. The value of 0.05 $\pm$ 0.01 mSv y^{-1} obtained for the mean annual effective dose is well below the limit of 1 mSv y^{-1} recommended for the public by the International Commission on Radiological Protection. This result indicates that radiation hazard is negligible on the campus.

Keywords: Radionuclides, Gamma, Soil, Neudamm, Namibia.

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1 Introduction

It is well-established that naturally occurring radionuclides such as ^{40}K, ^{232}Th and ^{238}U are present in the soil where they release ionizing radiation (Karunakara et al. 2001; Hashim et al. 2004; Abusini et al. 2008; Sahin and Cavas 2008). This radiation could pose health problems to the inhabitants of a given location especially when the concentrations of the radionuclides are high. It is for this reason that many researchers measure the concentrations of these radioisotopes in soils. When the concentrations are high so that the resulting radiation is high, the area is said to be a high background radiation area (Ghiassi-nejad et al. 2002). Namibia has many mineral resources including uranium, and the concentrations of these radionuclides in the soils may be high in some

*Corresponding author - E-mail: oyedelej@unam.na; Phone: +(264-61) 206-3373; Fax: +(264-61) 206-3791.

areas thus making them high background radiation areas. Furthermore, the Neudamm campus is less than 410 km from a major Uranium mine, Rossing Uranium Ltd, and many scientists, workers and students from different countries and continents are working or studying at the campus. It is therefore desirable to know the concentrations of naturally occurring radionuclides in the soils of the campus and thereby determine whether the campus has a normal or high background radiation.

Neudamm campus is about 38 km outside Windhoek. It is also close to Namibia's main international airport, the Hosea Kutako International Airport. The campus is well-known for teaching and research in agriculture and a number of foreign Heads of State and dignitaries have visited and commended the campus in recent years.

The main objective of this study was to determine the concentrations of the naturally occurring radionuclides ^{40}K, ^{232}Th and ^{238}U in soil samples collected from the Neudamm campus of the University of Namibia and use the data to obtain a mean annual effective dose for the campus. This information will help determine whether the campus has a normal or high background radiation as well as providing a base-line data on background radiation for the campus.

2 Materials and Methods

Ten soil samples were collected at different sites around the student hotels and staff quarters as well as in the academic area of the Neudamm campus. All the samples were packed with identification labels. The samples were subsequently processed and kept long enough for the radionuclides in them to reach secular equilibrium with their respective progeny.

The gamma-ray spectra for the soil samples were measured using a well-shielded HPGe detector connected to the usual electronic components of preamplifier, amplifier, etc. Reference samples supplied by the International Atomic Energy Agency (IAEA) - RGU-1, RGTh-1 and RGK-1 - were used to calibrate the detector. Each sample was counted for 10800 seconds. All the measurements were carried out in the Radiation Physics Laboratory of the Physics Department of the University of Namibia, Windhoek, Namibia.

The intensities of the gamma lines 1.465 MeV of ^{40}K, 0.911 MeV of ^{232}Th and 0.609 MeV of ^{238}U were used to determine the activity concentrations of ^{40}K, ^{232}Th and ^{238}U respectively. These concentrations were subsequently used to calculate a mean annual effective dose.

3 Results and Discussion

The activity concentrations of ^{40}K, ^{232}Th and ^{238}U determined in each sample are shown in Table 1 (columns 2-4). As could be observed in the Table, the concentration of ^{40}K varies from 229.1 $\pm$ 13.5 Bq kg^{-1} to 499.0 $\pm$ 16.5 Bq kg^{-1} with an average of 364.5 $\pm$ 79.3 Bq kg^{-1}. Similarly, the concentration of ^{232}Th varies from 10.4 $\pm$ 2.8 Bq kg^{-1} to 38.5 $\pm$ 3.8 Bq kg^{-1} with an average of 28.0 $\pm$ 9.2 Bq kg^{-1} while the concentration of ^{238}U varies from 11.7 $\pm$ 1.3 Bq kg^{-1} to 24.7 $\pm$ 2.1 Bq kg^{-1} with an average of 18.5 $\pm$ 4.8 Bq kg^{-1}. It therefore follows that the concentrations of these radionuclides are much different from each other (averages of 364.5, 28.0 and 18.5 Bq kg^{-1} for Potassium-40, Thorium-232 and Uranium-238 respectively). Also, the concentration of a given radionuclide varies significantly across the campus (229.1 - 499.0, 10.4 - 38.5, and 11.7 - 24.7 Bq

Table 1: Radionuclide concentrations in different soil samples and the corresponding annual effective dose.

Sample	Radionuclides concentration (Bq/kg)			Annual effective Dose (mSv)‡
	^{238}U	^{232}Th	^{40}K	
1	14.1±1.9	21.2±3.0	294.5±16.0	0.04
2	11.7±1.3	10.4±2.8	229.1±13.5	0.03
3	17.5±2.0	16.3±3.1	386.1±18.5	0.04
4	17.3±3.0	30.1±3.6	499.0±16.5	0.04
5	21.1±2.0	34.5±3.7	410.3±19.4	0.06
6	20.1±2.1	31.3±3.4	364.3±18.2	0.05
7	23.2±2.8	38.5±3.8	423.4±19.7	0.06
8	24.7±2.1	33.7± 3.5	420.5±19.3	0.06
9	23.3±1.9	36.6±3.6	312.0±17.8	0.06
10	11.7±1.3	27.4±3.3	306.2±16.3	0.04
All samples	18.5±4.8	28.0±9.2	364.5±79.3	0.05±0.01

‡The errors in the ten values are between (± 0.002 mSv) and (± 0.004 mSv).

kg^{-1} for Potassium-40, Thorium-232 and Uranium-238 respectively.) These results also show that ^{40}K has the highest concentrations in the soil of the campus while ^{238}U has the lowest concentrations in the soil. Furthermore, the concentrations of ^{40}K are much higher than those of ^{232}Th and ^{238}U. However, the relatively high concentrations of ^{40}K in the soil have also been observed in some other places in African countries such as Egypt (Al-Sharkawy et al. 2012).

The corresponding annual effective dose calculated for each site is shown in column 5 of Table 1. A conversion factor 0.7 Sv Gy^{-1} and an occupancy factor 0.2 was used to convert the absorbed dose rate $D = 0.0417AK + 0.462AU + 0.604ATh$ (where AK, AU, ATh are the activity concentrations of ^{40}K, ^{232}Th and ^{238}U respectively) to annual effective dose. The effective dose varies from 0.03 mSv to 0.06 mSv with an overall average of 0.05 mSv for the campus. All these values are below the maximum permissible annual dose of 1 mSv recommended for the public by the International Commission on Radiological Protection, ICRP (Wrixon 2008). This indicates that the Neudamm campus has a normal background radiation.

4 Conclusion

The concentrations of the three radionuclides ^{40}K, ^{232}Th and ^{238}U in the soil of the Neudamm campus are much different from each other and the concentration of a given radionuclide varies across the campus. ^{238}U has the lowest average concentration while ^{40}K has the highest average concentration. However, the corresponding average annual effective dose is much below the maximum permissible annual dose of 1 mSv recommended for the public by the ICRP thus indicating that the campus has an acceptable background radiation.

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