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Evaluation of Radiation Hazard Indices and Excess Lifetime Cancer Risk Due To Natural Radioactivity in Mined Tailings in Some Locations in JOS Plateau State Nigeria

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Abstract: *The radiological effects of mined tailings in some locations in Jos Plateau State have been estimated. The samples were collected from 14 different sites. The radio nuclides concentrations in the tailing samples were measured using gamma spectroscopy method. The average values of ^{226}Ra, ^{232}Th and ^{40}K obtained were 762.4Bqkg^{-1}, 17258.3Bqkg^{-1} and 5901.4Bqkg^{-1} respectively. These radioactivity concentration values obtained are far above the world average value of 400Bqkg^{-1} for ^{40}K, 35BQkg^{-1} for ^{226}Ra and 30Bqkg^{-1} for ^{232}Th by UNSCEAR. The hazard indices and excess lifetime cancer risk were estimated using standard analytical methods. The average values obtained for annual gonnadal equivalent dose, radium equivalent, external hazard index, internal hazard index, representative gamma indices, annual effective dose equivalent (outdoor), annual effective dose (indoor) and excess lifetime cancer risk respectively were 76348.49Svyr^{-1}, 25896.16Bqkg^{-1}, 70.20Svyr^{-1}, 71.98Svyr^{-1}, 181.60Svyr^{-1}, 86250.95μSvyr^{-1}, 13877.58μSvyr^{-1} and 48571.52 x 10^{-3}. The values when compared with the corresponding world recommended levels were found to be far above the standard limit and as such, radiation exposure to the miners, those that process it and those that live very close to the study area will pose significant health hazard to them. The results of this study show the importance to investigate the radioactivity levels in drinking water, vegetables grown and cattle reared in the study area*

Key Words: *Tailings, health Hazard indices, Radiation, Excess lifetime cancer risk, Jos*

I. Introduction

It is important to know radiation levels and radionuclide distribution in our environment in other to assess the effects of radiation exposure. Exposure to this radiation can cause damage to living cells resulting in either cell death as a result of exposure to large dose of radiation beyond the threshold of living cells or cell modification.

Exposure to radiation has been associated with most forms of leukemia and with cancers of many organs such as lung, breast and thyroid (UNSCEAR 2000). There is an increased chance of developing cancer as a result of exposure to radiation about the global average level of natural radiation (UNSCEAR 2000). This radiation induced cancer may manifest decades later after exposure which does not differs from cancers that arise as a result of other factors.

All individuals are exposed to radiation. This could emanate from natural sources such as cosmic rays and naturally occurring radioactive substances which may be internally or externally.

Various human activities which involve the use of radioactive substances and radiation tend to cause radiation exposure in addition to the natural exposure. Example of such includes mining, processing and the use of ores which contain naturally radioactive substances among others.

Although most human activities generally result in radiation exposures that are just a bit greater than the global average level of natural exposure even though there are some that result in much greater exposure, however individuals residing near installations that result in environmental exposure may be subjected to higher exposure.

A lot of mining activities have been taking place in Jos area, for several decades, with extensive commercial mining and processing starting in 1930's (Onuoba,1992). An extensive quantity of mine tailings have been generated by the several mining companies that operated in the area and these are either in the Premises of the mining companies or are dumped in and around the mining pits (Funtua, 2001).Different kinds of radioactive wastes both in liquid, gaseous and solid form have different levels of radioactivity and therefore required different methodsof management (GAEC, 2005). Tailings also known as tailings pile, tailsleach residue or slickens are the materials left over after the process of separating the valuable fraction from the worthless fraction of an ore. These are waste products that have no financial gain to a mineral operator at that particular point in time. These tailings consist of ground rock and process effluents that are generated in a mine processing plant.

Tailings characteristics can vary greatly and dependent on the ore mineralogy together with the physical and chemical processes used to extract the economic product. Tailings of the same type may possess different mineralogy and therefore will have different physical and chemical characteristics (Ritsey, 1989).

Tailings are around ten times moreradioactive than typical granites. If someone were tolive continuously on top of the ranger tailings, theywould receive about double their normal radiationdose from the actual tailings or even more (Nasir,

1993).

Typically, the tailings consist of heavyaccessory minerals that include: Zircon, monazite,xenotine, ilmenite, magnetite, some columbite andcassiterite (Funtua, 2001).These tailings that contain radioactiveelements remain active for a very long period of timeand will continue to be potentially dangerous. Overthe last century, the volume of tailings beinggenerated has grown dramatically as the demand forminerals and metals has increased and lower grades

of ore are being mined. In the 1960's, tens ofthousands of tons of tailings were produced eachday and by 2000 this figure has increased to hundredsof thousands (Kajubick, et al., 2003).Significantly, the hazardous nature ofradioactive source depends on the radionuclidesactivity.Monazite and Zircon are found to be morehazardous than the rest of the minerals that arefrequently associated with cassiterite (garnet, pyrite,rutilegeetc) (Umar and Rabiu, 1995). As such, allthese minerals are radioactive and a major source ofexternal radiation hazard to workers who handle themin the mines and mills as well as the general publicliving around the area.Both mechanical and chemical processes areused to extract the desired product from the mine oreand produce a waste stream known as tailings (Engelsand Dixon, 2009). As mining techniques and theprice of minerals improve, it is not unusual for tailingsto be reprocessed using new methods or morethoroughly with old methods, to recover additionalminerals. Yesterday's tails can be tomorrow's resourceas seen during the 1990's when the extensive tailingsdumps of Kalgoorlie/Boulder in Western Australiawere reprocessed profitably by kaltails mining(Wikipedia the free encyclopedia).

This study examines some of the radiation hazard indices of some natural occurring radionuclides (^{226}R, ^{232}Th and ^{40}K) in tailings from processing sites in Jos which is a principalcenter of tin and columbite mineralization, which forms the focal area of younger granites (Macleod et al., 1971). The mine tailings are associated with radioactive minerals as impurities such as monazite, zircon amongothers. These minerals are very radioactive and cause hazards to human health during mining and milling. This data will help to ascertain the safety of these processing sites. The data generated will add to the world data-base of naturally occurring radio nuclides and radiation hazard indices in tin processing areas and will be useful for authorities in charge of environmental monitoring such as the Plateau state environmental protection agency for implementation of radiation protection standards for Tin mining, processing area and the general public

II. Materials and method

The tailings samples were collected from the different locations and were left opened in the laboratory to dry. They were then packed in cylindrical containers of 7cm height by 6cm width containing approximately 630g of the sample. They were sealed and stored for 24 days to allow for radium equilibrium

A gamma ray spectrometry technique was employed using the high energy region of the γ-lines. The measuring system consists of a NaI (TI) detector housed in thick lead shield lined with cadmium and copper sheets. The samples were mounted on the detector surface and counted for 5,000 seconds. This configuration was strictly maintained throughout the analysis. A computer based multichannel analyser from ortec was used for data acquisition and analysis of gamma spectra. The 661.6KeV x-line of GS-137 was used in the assessment of the activity concentration of ^{40}K while 132.5KeV δ-line of Ci-60 was used for ^{232}Th. The single 1173.2KeV δ-line of Co-60 was used for ^{226}Ra.We eventually evaluate the hazard indices such as:

Annual Gonadal Equivalent Dose (AGED) since the gonads and the bone marrow are considered as organs of interest by UNSCEAR 1998 because of the most sensitive parts of the human body to radiation. The formula used is

$AGED(Sv/yr)=3.09C_{Ra} + 4.18C_{Th} + 0.314C_k$.

The absorbed dose rate was evaluated using (D) $0.416C_{Ra} + 0.623C_{Th} + 0.0417C_k$

The representative Gamma index I_{yr} is used to estimate the gamma radiation hazard associated with the radionuclides in the investigated samples i.e. $I_{yr}= C_{Ra}/150 + C_{Th}/100 + C_k/ 1500$

The annual effective dose equivalent (AEDE) is calculated by applying a dose conversion factor of 0.7Sv/Gy and occupancy factor for outdoor and indoor of 0.2(5/24) and 0.8(19/24) respectively with their respective formulas as

AEDE (outdoor) (μSv/yr)= Absorbed dose D (nGy/h) x 8760h x 0.7Sv/Gy x 0.2 x 10^{-3}

AEDE (indoor) (μSv/yr)= Absorbed dose D (nGy/h) x 8760h x 0.7Sv/Gy x 0.8 x 10^{-3}

While the excess lifetime cancer risk deals with the probability of developing cancer over a lifetime at a given exposure level. It is given as ELCR= AEDE x DL x RF where DL is the average duration of life estimated at 70 years and RF is the risk factor.

III. Results And Analysis

Table 1: Activity Concentration of Radionuclides

sample no.	^{40}K (Bgkg^{-1})	^{226}Ra (Bgkg^{-1})	^{232}Th (Bgkg^{-1})
A1	5809.6±298.7	1004.8±136.1	17523.6±205.1
A2	6065.9±278.8	819.9±120.1	15604.5±194.8
A3	4772.5±230.4	661.4±171.1	14793.4±165.4
A4	4299.4±197.2	1302.8±165.3	14954.4±170.8
A5	6037.0±287.7	681.1±179.0	16040.9±179.3
A6	5499.9±280.0	674.2±111.6	18882.4±218.1
A7	2849.0±230.3	1217.1±191.3	14602.9±205.7
A8	6415.7±279.7	609.8±179.2	18528.8±216.1
A9	5535.1±266.1	564.4±106.0	14921.4±156.5
A10	7081.6±278.8	549.3±173.7	19972.5±202.1
A11	9021.6±373.7	364.9±176.4	22583.3±247.7
A12	909.3±154.4	826.2±96.7	5055.5±102.0
A13	7899.8±359.7	533.1±115.0	20222.7±218.1
A14	10423.2±406.6	864.2±196.8	27930.0±257.8

Table 2: Radiation Hazard Indices

Sample no.	Requiv. (Bq/kg)	Rep. gamma index	AGED (Sv/yr)	Hex	Hin	Absorbed dose(nGyh^{1})	AEDE Indoor (sv/yr)	AEDE outdoor (sv/yr)	ELCR x10^{-6}
A1	26510.89	185.81	78177.69	71.58	74.30	11588.63	56849.18	14212.30	49743.05
A2	23601.41	165.56	69664.99	67.20	65.94	10322.14	50636.29	12659.07	44306.74
A3	22183.45	155.53	65378.70	59.90	61.69	9691.28	47541.54	11885.39	41598.86
A4	23018.65	161.10	67885.06	62.15	65.68	10067.86	49388.89	12347.22	43215.29
A5	24084.44	168.97	71051.18	65.03	66.87	10527.81	51645.22	12911.31	45189.57
A6	28099.52	196.99	82738.68	75.87	77.69	12266.80	60176.01	15044.00	52654.00
A7	22318.62	156.04	65695.55	60.26	63.55	97479.50	478195.44	11956.79	41848.77
A8	27599.99	193.63	81349.20	74.52	76.17	12055.65	59140.2	14785.05	51747.66
A9	22328.21	156.67	65853.47	60.29	61.81	9757.76	47867.67	11966.71	41883.49
A10	29655.26	208.11	87406.01	80.07	81.56	12952.00	63537.33	15884.34	55595.17
A11	33353.68	234.28	98358.52	90.06	91.04	14569.01	71469.74	17867.44	62536.04
A12	8125.58	56.67	23970.47	21.94	24.17	3559.09	17459.47	4364.87	15277.03
A13	30059.85	211.05	88658.70	81.16	82.60	13134.01	64430.20	16107.55	56376.43
A14	41606.69	292.01	122690.66	112.34	114.70	18178.44	89176.16	22294.04	78029.13

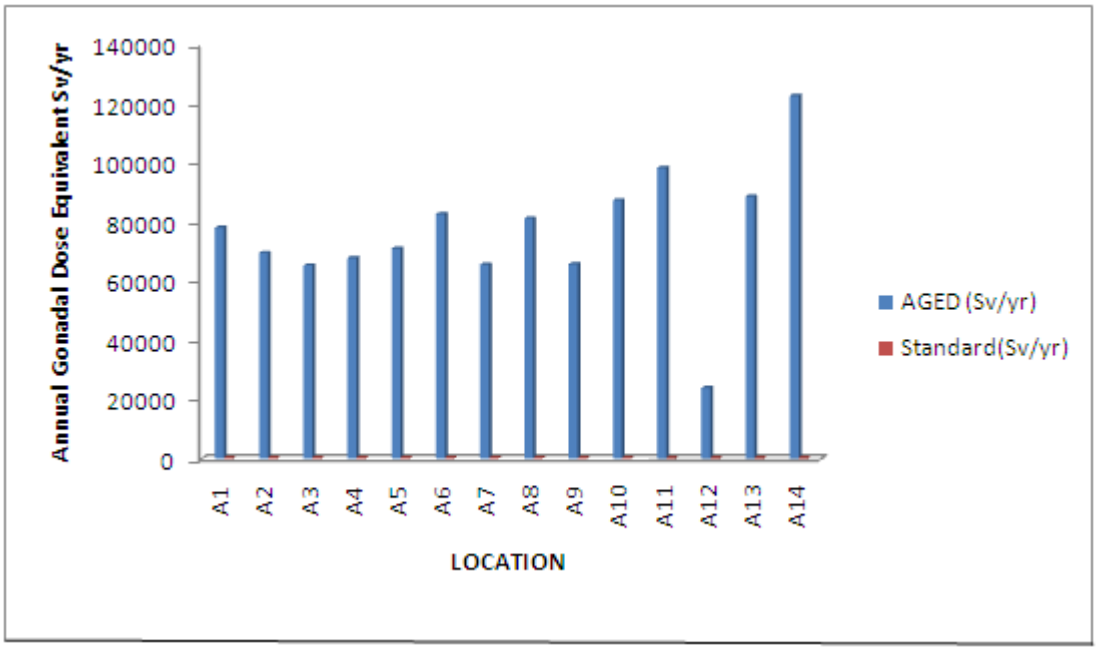

Figure 1. Annual Gonadal Equivalent compared with standard value

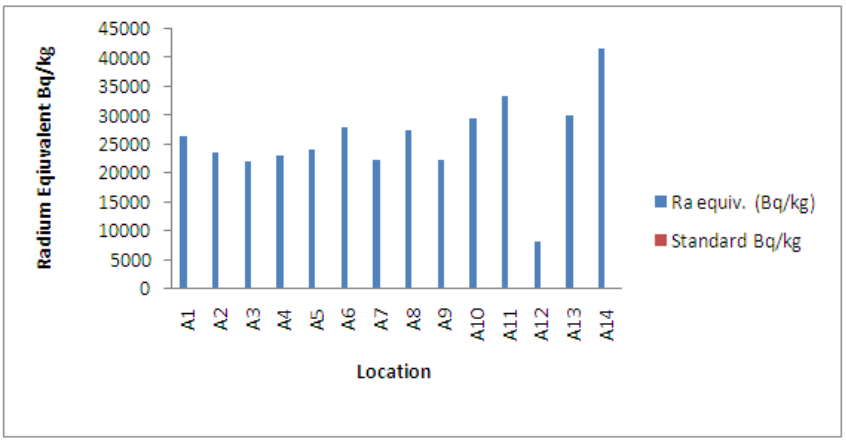

Figure 2. Radium Equivalent compared with Standard Value

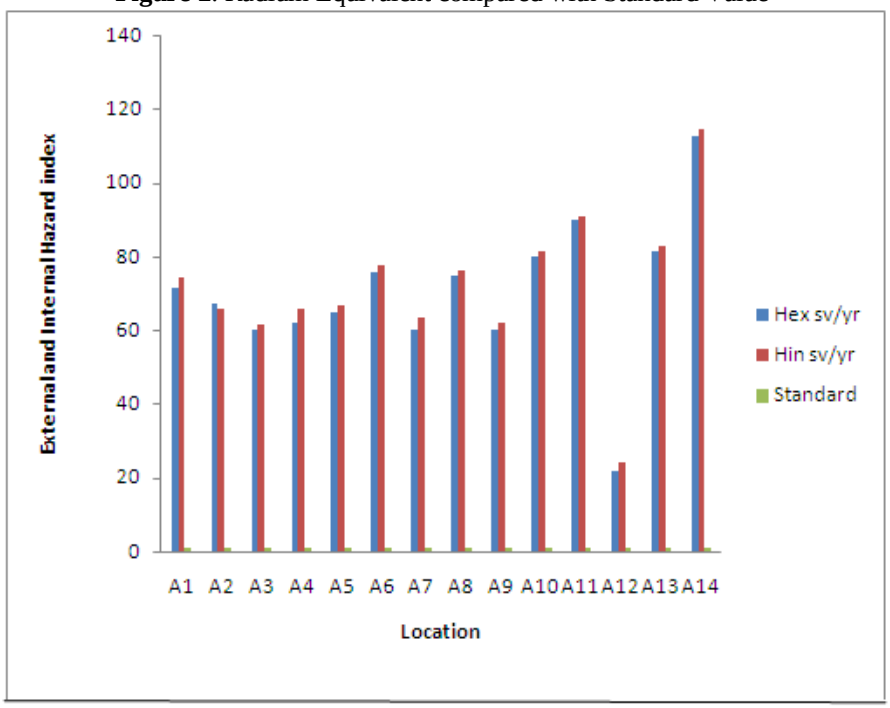

Figure 3. External and internal Hazard index compared with standard Value

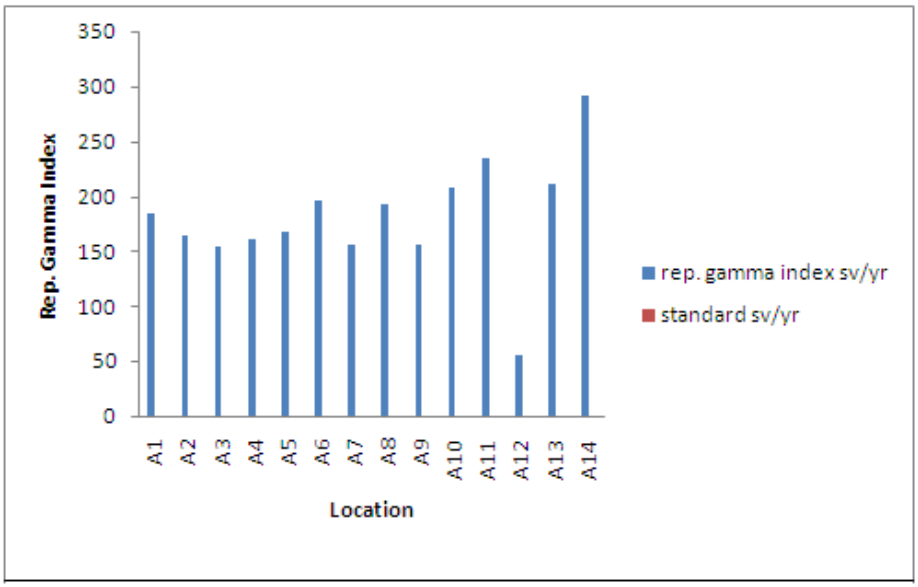

Figure 4. Rep. Gamma Index compared with standard value

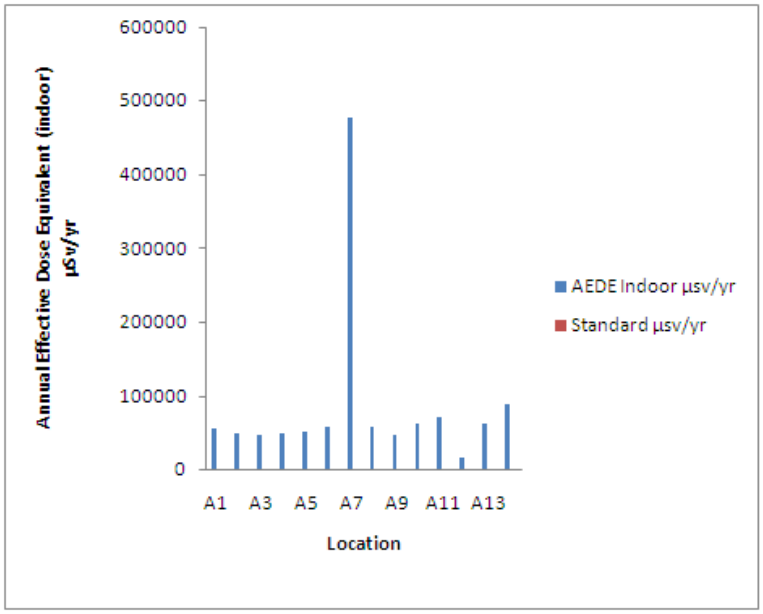

Figure 5. Annual Effective Dose Equivalent (indoor) compared with Standard Value

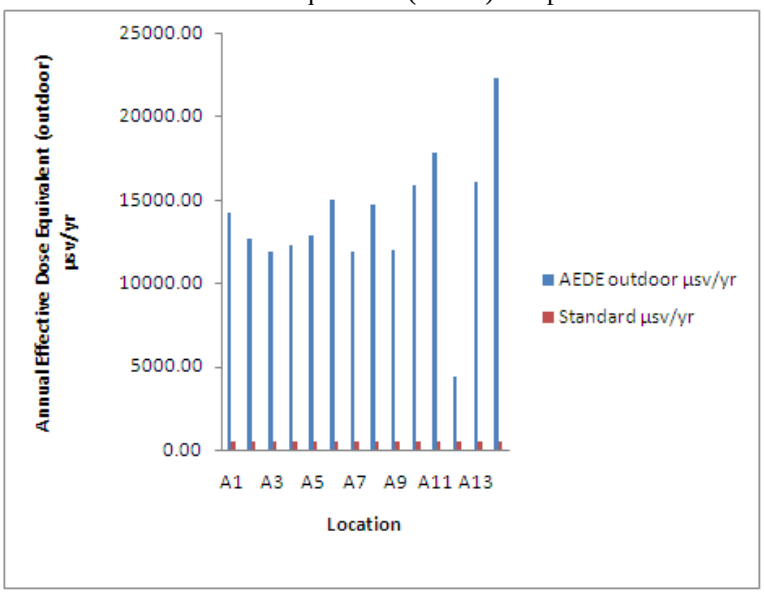

Figure 6. Annual Effective Dose Equivalent (outdoor) Compared with Standard Value

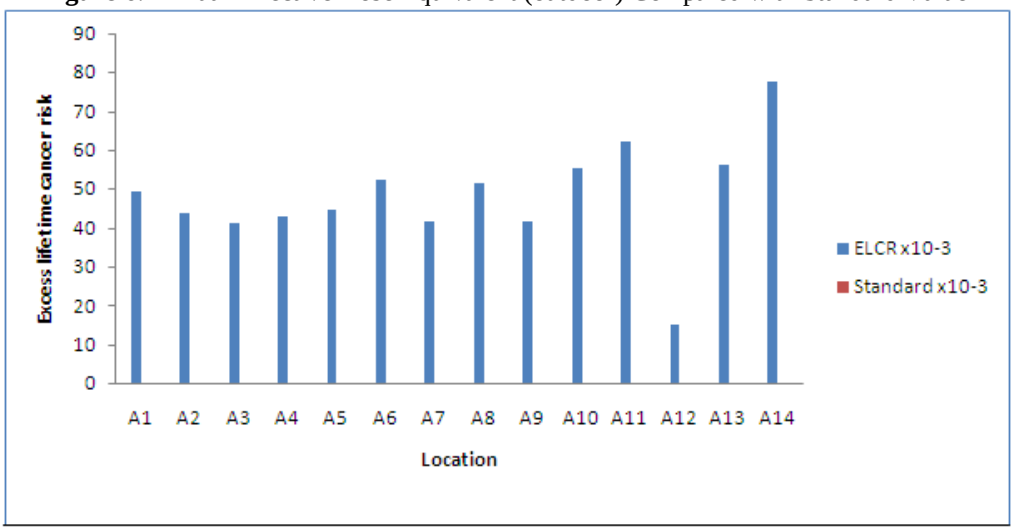

Figure 7. Excess lifetime cancer risk compared with standard value

IV. Discussion

Table 1 represent the three natural radionuclide isotopes ^{226}R, ^{232}Th and ^{40}K present in the tailings and also there hazard indices. The average values of ^{226}R, ^{232}Th and ^{40}K is 762.4Bqkg^{-1}, 17258.3Bqkg^{-1} and 5901.4Bqkg^{-1} respectively. These radioactivity concentration values obtained are far above the world average value of 400Bqkg^{-1} for ^{40}K, 35Bqkg^{-1} for ^{226}Ra and 30Bqkg^{-1} for ^{232}Th (UNSCEAR, 2000).

The results obtained for the annual gonnadal dose equivalent and radium equivalent activity is far above the permissible values of 300mSv/yr and 370Sv/yr respectively (UNSCEAR 2000). This implies that the gonadal values may pose serious threat to the bone marrow and the bone surface cells of the miners and working in the area under study. Also the external hazard index, internal hazard index and the representative gamma index are far more greater than the world permissible value of unity (Orgun et al.,2007). This implies that the value poses a high risk to respiratory diseases such as asthma, cancer including external diseases such as skin cancer, erythema, cataracts, and e.t.c.

In addition, the values for indoor and outdoor annual effective dose equivalent are higher than the world average values of 450μSv/yr and 70μSv/yr respectively. Average excess lifetime cancer risk (ELCR) for all samples is also far greater than the world average value of 0.29x10^{-3} (Taskin et al., 2009). This implies that the risk of developing cancer by the miners, workers and the people living near this environment in general is very high. Therefore processing and location of settlements in these areas poses a serious health hazard.

V. Conclusion

The evaluation of radiation hazard indices and excess lifetime cancer risk in some processed mined tailings in Jos plateau state, Nigeria was conducted.The average values obtained for annual gonnadal equivalent dose, radium equivalent, external hazard indices, internal hazard indices, representative gamma indices, annual effective dose equivalent (Outdoor) annual effective dose equivalent (indoor) and excess lifetime cancer risk respectively are 76348.49Sv/yr, 25896.16Bq/kg, 70.20Sv/yr, 71.98Sv/yr, 181.60Sv/yr, 86250.95μSv/yr, 13877.58μSv/yr and 48571.52 x10^{-3}.

The values obtained when compared with the various world permissible values were found to be above the standards and as a result exposure to the tailings by those processing and other members of the public will pose a serious health threat to human lives and the environment is said to be radiologically hazard unsafe especially the public.

References

[1]. Engels & Dixon 2009."Kaltails project, Kalgoorlie, Western Australia". Retrieved 19 October 2009.
[2]. Funtua I. I. (2001) Elemental compo of Sn-NbTg.Mine Tailings from Jos Area, CentralNigeria. ChemieErde. 56 pp. 45-53
[3]. Ghana Atomic Energy Commission (GAEC). Management and Control of radioactive wastes in Ghana (2005). Pp. 97-103
[4]. Mangset W.E. and A. T. Sheyin measurement of radionuclides in processed mine tailings in jos, plateau state Bayero Journal of Pure and Applied Sciences, 2(2): 56 – 60 Received: February, 2009 Accepted: July, 2009.
[5]. McLeod, W. N., Turner, D. C. Wright, E. P. (1971).The Geology of the Jos Plateau. I and IIGeol. Surv. Nig. Bull 32, 1 & 2.
[6]. Nasir, R. (1993). Radioactivity Levels around the Jos Tin Mines and Mills. An M.Sc Dissertation, Ahmadu Bello University, Zaria. Pp. 38-45.
[7]. Onugha W. M., (1992). The Boom and Burst in Nigeria's Solid Mineral Sub-Sector. Tin andColumbite Case, Histories. J. Min. Geol. 28, 352-362
[8]. Orgun, Y., N. Altinsoy, S.Y. Sahin, Y. Gungor, A.H. Gultekin, G. Karaham and Z.
[9]. Karaak,(2007) Natural and anthropogenic radionuclide in rocks and beach sands from Ezine region, Western Anatolia, Turkey.Applied Radiation and Isotopes., 65: 739-747.
[10]. Ritsey, N (1989). http://tailings.info/tailings.htm
[11]. Taskin, H.M, Karavus, P., Ay, A., Touzogh, S., Hindiroglu and Karaham, G., (2009)
[12]. Radionuclide concentration in soil and lifetime cancer risk due to the gamma radioactivity in Kirklareli, Turkey.Journal of environmental radioactivity, 100: 49-53
[13]. UNSCEAR (2000). Sources, Effects and Risks of Ionizing Radiation, Report to the General Assembly, New York.