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Assessment of Background Exposure Level in Some Selected Scrap Metals Dumpsites in Keffi Metropolis, Nasarawa State, Nigeria

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Abstract: In this study, the background exposure level of some selected scrap metal dumpsites in Keffi metropolises, Nasarawa State, Nigeria was assessed. A total of ten dumpsites were selected and the exposure rate for three sampling points for each of the dumpsites was measured using a Ludlum micro survey meter. The survey meter was held at an elevation of 1.0 m above ground level and a geographical positioning system (GPS) was used to record the location. The radiological hazard indices such as absorbed dose rate, annual effective dose rate, and excess lifetime cancer risk were calculated. The result of exposure rate, absorbed dose rate, annual effective dose, and excess lifetime cancer risk are in the range of 5.00-8.5 μR/h, 43.50-73.95 nGy/h, 0.0534- 0.0907 mSv/y and 0.1867- 0.8800, respectively. The calculated annual effective dose is within the recommended dose limit by ICRP and UNSCEAR. This indicates that the inhabitants around scrap metal dumpsites in Keffi metropolis and its workers are safe from radiation hazards. However, no radiation level is too low for it to accumulate and become hazardous to human health. There is a need to educate, and create awareness among scrap metals dumpsite workers and members of the public around the dumpsite on the risks associated with background radiation and precautions to take.

Keywords: Background exposure level, scrap metal, annual effective dose equivalent, and excess lifetime cancer risk.

1 Introduction

Environmental radiation has been both advantageous and disadvantageous to man and the environment because of its many uses and hazards. Radiations come from mainly three sources namely: cosmic radiation, terrestrial radiation, and radioactivity in the human body [1- 4]. It is the spontaneous decay of the nuclei of heavy isotopes that leads to the emission of radiation. Man is continuously exposed to background ionization radiation emitting from Naturally Occurring Radioactive Materials (NORM) and petroleum products like fuel, kerosene, diesel, engine oil, etc used by man both at home and in the workplace. Furthermore, the earth is naturally radioactive, and about 90% of human radiation exposure arises from natural sources such as cosmic radiation, exposure to radon gas, and terrestrial radionuclides [5-8]. If inhaled the aerosols containing radon may attach themselves to the lungs where gamma rays emitted in the decay may pose an increased risk of lung cancer, eye cataracts, and mental imbalances to man. It is important to monitor the terrestrial background ionization radiation mainly from automobile mechanic workshops.

Background exposure from normal levels of naturally occurring radioactive materials (NORMS) is present in all environmental materials and does not vary remarkably from place to place. Where human activities (Laboratory activities, pollution mining, and others) have increased the relative concentration of the radionuclides, they are referred to as technologically enhanced naturally occurring radioactive materials (TENORMS) [9-11]. Natural radioactivity has a great ionizing radiation effect on the world population due to its presence in our surroundings at different amounts, thus man by the very nature of his environment exposed to varying amounts of radiation with or without his consent. The ambient radiation encompasses both the natural and artificial radioactivity in his environment [12- 14]. A survey taken by the World Health Organization (WHO) and the International Commission on Radiological Protection (ICRP) shows that residents of temperate climates spend only about 20% of their time outdoors and about 80% indoors (homes, schools offices, or other buildings) [15-17].

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Petroleum products (a by-product of crude oil) contain radionuclides since it is a naturally occurring liquid mineral deposited beneath the earth's surface. Crude oil occurrence is most times accompanied by the existence of natural gas. The oil, gas, produced water and associated gas are generally the by-products of crude oil by automobile mechanics, and the natural ecosystem has been altered. This can give rise to elevated background gamma radiation and environmental pollution. Background gamma radiation is emitted to the immediate environment from the used byproducts of crude oil and artificial sources. Excessive exposure to this ionizing radiation from by-products of crude oil can cause various long-term health hazards to workers, immediate environments, and the general public like, cancer, mental disorders, genetic mutation, etc. [18].

Researchers have found a strong correlation between radiation exposure and health hazards on man and its environmental ecosystem which are attributed to domestic waste, agricultural waste, chemical toxic wastes, radiation waste, hazardous industrial waste, medical waste, metal scraps, etc. Radiation dose depends on the intensity and energy of radiation, type of radiation, exposure time, the area exposed, and the depth of energy deposition. Quantities, such as the absorbed dose, the effective dose, and the equivalent dose have been introduced to specify the dose received and the biological effectiveness of that dose.

The absorbed dose (D); specifies the amount of radiation absorbed per unit mass of material. Its S.I. unit is gray. ($1Gy = 1Jkg^{-1}$). The absorbed dose rate (DR); is the rate at which an absorbed dose is received its units are ($Gys^{-1}$and $mGyhr^{-1}$). It is however important to mention that the biological effect depends not only on the total dose the tissue is exposed to but also on the rate at which the dose was received. The equivalent dose rate (EDR); the absorbed dose does not give an accurate indication of the harm that radiation can do since equal absorbed doses do not necessarily have the same biological effects. An absorbed dose of 0.1Gy of alpha radiation is more harmful than an absorbed dose of 0.1Gy of beta or gamma radiation. To reflect damage done in biological systems from different types of radiation, the equivalent dose is used. It is defined in terms of the absorbed dose weighted by a factor that depends on the type of radiation. It unit is Sievert (Sv).

Exposure to ionizing radiation poses a high risk and this risk may include cancer induction, radiation keratogenesis, and indirect chromosomal transformation. The practice being to keep one's exposure to ionizing radiation as low as reasonably possible is known as the ALARA principle [19].

Thus, an Assessment of background radiation has not been conducted in this study area, so there is a necessity to check the risk and the nominal background radiation and Annual exposure limit to some scrap metals dumpsites in Keffi metropolis if are within the permissible limit recommended by ICRP. Otherwise, the workers in scrap metals dumpsites will continue to be exposed to unknown levels of background radiation. The findings of this study will serve as safety awareness to scrap metal dumpsites in the Keffi metropolis to ensure the effectiveness of radiation protection. This study aimed at measuring the background radiation dose level in some selected scrap metal dumpsites in Keffi Metropolis, Nasarawa State, Nigeria.

2 Experimental Section

2.1 Materials

Materials used are: Measuring tape, Mobile GPS (APP), Ludlum micro survey meter, Writing material, and PC

2.2 Deposition Method of Microsoft Word

Study Area

The location of the study is Keffi Metropolis, Nasarawa State, Nigeria. Keffi Local Government Area covers 138 square kilometers in total and experiences average temperatures of 30°C. According to the 2006 census, Keffi LGA has a population of approximately 92,000 people. With latitude N8^{0}50’0, and longitude of E7^{0}53’0.

The study covered scrap metal sites within Keffi metropolises, Nasarawa State. The site was represented as Around Baptist Church (ABC), Around Nagari Hospital (ANH), Beside Al-Mmutaz Academy (BAM), Around Fly Over (AFO), Around General Hospital(AGH), Around Living Faith church(ALF), Beside Malony FM(BMF), Angwan NEPA (ANP), Angwan Tanko (ATK), Around Kaduna Road (AKR).

Fig. 1: Map of the study area.

Data Collection Procedure

Data was collected between the hours of 11:00 am to 3:00 pm, using Ludlum micro survey meter. The survey meter was placed at a point in the location at a distance of one meter (1m) from the ground level and the readings were recorded, the Geographical Positioning System (GPS) was used to take the geo-point of the locations and was recorded. The exposure levels were obtained in µR/hr and were also recorded.

Calculation of Radiological Hazards Indices

i. The exposure rate(σ) is measured in µR/h is converted to the annual absorbed dose rate ADR in mSv/yr according to

ADR (mSv/yr)= σ(µSv/yr) x OF x 24hrs x 365days x 10^{-3} 1

OF is the occupancy factor and the absorbed dose is obtained in Gy/h from the measured exposure in µSv/h using equation 2:

D(nGy/h)= (σ(µSv/h))/Q x 10^{-3} 2

Q is the quality factor -1.0 for gamma radiation

ii. The annual effective dose rate (AEDR) per year received by workers and the population, is obtained from equation 2 (UNSCEAR, 2000) [20].:

AEDR (mSv/yr) = D(nGy/h)x 8760h x CF x OF 3

CF is the conversion factor of the absorbed dose in air to the effective dose (0.7Sv/Gy), OF is the occupancy factor, the expected period the member of the population would spend within the study area. OF= 0.2 for outdoors as it is expected that human beings would spend 20% of their time outdoors therefore AEDR for outdoors is obtained from equation 4:

AEDR (mSv/yr) outdoor= D(nGy/h) x 8760hr x 0.7Sv/Gy x 0.2 x 10^{-3} 4

iii. The Excess Lifetime Cancer Risk (ELCR) is calculated from equation [21].

ELCR=AEDR x DLx RF 5

Where DL is the duration of life (70yrs) and RF is the risk factor that is, the fatal cancers per Sievert. For stochastic effects, ICRP 60 recommended RF=0.05 for the public [21].

3 Results and Discussion

3.1 Data Presentation

The result of the Background exposure level assessment from the scrap metals dumpsite in Keffi metropolis are presented in Table 1 Ludlum micro survey meter was used to measure the background exposure rate in (µR/hr). A geographical positional system (GPS) was used to record the geographical points of the scrap metal dumpsites. Each metal's dumpsites were coded for easy identification. Table1 presents the measured background exposure level of the study areas in (µR/hr).

Table 1: Result of Background Exposure level of scrap metals dumpsite in the study area.

S/N	Sampling Code	Exposure (µR/hr)	Latitude	Longitude
1	ABC 1	6.20	N8^{0}50’40.3188	E7^{0}53’3.6976
2	ABC 2	6.50	N8^{0}50’40.2366	E7^{0}53’3.863
3	ABC 3	5.50	N8^{0}50’40.12044	E7^{0}53’3.5646
4	BAM1	6.50	N8^{0}49’49.56456	E7^{0}52’52.54
5	BAM 2	7.20	N8^{0}49’45.9894	E7^{0}52’44.913
6	BAM 3	7.00	N8^{0}49’48.383	E7^{0}52’44.936
7	ANH 1	6.10	N8^{0}50’59.77288	E7^{0}52’54.8012
8	ANH 2	5.20	N8^{0}50’51’0.0342	E7^{0}52’55.2345
9	ANH 3	7.10	N8^{0}50’51’0.1342	E7^{0}52’55.2356
10	AGH 1	8.00	N8^{0}50’16.656	E7$^{°}$ 547.67568
11	AGH 2	7.20	N8º5O’17.4822	E7º51’48.417
12	AGH 3	7.50	N8º50’19.00126	E7º51’49.426
13	BMF 1	7.00	N8^{0}50’17.45412	E7º51’48.402
14	BMF 2	6.50	N8^{0}50’16.5966	E7º54’1.0024
15	BMF 3	8.10	N8^{0}50’17.6822	E7º51’48.4178
16	AKR 1	6.20	N8^{0}50’1.1122	E7º51’50.0127
17	AKR 2	7.10	N8^{0}50’16.1023	E7º51’50.2210
18	AKR 3	6.50	N8^{0}50’17.33265	E7º51’50.9556
19	ATK 1	5.20	N8^{0}51’20.91663	E7º51’50.8263
20	ATK 2	6.50	N8^{0}52’55.49511	E7º52’54.4663
21	ATK 3	7.00	N8^{0}51’54.45521	E7º52’55.1021
22	ANP 1	5.00	N8^{0}51’1.0341	E7º52’54.2966
23	ANP 2	5.20	N8^{0}51’0.24804	E7º52’54.7236
24	ANP 3	5.50	N8^{0}51’0.11196	E7º52’54.9164
25	ALF 1	7.20	N8^{0}51’40.2422	E7º53’3.048
26	ALF 2	7.50	N8^{0}50’59.666	E7º53’2.1146
27	ALF 3	6.30	N8^{0}49’48.37908	E7º52’44.8692
28	AFO 1	8.50	N8^{0}51’19.7336	E7º51’50.9562
29	AFO 2	8.20	N8^{0}51’22.12812	E7º51’50.8712
30	AFO 3	8.00	N8^{0}51’22.11012	E7º51’51.0058

3.2 data analysis

The data obtained from the study area were analyzed using the radiological hazard parameters which are the absorbed dose rate, annual effective dose equivalent, and excess lifetime cancer risk.. Table 2 presents the calculated radiological hazard indices of the result obtained.

Table 2: Calculated Radiological Hazard Indices.

S/N	Sampling Code	Exposure (μR/hr)	Absorbed (nGy/hr)	AEDER (mSv/yr)	ELCR (10^{-3})
1	ABC 1	6.20	52.20	0.0640	0.2247
2	ABC 2	6.50	56.55	0.0694	0.2427
3	ABC 3	5.50	47.85	0.0587	0.2054
4	BAM1	6.50	56.55	0.0693	0.2427
5	BAM 2	7.20	60.90	0.0747	0.2614
6	BAM 3	7.00	60.90	0.0747	0.2614
7	ANH 1	6.10	52.20	0.0640	0.2241
8	ANH 2	5.20	43.50	0.0534	0.1867
9	ANH 3	7.10	60.90	0.0747	0.2800
10	AGH 1	8.00	69.60	0.0854	0.2988
11	AGH 2	7.20	60.90	0.0747	0.2614
12	AGH 3	7.50	65.25	0.0800	0.2800
13	BMF 1	7.00	60.90	0.0747	0.2614
14	BMF 2	6.50	56.55	0.0694	0.2427
15	BMF 3	8.00	69.60	0.0854	0.2988
16	AKR 1	6.20	52.20	0.0640	0.2241
17	AKR 2	7.10	60.90	0.0747	0.2614
18	AKR 3	6.50	56.55	0.0694	0.2427
19	ATK 1	5.20	43.50	0.0534	0.1867
20	ATK 2	6.50	56.55	0.0694	0.2427
21	ATK 3	7.00	60.90	0.0747	0.2614
22	ANP 1	5.00	43.50	0.0534	0.1867
23	ANP 2	5.20	43.50	0.0534	0.1867
24	ANP 3	5.5 0	47.85	0.0587	0.2054
25	ALF 1	7.20	60.90	0.0747	0.2614
26	ALF 2	7.50	65.25	0.0800	0.2800
27	ALF 3	6.30	52.20	0.0640	0.2241
28	AFO 1	8.50	73.95	0.0907	0.3174
29	AFO 2	8.20	69.60	0.0854	0.2988
30	AFO 3	8.00	69.60	0.0854	0.2988
Mean		**6.96**	**53.65**	**0.0708**	**0.2342**
Minimum		**5.00**	**43.50**	**0.0534**	**0.1867**
Maximum		**8.50**	**73.95**	**0.0907**	**0.3174**

Exposure Rate: the background exposure rate measured ranges from 5.00 μR/h at ANP to 8.50 μR/h at AFO with an average value of 6.95 μR/h. The mean background exposure rate from the study area is within the permissible recommended average limit of 5-10 μR/h. By US Environmental Protection Agency (EPA).

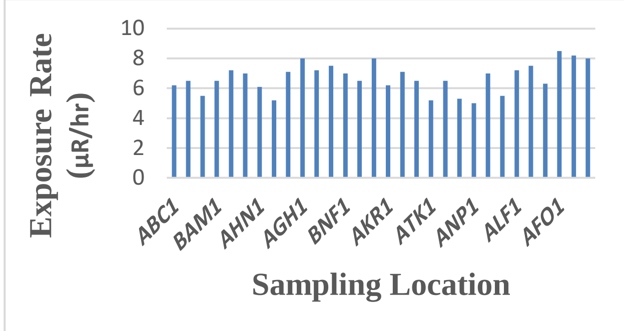

Fig. 2: Plot of calculated exposure rate for all sampling locations.

Absorbed Dose Rate: The range of calculated absorbed dose rate values is between 43.50 nGyh^{-1} and 73.95 nGyh^{-1} with an observed mean value of 153.65 nGyh^{-1}. The mean of the absorbed dose rate appears to be less than the recorded world weighted average of 59.00 nGyh^{-1} [22]. and the recommended safe limit of 84.0 nGy/h^{-1} for outdoor exposure. These dose rates indicate less contamination of the environment by radiation. Although the health effect on the residents of the locality may not be immediate , however, there is the potential for long-term health hazards in the future due to the doses accumulated.

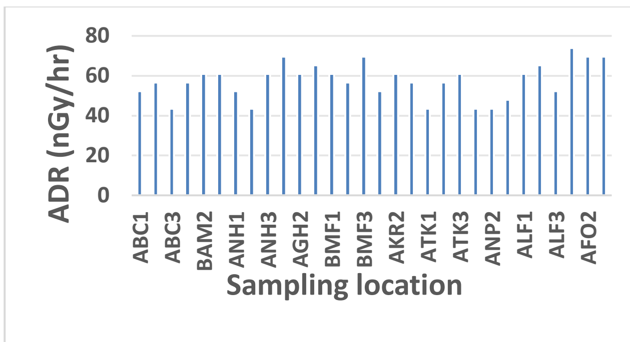

Fig.3: Plot of calculated absorbed dose rate for all sampling locations.

Annual Effective Dose Equivalent: The calculated values of AEDE vary from 0.0534 mSv/yr to 0.0907 mSv/y with an average value of 0.0708 mSv/yr. This is within the world average value of 0.07 mSvy^{-1} but within UNSCEAR and ICRP recommended permissible limits of 1.00 mSvy-1 for the general public. This indicates that the studied location is radio-logically less contaminated but still within the ICRP and UNSCEAR permissible limit. However, there is no immediate radiological health effect on members of the public.

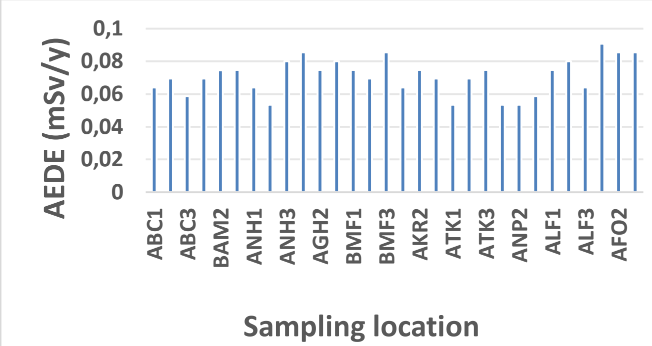

Fig.4: Plot of the calculated annual effective dose equivalent for all sampling locations.

Excess lifetime cancer risk: The mean excess lifetime cancer risk is 0.234×10^{-3} for the study area. This mean value is within the world's average value of 0.29×10^{-3}. This lifetime cancer risk is within and the possibility of cancer development by residents who wish to spend all their lifetime in the area is imminent. The ELCR values reported in this study are less than those reported by [22-23].

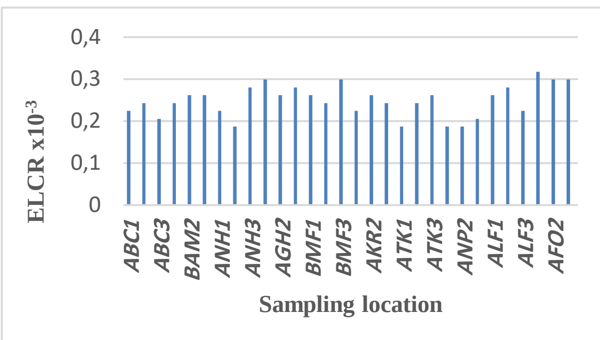

Fig. 5: Plot of calculated excess lifetime cancer risk for all sampling locations.

Thus, the Annual Effective Dose Equivalent value falls within the safe limit for the public, set by the International Commission of Radiological Protection (ICPR). Also, the radiation levels of the thirty studied areas are below the global standard limit (1 (mSv/yr)) for the members of the public and very far below the limit of 20 (mSv/yr) for radiation workers.

4 Conclusions

In summary, The study estimates the level of background radiation around some scrap metal sites in the Keffi metropolis, Nasarawa State. The annual effective dose rate was found to be lower than the dose limit set by ICRP for members of the public and radiation workers. However, no radiation level is too low for it to accumulate and become hazardous to human health. So, there is a need to educate and create awareness among radiation workers and members of the public on the risks and precautions.

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