Original Research Article

ASSESSMENT OF RADIATION EXPOSURE LEVEL FROM SOME SCRAP METAL DUMPSITES IN NASARAWA STATE, NIGERIA

ABSTRACT

In this study, the radiation exposure rate emanating from scrap metals dump site was assessed using an Interceptor Spectroscopic personal radiation detector (SPRD). Sixteen (16) scrap metal dumpsites were selected at random across four Local Government Areas (Nasarawa, Lafia, Akwanga, and Keffi) of Nasarawa State, Nigeria. The gamma activity level in µrem/hr on three (3) randomly selected points on each of the scrap metal dumpsite was determined. A reading was taken on point 100m away from each of the scrap metal dump site. Results shows that, the highest annual effective dose equivalent was observed in Akwanga (AKW4) scrap metal dumpsite with annual effective dose equivalent of 0.2167mSv/yr. The scrap metal dumpsite with the lowest annual effective dose equivalent were observed in Lafia (LAF3) and (LAF4) with annual effective dose equivalent of 0.0613mSv/yr. The excess lifetime cancer risk of 0.7585×10^{-3} was the highest value recorded in AKW4, while the lowest value was found to be 0.2146×10^{-3} in LAF3 and LAF4. The control radiation exposure level, 100m from scrap metal dumpsites, shows the value of gamma activity level and annual effective dose equivalent obtained, is ranged between 13µrem/hr and 0.1594mSv/yr respectively on location KEF1 to 3µrem/hr and 0.0368mSv/yr on locations LAF2 and LAF3 respectively. The annual effective dose equivalent values obtained were below the ICRP dose limit of 1mSv/yr indicating that, the environments around these scrap metal dumpsites are safe. The excess lifetime cancer risk value (ELCR) obtained in some locations are higher than the world average value of 0.29×10^{-3}. Therefore, we recommend that scavengers, workers and the public around the scrap dumpsites are to minimise the period of their stay within the dumpsites, so as to minimise the risk of developing any health problem relating to cancer in future.

Keywords: Annual Effective Dose Equivalent, Dumpsites, Scrap Metals, Interceptor Spectroscopic Detector, Excess Lifetime Cancer Risk.

INTRODUCTION

The rise in the importance of scrap metal as a resource has been paralleled by an increase in the frequency that radioactively contaminated scrap metal, activated scrap metal and scrap metal with radioactive source(s) or substances contained within it is detected in scrap metal shipments [1]. In 2004, the worldwide consumption of scrap metal was of the order of 440 million tonnes out of which around 184 million tonnes were traded internationally [2]. UNECE in 2006, acknowledge that radioactive substances associated with scrap metals can cause health hazard to workers and the public with an environmental concerns of a serious commercial implications. Recycled materials that are radioactively contaminated threaten human health and the environment while having a huge economic impact on the manufacturer. According to Mohammed, 2002 this radioactivity can expose workers and ultimately be incorporated into consumer products [3]. Radioactive sources can escape from regulatory control by being abandoned, lost, or stolen. Likewise, Ola *et al.*, 2009 stated that uncontrolled material contaminated with natural or man-made isotopes from industrial processes can also enter the recycling stream [4]. An example is, material improperly released from any nuclear related industry that is contaminated with man-made radionuclides above regulated limits [5]. Research by Turner, 2006 has shown that in the United States of America alone, over 5,000 incidents were recorded in 2004 that involved various types of radioactive scrap metal [6]. In addition, some of this radioactive scrap metal has gone undetected and has been accidentally melted down or processed and thus entered the metal stream. Studies by Sacco *et al.* (1995) has characterized different types of radioactive materials that can be found in scraps, pointing out the potential hazards from exposure of workers and people and from environmental contamination [7]. The frequency at which radioactive scrap metal is detected may be expected to continue to rise with the ever-increasing use of scrap to produce processed materials [1]. A lost source accident occurs when a radioactive object is misplaced or stolen. Such objects may appear in the scrap metal industry if people mistake them for harmless bits of metal [8]. Metals that have been exposed to radioactive sources may also become radioactive in settings such as medical environments, research laboratories, or nuclear power plants [9]. Many specialized tools used in scrapyards are hazardous, such as the alligator shear which cuts metal using hydraulic force, compactors, and scrap metal shredders. The aim of this research is to assess the exposure level in scrap metals dump site in Nasarawa State, Nigeria.

MATERIALS AND METHOD

The Study Area

The location of the study is in Nasarawa state that has a central location in the middle belt region of Nigeria. The state lies within latitude 8^0 32' N and longitude 8^0 18' E and occupy a land area of about 27, 290sq km, with a population of over two million people. Nasarawa state is known with the slogan ''Home of Solid Minerals'' the major ethnic groups are Mada, Eggon, Alago, Migili, Nyankpa, Gbagyi, Rindere, and Tiv. Nasarawa state has thirteen (13) Local Government Areas, with the state capital in lafia.

The area under investigation is the metal scrap dumpsites in Keffi, Akwanga, Nasarawa and Lafia towns of Nasarawa State, Nigeria. The four (4) towns chosen for the study was because they are among the major populous towns in the state and represents the three senatorial zones of Nasarawa state, which actively participate in scrap metal business in large commercial quantities.

The four (4) towns are seen as ideal locations to assess the radiation exposure level from scrap metal dumpsites using the systematic sampling techniques to get the appropriate sample size for the study.

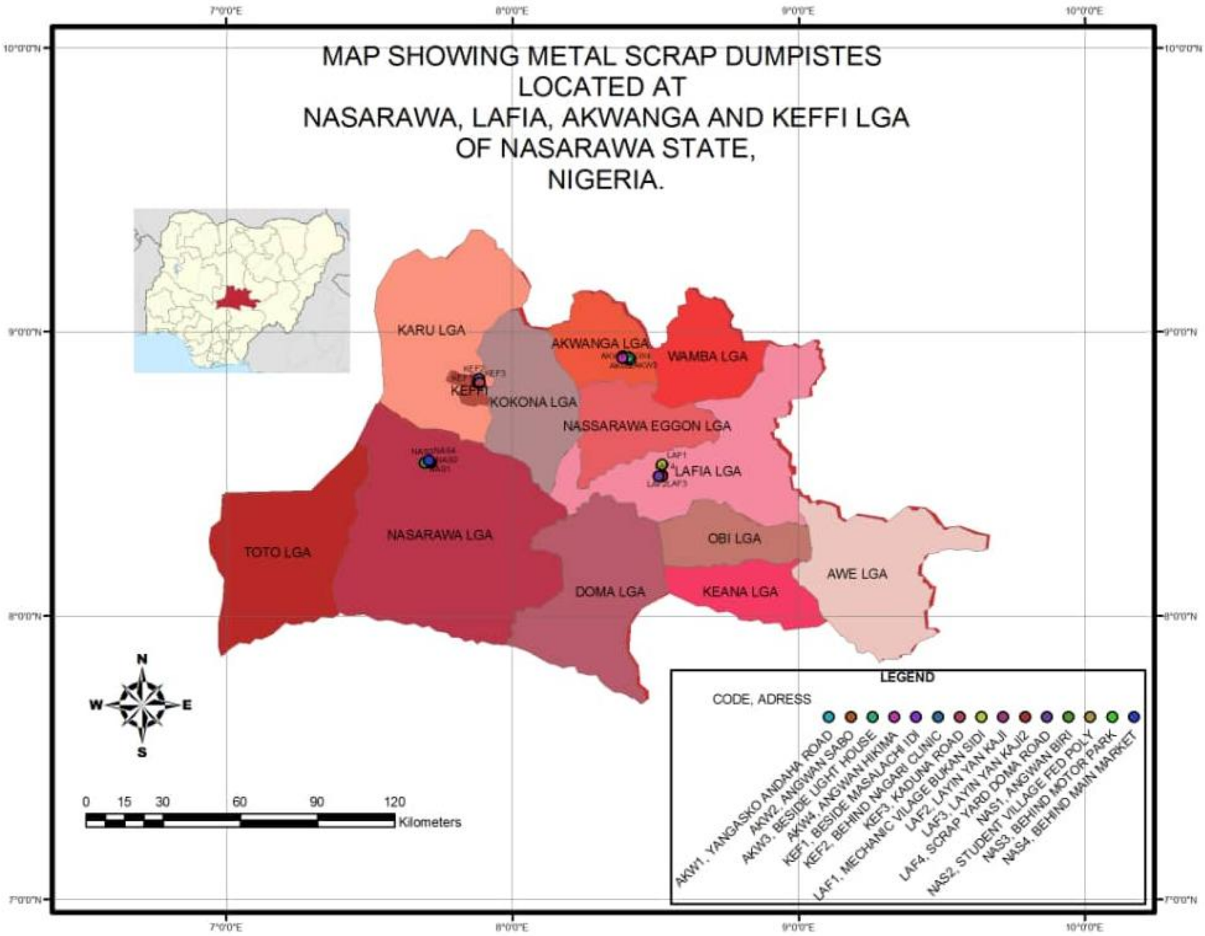

Fig 1. Metal Scrap Dumpsites Located at Nasarawa, Lafia, Akwanga and Keffi of Nasarawa State.

Sampling

Sixteen (16) scrap metal dump site were selected at random across four local Government area (Nasarawa, Keffi, Lafia, and Akwanga) of Nasarawa state, Nigeria and readings were taken in µrem/hr on three (3) randomly selected points on each of the scrap metal dumpsite. An area monitoring survey was carried out using a well calibrated Interceptor - Spectroscopic Personal Radiation Detector (SPRD), with a serial number, 101664002659 to measure the radiation exposure level from the selected dumpsites, the calibration were established at the reference conditions (Temperature= 20.0^{0}C, Pressure= 101.325kPa and Relative Humidity= 50.0%).

Method of Data Collection

The metal scrap dump site was divided into several parts and three points were randomly selected from each metal scrap dump site and a point 100m away from the waste dump site. Interceptor- Spectroscopic Personal Radiation Detector (SPRD), was used to measure the ambient radiation that is emitting the radiation. The instrument was switched ON and was kept on the metal scrap dump site points (P1 to P3) on the randomly selected points in each of the scrap dump site in the selected towns. The Gamma Activity level was recorded for each point. At point P4 (100 meters away from the metal scrap dumping site) was measured to ascertain the radiation level around the metal scrap dumping site.

Radiological Impact Parameters

The measured results (raw data) obtained from the metal scrap dump sites in the selected towns were analysed and compared with regulatory standards. For effective computation of the experimental data from Gamma Activity level (in µrem/hr) to Exposure rate (in µSv/hr), from Exposure rate (in µSv/hr) to Absorbed Dose (in nGy/hr), and to calculate the Annual Effective Dose Equivalent (in mSv/yr), the following conversion formula were used;

To Convert from Gamma Activity level (in µrem/hr) to Exposure rate (in µSv/hr)

$$1\mu rem/hr = 0.01\mu Sv/hr \quad (1)$$

To Convert from Exposure rate (in µSv/hr) to Absorbed Dose (in nGy/hr)

$$1\mu Sv/hr = 10^{3} nGy/hr \quad (2)$$

To Calculate the Annual Effective Dose Equivalent (in mSv/yr)

$$E\ (mSv/yr) = D\ (nGy/hr) \times T \times OF \times CC \times 10^{-6} \quad (3)$$

where

E = Annual Effective Dose Equivalent (mSv/yr)

D = Absorbed Dose (nGy/hr)

T = Working Hours per Year = 8760 hours

OF = Occupancy Factor = 0.2 (Outdoor)

CC = Conversion Coefficient = 0.7 Sv/Gy

To Calculate the Excess Lifetime Cancer Risk (in mSv/yr)

$$ELCR = AEDE \times DL \times RF \quad (4)$$

where

AEDE = Annual Effective Dose Equivalent

DL = Duration of Life = 70 years

RF = Risk Factor = 0.05 Sv^{-1}. For stochastic effects ICRP 60 recommend RF = 0.05 for the public [10].

RESULTS AND DISCUSSION

The meter readings (gamma activity level in μrem/hr) and calculated hazard parameters (exposure rate in μS/hr, absorbed dose in nGy/hr, annual effective dose in mSv/yr and excess lifetime cancer risk) using equations 1, 2, 3 and 4 are presented in Table 1.

Table 1: Analyzed Radiation Exposure and Calculated Gamma Activity Level

Town	Locations	Gamma Activity Level (µrem/hr)	Exposure Rate (µS/hr)	Absorbed Dose (nGy/hr)	AEDE Outdoor (mSv/yr)	ELCR Outdoor $\times 10^{-3}$
NASARAWA	NAS 1	09.6667	0.0967	96.6667	0.1186	0.4151
	NAS 2	10.0000	0.1000	100.0000	0.1226	0.4291
	NAS 3	09.0000	0.0900	90.0000	0.1104	0.3864
	NAS 4	08.0000	0.0800	80.0000	0.0981	0.3434
LAFIA	LAF 1	09.3333	0.0933	93.3333	0.1145	0.4008
	LAF2	05.6667	0.0567	56.6667	0.0695	0.2433
	LAF 3	05.0000	0.0500	50.0000	0.0613	0.2146
	LAF 4	05.0000	0.0500	50.0000	0.0613	0.2146
AKWANGA	AKW 1	09.6667	0.0967	96.6667	0.1186	0.4151
	AKW 2	09.3333	0.0933	93.3333	0.1145	0.4008
	AKW 3	11.3333	0.1133	113.3333	0.1380	0.4830
	AKW 4	17.6667	0.1767	176.6667	0.2167	0.7585
KEFFI	KEF 1	14.3333	0.1433	143.3333	0.1758	0.6153
	KEF 2	09.6667	0.0967	96.6667	0.1186	0.4151
	KEF 3	14.0000	0.1400	140.0000	0.1717	0.6000
	KEF 4	10.3333	0.1033	103.3333	0.1267	0.4435

The gamma activity level from the analyses of data obtained from an area monitoring survey from the metal scrap dumpsites in Nasarawa, Lafia, Akwanga and Keffi, revealed the mean exposure rate that ranged between 0.0500µSv/hr in LAF3 and

LAF4 to 17.6667µSv/hr in AKW4. The calculated mean absorbed dose has the ranged of values between 50.000nGy/hr in LAF3 and LAF4 to 176.6667nGy/hr in AKW4. The outdoor AEDE has a ranged of values between 0.0613mSv/yr in LAF3 and LAF4 to 0.2167mSv/yr in AKW4. The calculated ELCR is ranged between 0.2146×10^{-3} in LAF3 and LAF4 to 0.7585×10^{-3} in AKW4.

Table 2: Control Analysed Radiation Exposure and Calculation of Gamma Activity Level 100m from scrap metal dumpsites

Locations	**Gamma Activity Level (µrem/hr)**	**Exposure Rate (µSv/hr)**	**Absorbed Dose (nGy/hr)**	**AEDE Outdoor (mSv/yr)**
NAS1	07	0.0700	70	0.0859
NAS2	06	0.0600	60	0.0736
NAS3	08	0.0800	80	0.0981
NAS4	07	0.0700	70	0.0859
LAF1	06	0.0600	60	0.0736
LAF2	03	0.0300	30	0.0368
LAF3	03	0.0300	30	0.0368
LAF4	04	0.0400	40	0.0491
AKW1	08	0.0800	80	0.0981
AKW2	07	0.0700	70	0.0859
AKW3	10	0.1000	100	0.1226
AKW4	12	0.1200	120	0.1472
KEF1	13	0.1300	130	0.1594
KEF2	08	0.0800	80	0.0981
KEF3	11	0.1100	110	0.1349
KEF4	09	0.0900	90	0.1104

The control analyzed radiation exposure level, 100 meters from scrap metal dumpsites shows the highest value of gamma activity level and annual effective dose equivalent were found to be 13µrem/hr and 0.1594mSv/yr respectively on location KEF1, while the lowest values were found to be 3µrem/hr and 0.0368mSv/yr respectively on locations LAF2 and LAF3. The essence of the control radioactivity level 100 meters from scrap metal dumpsites is to ascertain the background radiation level within the environs of the selected scrap metal dumpsites.

A survey of radiation exposure level from scrap metal dumpsites in some selected towns of Nasarawa state, Nigeria was intended to evaluate whether the levels of exposure are sufficiently high to the extent that radiological health effect may result and such scrap metal dumpsite may require the implementation control.

The international commission on radiological protection (ICRP, 2007) recommends that any exposure above the natural background radiation should be regulated and kept as low as reasonably achievable (ALARA) [11].

Findings has revealed that the analysed results presented in Table 1 shows the calculated mean exposure rate of 0.1767μSv/hr which was the highest value of gamma activity level recorded on location AKW4, and the lowest value of gamma activity level of 0.0500μSv/hr were observed on locations LAF3 and LAF4 at the cause of this findings. The findings of the mean exposure level is in line with the findings of James *et al.* (2014), Essien and Essiett (2016), but not in line with the findings of Ogundare and Nwankwo (2015) who found the exposure rate to be ranged between 3.28-188.64μSv [12, 13, 14].

Findings revealed that the analysed results presented in Table 1 shows the calculated mean absorbed dose rate of 176.6667nGy/hr which was the highest value of gamma activity level recorded on location AKW4 is not comparable to the world average value of 57nGy/hr, while the lowest mean absorbed dose rate of 50nGy/hr recorded on location LAF3 and LAF4 was found to be comparable to the world average of 57nGy/hr. The main contributor to the dose rate absorbed in the air is from the gamma radiation generated from the radionuclides in the scrap metal dumpsite investigated. Hence, the dose rate absorbed depends on the concentrations of some specific radionuclide identified during the study. According to Al-kaabi and Al-Shimary (2016) if the concentration of radionuclide in the study area is high, absorbed dose will also be high [9].

Findings of the analysed results presented in Figure 2 revealed that the calculated annual effective dose equivalent of 0.2167mSv/yr was the highest value of gamma activity level recorded on location AKW4, While the lowest value of annual effective dose equivalent of 0.0613mSv/yr were observed on locations LAF3 and LAF4. The evaluated annual effective dose equivalent from scrap metal dumpsites were below the dose rate of 1mSv/yr a limit for the public exposure, and as well lower than the occupational dose limit of 20mSv/yr, which are not sufficiently high to warrant regulatory control and may not cause any radiological health hazards on workers of scrap metal dumpsites. The annual effective dose equivalent evaluated for all the studied scrap metal dumpsites were below the ICRP dose limit of 1mSv/yr for public exposure may be associated with the differences in the radiation sources and the activity concentrations of the radionuclides found in the scrap metal dumpsites investigated. Findings of the annual effective dose equivalent is in line with the findings of Ogundare and Nwankwo [14], James *et al.* [13] and Essien and Essiett [12], but not in line with the findings of Tawfik and Ahmed [15] who found effective dose rate to be 2.14E-04, 1.4E-06, and 1.86E-05 (mSv) respectively. Also Oluyide *et al.* [16] who found the Annual Effective Doses (AED) to be 37.90, 178.79 and 1085.23μSv y^{-1} respectively.

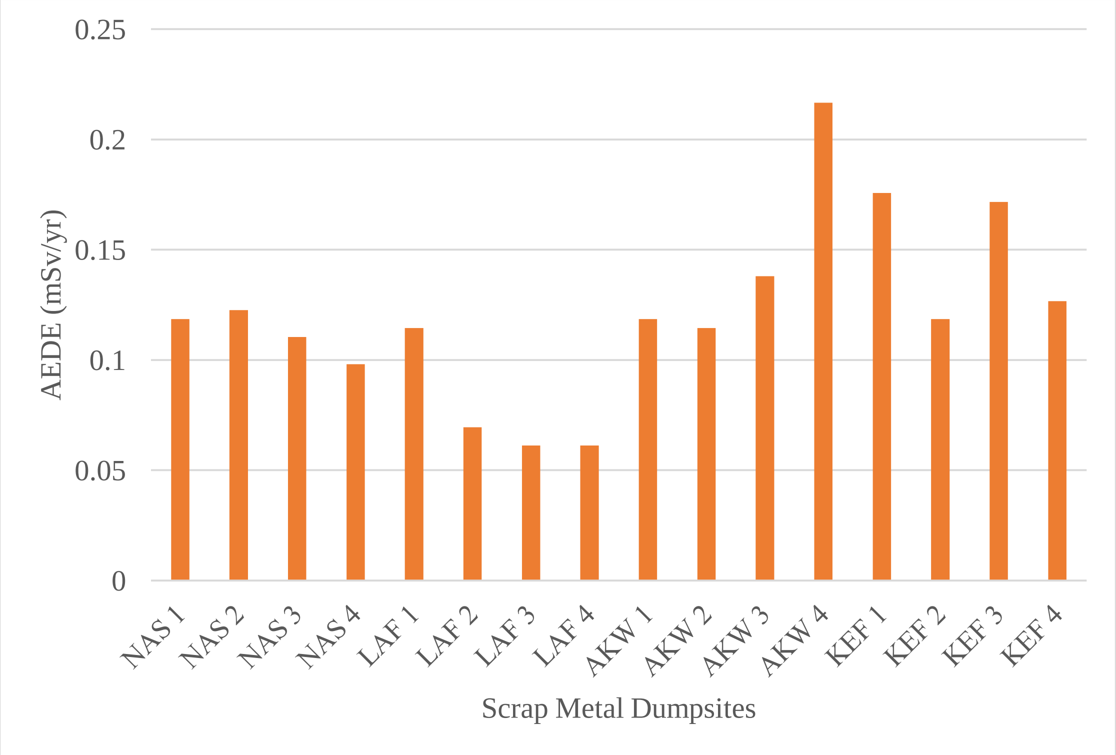

Fig. 2: Annual Effective Dose Equivalent of the Various Metal Scrap Dumpsites in some Towns of Nasarawa State, Nigeria.

Findings of the analysed results presented in Fig. 3 revealed that the calculated excess lifetime cancer risk (ELCR) of 0.7585×10^{-3} was the highest value recorded in AKW4. And most of the scrap metal dumpsites in the study area are higher than the world limit of 0.29×10^{-3} [10]. This implies that the risk of developing cancer by the scavengers, workers and the people living near the scrap metal dumpsites in general is very high. Hence processing activities and location of settlements in the scrap metal dumpsite pose a serious health risk. Findings of the analysed results also revealed the calculated excess lifetime cancer risk (ELCR) of 0.2433×10^{-3}, 0.2146×10^{-3}, and 0.2146×10^{-3}, of the location LAF2, LAF3 and LAF4 of lafia, respectively, were comparable to the world limit of 0.29×10^{-3} [12, 17].

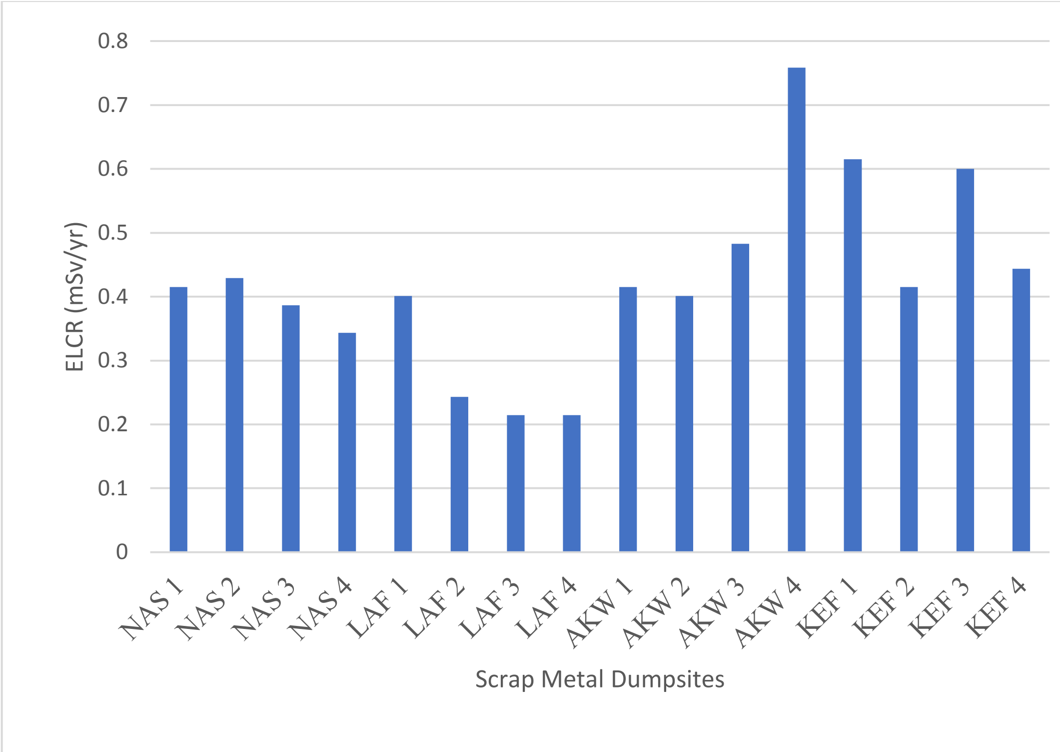

Fig. 3: Excess Lifetime Cancer Risk (ELCR) of the various Metal Scrap Dumpsites in some Towns of Nasarawa State, Nigeraia.

Fig. 4 presents the findings of the analysed gamma radioactivity level 100 meters from scrap metal dumpsites to serve as a control gamma radioactivity level. The exposure rate, absorbed dose rate and annual effective dose equivalent were all analysed to ascertain the gamma radioactivity level 100 meters from the scrap metal dumpsites. The highest annual effective dose equivalent of 0.1594mSv/yr was recorded on location KEF1. And the lowest annual effective dose equivalent of 0.0368mSv/yr were recorded on locations LAF2 and LAF3. The result recorded was as a result of residual radioactivity within the environs of the scrap metal dumpsites.

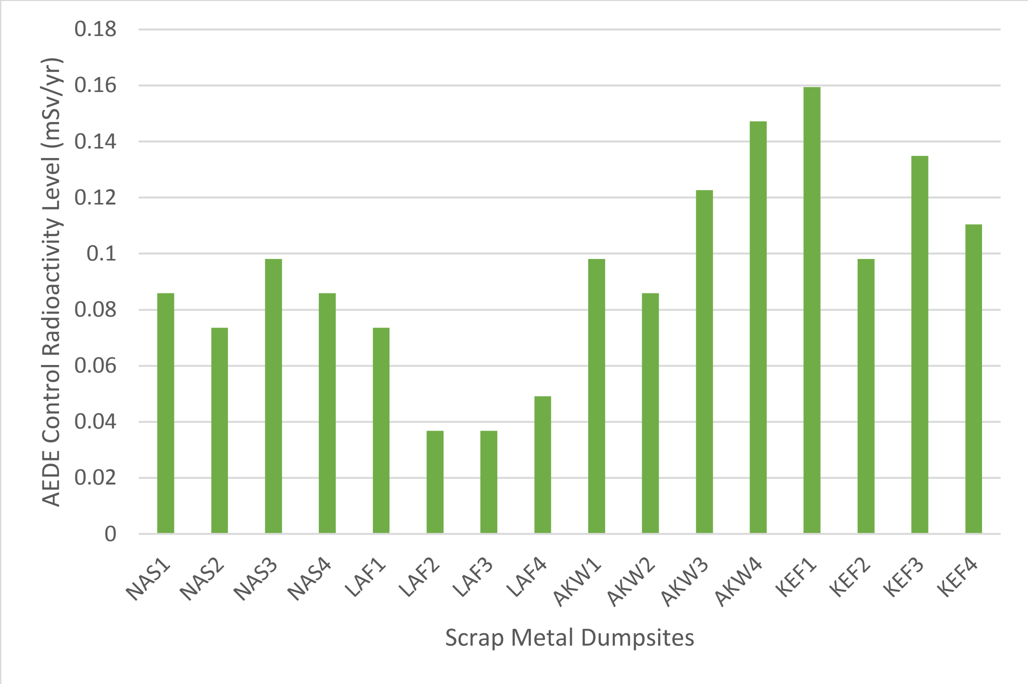

Fig. 4: Annual Effective Dose Equivalent of control Gamma Radioactivity Level 100 Meters from some Scrap Metal Dumpsites in Nasarawa State, Nigeria.

This study was carried out to assess the level of radiation emanating from scrap metal dumpsites. Sixteen (16) scrap metal dump sites were selected at random across four local Government area (Nasarawa, Keffi, Lafia, and Akwanga) of Nasarawa state, Nigeria and readings were taken in µrem/hr on three (3) randomly selected points on each of the scrap metal dumpsite. The gamma activity level obtained from the scrap metal dumpsite, were analyzed for parameters to determine the exposure rate (in µSv/hr), absorbed dose (in nGy/hr) and annual effective dose equivalent (in mSv/yr). The results show that all the gamma radioactivity level evaluated were all below the 1mSv/yr threshold stipulated standard recommended by the ICRP dose limit that a member of public should not exceed. This indicates that the scrap metals in the dumpsites may not pose any significant radiation hazard to the scrap metal workers and public around the dumpsites.

CONCLUSION

This study was carried out to assess the level of radiation emanating from scrap metal dumpsites. Sixteen (16) scrap metal dump sites were selected at random across four local Government area (Nasarawa, Keffi, Lafia, and Akwanga) of Nasarawa state, Nigeria and readings were taken in µrem/hr on three (3) randomly selected points on each of the scrap metal dumpsite. The gamma activity level obtained from the scrap metal dumpsite, were analyzed for parameters to determine the exposure rate (in µSv/hr), absorbed dose (in nGy/hr) and annual effective dose equivalent (in mSv/yr). The results show that all the gamma radioactivity level evaluated were all below the 1mSv/yr threshold stipulated standard recommended by the ICRP dose limit that a member of public should not exceed. This indicates that the scrap metals in the dumpsites may not pose any significant radiation hazard to the scrap metal workers and public around the dumpsites.

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