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ASSESSMENT OF RADIATION EXPOSURE LEVEL IN BLACKSMITHING WORKSHOP IN GOMBE, GOMBE STATE

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ABSTRACT

Measurement of terrestrial background ionizing radiation of blacksmith workshops of Gombe State, Nigeria was carried out using well-calibrated Geiger-Muller counter meters and a meter tape. The measured average exposure rate of two line-sections are 0.018±0.002 and 0.017±0.002 mRh^{-1}. Estimated equivalent dose rates for the two line-sections are 1.50 and 1.45 $mSvy^{-1}$. The average absorbed dose rates estimated in line-section one and line-section two are 154.94 and 149.97 $nGyh^{-1}$ respectively. Annual effective dose equivalent (AEDE) of 0.48 $mSvy^{-1}$ was obtained for outdoor exposure in line-section one while in line-section two, AEDE was 0.23 $mSvy^{-1}$. The calculated mean excess lifetime cancer risk values for the blacksmith workshop sections are 0.83×10^{-3} and 0.80×10^{-3}. The obtained values for background ionizing radiation in the line-sections of blacksmith workshop were above the recommended standard limit by ICRP while the absorbed doses (D) were above the recommended value and AEDE calculated in two line-sections of blacksmithing workshops were within the safe values this implies that blacksmithing activities in these areas may not influence the doses received by public. The excess lifetime cancer risk (ELCR) estimated were higher than their world permissible values of 0.29×10^{-3} respectively. The calculated dose to organs showed that the testes have the highest organ dose of 0.153 $mSvy^{-1}$while liver has the lowest organ dose of 0.086 $mSvy^{-1}$. This result shows that exposure to background ionizing radiation levels in all line-sections of blacksmithing workshops contribute insignificantly to the radiation dose to these organs in adults and no case of symptoms referable to the radiation exposure.

Keywords: *background radioactivity, equivalent dose, effective dose and excess lifetime cancer risk.*

INTRODUCTION

Natural environments are known to be made up of some level of radiation concentration, due to human activities these natural environments have experienced elevated level of radiation emissions. Human beings are still exposed to ionizing and non-ionizing radiation from various sources. The use of productive sources of radiation has spread widely, leading to greater interactions between people. (Kumar et al., 2016; Mosavianasl et al., 2018). Aremu (2008) showed that the spongy mass of metallic iron known as the flower is mostly sold to blacksmiths after mining, with whom they produce many items, such as farm implements, hunting and fishing tools, ceremonial staff, military arms and royal political swords. This local industry has created employment opportunities starting from the miners, to blacksmiths, purveyors and even to users of products from the blacksmithing industry. Of all the crafts, blacksmithing is easily one of the most hazardous usually extensively marked and scars by burns and injuries gotten through their activities as well as radiation exposure. Exposure of workers to aluminum or iron furnaces may induce a serious damage to the eyes and develops cataract. Monitoring of radiation to protect workers ' health conditions can reduce the cost of injuries.

Blacksmithing requires creating objects for ease of manipulation by heating iron and its alloys. In essence, blacksmithing turns metal by heating and hammering into its physical form and appearance (Shelter Centre, 2013). The ability to translate the desired result from the mind to the metal, significantly, is the art of blacksmithing (Wyland, 2014). Blacksmithing is one of the major industries and certain adverse physical factors such as noise , heat and radiation are exposed to its workers (Peng et al., 2007). Exposure to all these (heat, noise and radiations) from the blacksmithing workshops may pose a threat to human health. Hence, there is need to examine the present radioactivity status of the blacksmithing workshops. A critical purpose of radiation safety for scientists and regulatory agencies is to determine exposure to ionizing radiation. This study assessed the background radiation level in blacksmithing workshops in Gombe, Gombe State.

One of the necessary mechanisms of unified assessment in the public health organization of radiation emergencies is to easily and surely calculate and categorize exposure (UNSCEAR-A,2000). Proof of the extent of background radiation is therefore of utmost importance (Drek, 2010). Generally, measurement and categorization of background radiation level of our environment is of paramount importance. Kuroda (1991) show that the background radiation levels were estimated to be from a mixture of terrestrial levels (K-40, Th-232, Ra-226). He stated that the worldwide level is fairly constant, being 0.008-0.015 mRh^{-1}. Avwiri and Ebeniro (1998) In an industrial area of the Rivers State, external environmental radiation has been studied. They suggested an average value of 0.014 mRh^{-1}. Sadiq and Agba (2011) measured with the of use of an Inspector Nuclear Radiation Detection Meter, indoor and outdoor background radiation measurements were taken and stated that the indoor readings ranged from 1.04 to 1.75 $mSvy^{-1}$ while the readings at the outdoor level ranged from 0.24 to 0.44 $mSvy^{-1}$. Studies have shown that radiation exposure to occupational and non-occupational radiation is blacksmithing and welding workplaces may lead to some health hitches such as Erythema, Cataract, Photokeratitis, Dermatitis and Skin Melanoma (Megbele et al., 2012). Gombe State is a state known to be vast in agricultural and blacksmithing activities. The state is situated right within the expansive savannah region in North-East geopolitical zone of Nigeria. The state covers an expanse of 20,265 Square kilometers area with geographical positioning 10.3638^{0}N, 11.1928^{0}E and it shares a common boundary with the states of Borno, Taraba, Adamawa and Bauchi States (The World Gazetteer TWG, 2007). Gombe State has two distinct climates, the dry season between November and March; and the rainy season between April and October with an average rainfall of 850 mm, this is quite abruptly changes presently as a result of climate change. Agriculture is the primary profession of the citizens of the state, these have encouraged the local production of farm tools implement. Blacksmithing activities cater for most of the local production of these farm tools implement which enhances farming activities in the state. Precious mineral resources such as columbite, coal and aquamarine are blessed by the ministry.

MATERIALS AND METHODS

The measurements of *in situ* for the terrestrial background radiation were done openly in an undisturbed manner above the surface of the soil of the blacksmithing workshops. This was achieved with use of a well calibrated Geiger-Muller rad-monitor (S.E. International Incorporation, Summer Town, USA). The Geiger-Muller monitor includes a tube capable of detecting alpha, beta, gamma and X-rays within the 10 °C and 50 °C temperature range. Every time radiation passes through the tube and induces ionization, the Geiger-Muller tube produces a pulse current. Each pulse is sensed and recorded electronically as a count. The radiation meters were calibrated with a ^{137}Cs source of a specific energy and set to measure exposure rate in milli-Roentgen per hour ($mRhr^{-1}$) (Olanrewaju and Avwiri, 2017). The meter has an accuracy of ±15%. The measurements were performed by placing the radiation meter at the target sampling points or at various distances from the blacksmithing workshops. The background radiation level was recorded within the period necessary in line with the peak response to environmental radiation

RADIATION RISK PARAMETERS

Equivalent Dose Rate

Evaluation of the annual all-body equivalent exposure rate, guidelines of the National Council on radiation protection and Measurement has been employed (UNSCEAR, 2000). Effects of the whole body equivalent dose rate estimated (UNSCEAR, 2000) were obtainable as shown in Tables 1 and 2.

$$1\ mRh^{-1} = \frac{0.96\times 24\times 365}{100}\ mSvy^{-1} \quad (1)$$

Absorbed Dose Rate

The data obtained for the outdoor contact rate in μRh^{-1} were also converted into absorbed dose rates $nGyh^{-1}$ with the conversion factor (Rafique et al., 2014).

$$1\ \mu R/h = 8.7\ nGy/h = 8.7\times 10^{-3}\ \mu Gy/(1/8760\,y) \quad (2)$$

Annual Effective Dose Equivalent (AEDE)

To estimate the annual effective dose equivalent (AEDE) exposure of workers in the blacksmithing workshop area, estimated absorbed dose rates were used. The dose conversion factor of 0.7 Sv / Gy and the outdoor occupancy factor of 0.25 (UNSCEAR, 2000) (6 hours out of 24 hours) were used in AEDE computing since people in the study area typically spend this time because of the nature of their activities. The outdoor occupancy factor was determined on the basis of an interview with employees in the field of research. Owing to the design of their routine, worker in the study area spend almost 6 hours outside. Using the following relationship, the annual effective dose was calculated (UNSCEAR, 2000).

$$AEDE\ (outdoor)(mSvy^{-1}) = Absorbed\ dose\ rate\ \left(\frac{nGy}{h}\right) \times 8760h\ \times 0.7\,\frac{Sv}{Gy} \times 0.25 \quad (3)$$

Excess Life Cancer Risk (ELCR)

Excess Lifetime Cancer Risk (ELCR) can be calculated with the possibilities of blacksmithing workers and study area residents having cancer in this setting, although there is no evidence of radioactive component outbreaks. Extrapolation from indication-maintained, high-dose reactions to low-dose responses from the Linear No Threshold (LNT) hypothesis states that all acute ionizing radiation exposures down to zero are harmful. The harm is proportional to the dose and, irrespective of how low the dose rate is, is cumulative throughout life (Mishra, 2017). This research is focused on the conventional late (stochastic) results of worldwide radiation safety criteria that are focused on the LNT hypothesis (Stewart et al., 2012). The estimated annual effective dose was used to estimate the ELCR (Excess Lifetime Cancer Risk) equation.

$$ELCR = AEDE\ \times Average\ duration\ of\ life(DL) \times Risfactor\ (RF) \quad (4)$$

where AEDE, DL and RF is the annual effective dose equivalent, duration of life (70 years) and

risk factor (Sv^{-1}), fatal cancer risk per sievert. For low dose background radiations which were

considered to produce stochastic effects, ICRP 60 uses values of 0.05 for the public exposure (Taskin et al., 2009; Mohammed et al., 2014)

Effective Dose Rate Dorgan in $mSvy^{-1}$ to Different Organs and Tissues

The effective dose rate for a particular organ can be determined using the following ratios:

$$Dorgan\ (mSvy^{-1})\ =\ O\ x\ AEDE\ x\ F \quad (5)$$

where AEDE is annual effective dose, O is the occupancy factor 0.8 and F is the conversion factor for organ dose from ingestion. Conversion factor (F) values are 0.64, 0.58, 0.69, 0.82, 0.62, 0.46 and0.68 for lungs, ovaries, bone marrow, testes, kidneys, liver and whole body, respectively, as obtained from ICRP (Avwiri, 2007).

Table 1. The mean radiation exposure rate and estimated radiation risk parameters of line-section one

S/No.	**Distance (m)**	**Average exposure rates (mRh^{-1})**	**Equivalent dose rates ($mSvy^{-1}$)**	**Absorbed dose ($nGyh^{-1}$)**	**Annual Effective Dose Equivalent ($mSvy^{-1}$)**	**Excess Lifetime Cancer Risk (x 10^{-3})**
1	0	0.020±0.001	1.71	176.90	0.27	0.95
2	5	0.019±0.003	1.60	165.30	0.25	0.89
3	10	0.014±0.002	1.21	124.70	0.19	0.67
4	15	0.016±0.002	1.37	142.10	0.22	0.76
5	20	0.020±0.005	1.68	174.00	0.27	0.93
6	25	0.018±0.005	1.54	159.50	0.24	0.86
7	30	0.016±0.003	1.37	142.10	0.22	0.76
	Average values	**0.018±0.002**	**1.50**	**154.94**	0.24	0.83

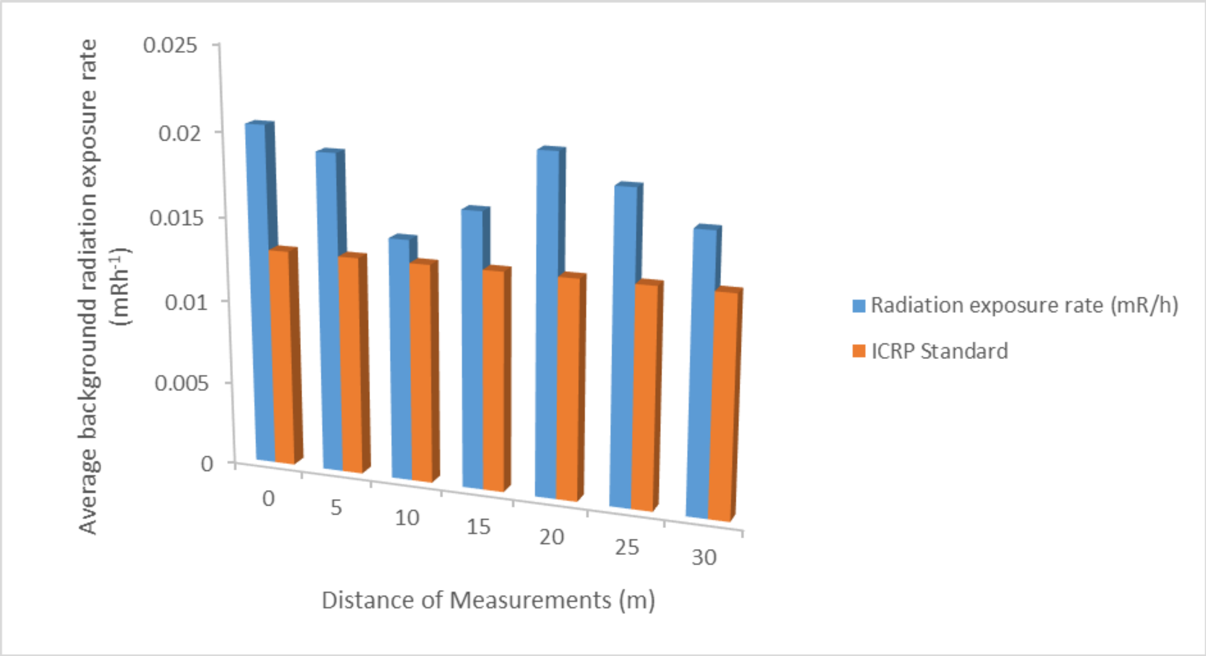

Fig. 1: Comparison of measured BIR levels in Section-Line one (Blacksmithing workshop) with standard

Table 2. The mean radiation exposure rate and estimated radiation risk parameters of line-section two

S/No.	Distance (m)	Average exposure rates (mRh^{-1})	Equivalent dose rates ($mSvy^{-1}$)	Absorbed dose ($nGyh^{-1}$)	Annual Effective Dose Equivalent ($mSvy^{-1}$)	Excess Lifetime Cancer Risk (x 10^{-3})
1	0	0.021±0.003	1.74	179.80	0.28	0.96
2	5	0.017±0.005	1.43	147.90	0.23	0.79
3	10	0.018±0.005	1.49	153.70	0.24	0.82
4	15	0.014±0.003	1.18	121.80	0.19	0.65
5	20	0.016±0.005	1.32	136.30	0.21	0.73
6	25	0.018±0.002	1.54	159.50	0.25	0.86
7	30	0.017±0.003	1.46	150.80	0.23	0.81
	Average values	**0.017±0.002**	**1.45**	**149.97**	**0.23**	**0.80**

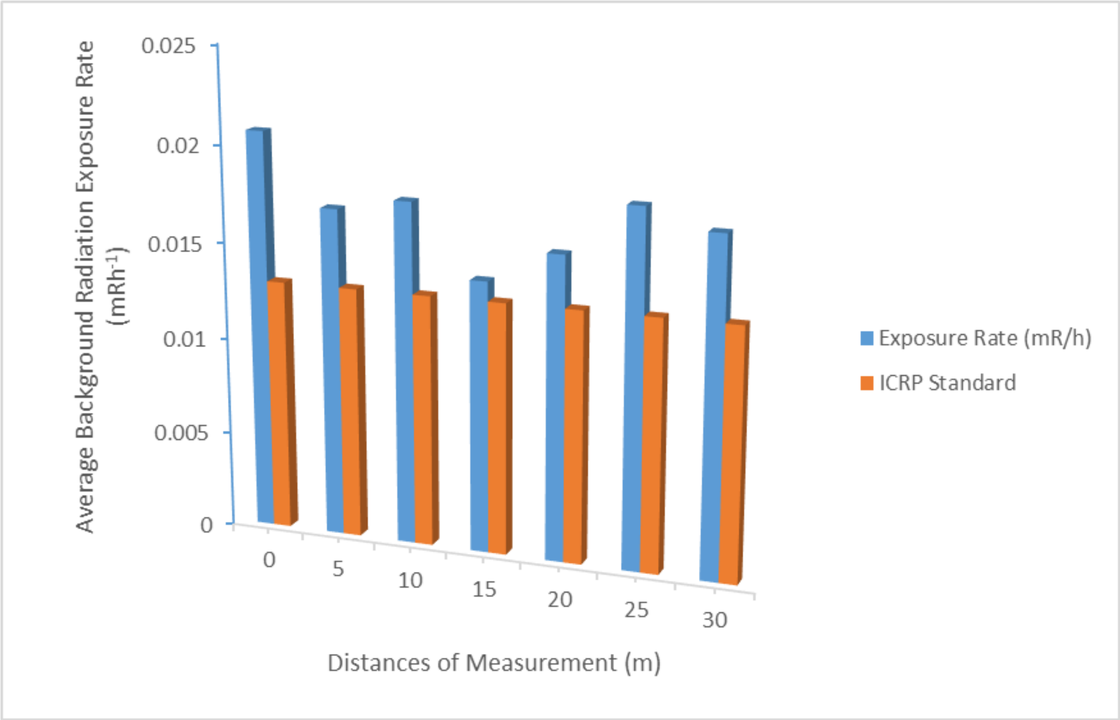

Fig. 2: Comparison of measured BIR levels in Section-Line two (Blacksmithing workshop) with standard

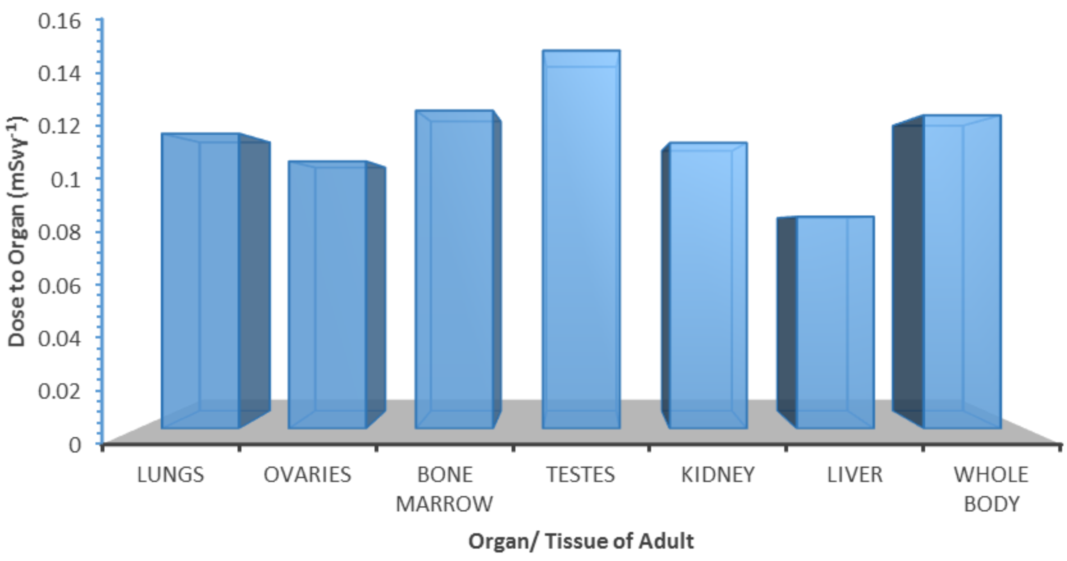

Fig. 3: Effective dose rate to different organs / tissues for workers in Blacksmithing workshop

DISCUSSION

The level of radiation exposure and radiation parameters in the background for the two line-sections of the blacksmith workshops in Gombe, Gombe State with estimated uncertainty was determined with a well-calibrated Geiger-Muller counter meters. The respective results are presented in Tables 1 and 2. The average radiation exposure levels of line-section one ranges between 0.014±0.002 to 0.020±0.001 mRh^{-1} with a mean value of 0.018±0.002 mRh^{-1}. The average exposure rate for line-section two ranges from 0.014±0.003 to 0.020±0.003 mRh^{-1} with a mean value of 0.017±0.002 mRh^{-1}. The values of the radiation exposure rate are highest at the source (0 m) which is due to abundant concentration of materials for blacksmithing operation and localized activities while the least values were obtained at 10 m away from the source in line-section one and 15 m in line-section two and these could be an outcome of attenuation in the spread of localized emission from the blacksmithing operations. The mean value obtained in all the distance of measurement for line-sections one and two were above the safe value, stipulated by ICRP, needs to be taken into serious consideration. Figures 1 and 2 show the comparison of exposure rates measured with the standard background radiation level. The least values obtained in line-sections one and two indicated that 3% and 2% of the values respectively were above the ICRP standard of 0.013 mRh^{-1}. A consequence of environmental conditions and very squeaky-clean exercise in some parts may be the slight difference in the exposure rates in various blacksmith workshops. The results showed that the exposure rates for the blacksmithing workshop sites are in accordance with the values recorded in all the distance of line sections one and two by Rafique et al., (2014) and Ademola and Onyema, (2014). The average exposure rate of the two line-sections of blacksmithing workshops were found to be higher than the range of values obtained in Industrial areas, Rivers state by Avwiri and Ebeniro, (1998). The equivalent dose rates estimated for the two line-sections of the blacksmith workshop presented in tables 1 and 2 were higher than the average standard of 1.0 $mSvy^{-1}$. These may be due to the elevated background radiation levels in part of the study areas. The absorbed dose estimated in the line-section one of the workshops ranges from 124.70 to 176.90 $nGyh^{-1}$ with mean value of 154.94 $nGyh^{-1}$ and in line-section two the values varies from 121.80 to 179.80 $nGyh^{-1}$ with the mean value of 149.97 $nGyh^{-1}$. The mean absorbed dose values averaging over thirty metres in line-section one deviate considerably from the values obtained in line-section two of the blacksmith workshops as shown in tables 1 and 2. This could be attributed to radiation from heat of the mass of hard cake coal (stock) performed in the two line-sections of the blacksmith workshops. The absorbed dose rates were higher than the world permissible value of 89.0 $nGyh^{-1}$(UNSCEAR, 2000). These deviations could have severe consequences as the rate of energy dissipated as a results of blacksmithing activities are fairly high. The measured outdoor gamma dose rates are also within the values reported in Turkey (78.3 - 135.7 $nGyh^{-1}$) (Erees et al., 2006) and in Poonch district (102 $nGyh^{-1}$) (Rafique et al., 2013). The annual effective doses in the blacksmith workshops were less than the world average of 0.48 $mSvy^{-1}$ (UNSCEAR, 2000). This implies that blacksmithing activities in these areas may not influence the doses received by public as the people in the study areas spend almost 6 hours outdoor due to the nature of their routine. The Excess lifetime cancer risks obtained for the blacksmith workshops were higher than the average world standard of 0.29 x 10^{-3} (UNSCEAR, 2000).

In Figure 2, the measured effective dose rates administered to the various organs in the adult body are presented with numerical values in $mSvy^{-1}$. The annual effective dose model for organs estimated the amount of radiation intake of a person entering and accumulating on different organs and tissues of the body (Agbalagba Ezekiel, 2017). Tests have been shown to have reported the maximum dose of 0.15 $mSvy^{-1}$ while the liver has recorded the lowest dose of 0.09 $mSvy^{-1}$.

Different absorption rates and conversion factors may be responsible for the relatively high test dose and low liver dose intake (Agbalagba et al., 2012). These findings suggest that the doses to various organs were below the 1.0 $mSvy^{-1}$ body organ dosing tolerance limits. This result shows that in all line-sections of blacksmithing workshops, exposure to background ionizing radiation levels makes an insignificant contribution to the radiation dose to these organs in adults and no case of symptoms referable to the radiation exposure

CONCLUSION

The background radiation exposure rate of the two line-sections of blacksmithing workshops in Gombe State has been measured and health risk parameters was calculated using applicable radiation models. With the exception of the excess lifetime cancer risk, which was higher than the

worldwide acceptable standard, all the measured health risk parameters are within their safe values. The result showed that there was no effect on the background radiation level of the region from the activities of blacksmithing workshops in the study areas. The estimated excess lifetime cancer risk revealed that the likelihood of contracting cancer for study area residents who spend all their lives in those communities is low and the estimated effective doses of adult organs in all organs are negligible. Therefore, the operation of blacksmithing workshops in the study areas have not influence enhance the level of background ionizing radiation level.

REFERENCES

Ademola J.A and Onyema U.C (2014). Assessment of natural radionuclides in fly ash produced at Orji River Thermal Power Station, Nigeria and the associated radiological impact. *Nat. Sci.*; 6:752–759.

Agbalagba E.O., Avwiri G.O. and Chad-Umoren Y.E. (2012). γ-Spectroscopy measurement of natural radioactivity and assessment of radiation hazard indices in soil samples from oil fields environment of Delta State, Nigeria. *J Environ Radioact*.; 109:64-70.

Agbalagba Ezekiel, (2017). Assessment of excess lifetime cancer risk from gamma radiation levels in Effurun and Warri city of Delta State, Nigeria. *Journal of Talbah University for Science,* 11:367-380.

Aremu, D.A. (2008). Nigerian Heritage Sites for Cultural and Ecotourism Development. In Aremu, D.A. (ed.) Preservation of Land, Culture and Wildlife for the Development of Ecotourism in Africa.Spectrum Books Limited Ibadan.

Avwiri G.O., Agbalagba EO, Enyinna PI. (2007). Terrestrial radiation around oil and gas facilities in Ughelli, Nigeria. Asian Network for Science Information. *Journal. Applied Sci.*;7(11):1543-1546.

Avwiri GO, Ebeniro JO, External environmental radiation in an industrial area of Rivers state. *Nig. J. Phys.* 1998; 10:105-107.

Drek H.C, May C.C and Zanat C (2010). Global networking for Biodosimetry laboratory capacity in radiation emergencies. Health phys. 92(2): 168-171

Erees F.S, Akozcan S, Parlak Y, and Cam S. (2006). Assessment of dose rates around Manisa (Turkey). *Radiation Measurements.*; 41(5):598-601.

Kumar D, Kumari S, Salian SR, Uppangala S, Kalthur G, Challapalli S, et al. (2016). Genetic instability in lymphocytes is associated with blood plasma antioxidant levels in health care workers occupationally exposed to ionizing radiation. International journal of toxicology. 2016;35(3):327-35.

Kuroda P. K. (1991). Estimation of burn up in the Okio natural nuclear reactor from ruthenium isotopic compositions. *J. Radioanal Nucl. Lett*.;155:107-133.

Megbele Y, Lam K, and Sadhra S. (2012). Risks of cataract in Nigerian metal arc welders. Occupational medicine. 2012;62(5):331

Mishra KP (2017). Carcinogenic risk from low dose radiation exposure is overestimated. *J Radiat Cancer Res.*; 8:1-3.

Mohammed A, Obeissi K, Omar ES, Khaled Z, and Ibrahim R. (2014). Assessment of indoor and outdoor radon levels in South Lebanon. *Springer.*;214-226.

Mosavianasl Z, Pouya AB and Borun R. (2018). Evaluation of Human Reliability in Steel Industry Using SPAR-H and CREAM Techniques. Pakistan Journal of Medical and Health Sciences. 2018;12 (2): 901-905.

Peng C. Y, Lan C.H, Juang Y.J, Tsao T.H, Dai Y.T, Liu H.H, et al. (2007). Exposure assessment of aluminum arc welding radiation. Health physics. 2007;93(4):298-306.

Rafique M, Basharat M, Azhar Saeed R and Rahamn S. (2013). Effect of geology and altitude on ambient outdoor gamma dose rates in district Poonch, Azad Kashmir, Carpathian. *Journal of Earth and Environmental Sciences*.; 8(4):165–173.

Rafique M, Rahman SU, Basharat M, Aziz W, Ahmad I, Lone KA, Ahmad K, and Matiullah. (2014). Evaluation of excess life time cancer risk from gamma dose rate in Jhelum valley. *Journal of Radiation Research and Applied Sciences*; 7:29-35.

Shelter Centre (2013). “Blacksmithing”. Retrieved 24 April 2014 from http://humanitarianlibrary.org/resource/blacksmithing factories. AIHAJ-American Industrial Hygiene Association. 2000;61(1):5-10.

Stewart FA, Akleyev AV, Hauer‑Jensen M, Hendry JH, Kleiman NJ, et al. (2012). ICRP publication 118: ICRP statement on tissue reactions and early and late effects of radiation in normal tissues and organs –Threshold doses for tissue reactions in a radiation protection context. *Ann ICRP*.;41:1‑322.

Taskin H, Karavus M, Ay P, Topozoglu A, Hindiroglu S, Karahan G. (2009) Radionuclide concentrations in soil and life time cancer risk due to gamma radioactivity in Kirklareli, Turkey. *Journal of Environmental Radioactivity*.;100:49-53.

TWG (2007). The World Gazetteer. Archived from the original on 2007-10-01. Retrieved 2004-03-07.

UNSCEAR (2000). Ionizing radiation: Sources and biological effects report to the general assembly with scientific annexes. United Nations Scientific Committee for Effects of Atomic Radiation New York, United Nation.;44-89.

UNSCEAR-A (2000). Annex-A, Dose assessment methodologies. United Nations Scientific Committee on the Effects of Atomic radiation; 2000.