Continental J. Applied Sciences 9 (1): 1 - 6, 2014
ISSN: 1597 – 9928

http://www.wiloludjournal.com
Printed in Nigeria
doi:10.5707/cjapplsci.2014.9.1.1.6

ASSESSMENT OF RADIATION DOSE RATE LEVELS IN SELECTED MECHANIC WORKSHOPS IN ABUJA, NORTH CENTRAL NIGERIA.

James, I. U.; Moses, I. F.
Nuclear Technology Centre, Nigeria Atomic Energy Commission, Sheda-Abuja, P.M.B O7, Gwagwalada, Abuja

ABSTRACT

Environmental radiation measurement was carried out in several mechanic workshops in four (4) local area councils in Abuja. A universal survey meter RDS-200 was used to ascertain the level of radiation to which these workers are daily exposed. The study revealed that the dose equivalent rate varied from 0.088±0.028 µSv/h to 0.149±0.034 µSv/h with a mean dose of 0.109±0.029 µSv/h. This work also revealed that the dose rate at the various mechanic workshops is essentially from natural background radiation. The results also show that the radiation dose rate from all the mechanic workshops did not exceed the maximum permissible limit of 1mSvy^{-1} recommended for the public and non-nuclear industrial environment by the International Commission on Radiological Protection ICRP [2007]. The cancer risk and hereditary effects to the adult workers were also estimated.

KEYWORDS: Background Radiation; Cancer Risks; Dose Equivalent; Hereditary Effects; Survey Meter

Received for Publication: 23/11/13 Accepted for Publication: 20/02/14
Corresponding Author: jamesfam2002@yahoo.com

INTRODUCTION

Background radiation is that which is naturally and inevitably present in our environment. Human beings are exposed to background radiation that stems both from natural and man-made sources. In general, approximately 85% of the annual total radiation dose of any person comes from natural radionuclides of both terrestrial and cosmogenic origin (Belivermis et al. 2010; UNSCEAR 2000). The worldwide annual effective dose from natural sources is estimated to be 2.4 mSv (UNSCEAR 2000).

The earth's crust contains various radioactive isotopes such as uranium, thorium, radon, tritium, carbon, and potassium among others. These isotopes and their decayed products have differences in their half lives, which emit various types of radiations such as alpha, beta and gamma rays. Additionally, cosmic radiation from the sun contributes to gamma rays surrounding the human body. Conversely, the controlled manmade-artificial background radiation results from several sources such as fallouts of weapons testing, radioactive waste, and the use of radioisotopes in radiation-therapy. Both controlled and uncontrolled sources of radiation may have undesired biological effects to living species (Orwa et al 2012). Small traces of many naturally occurring radioactive materials are present in the human body. These come mainly from naturally occurring radioactive nuclides present in the food we eat and in the air we breathe. These isotopes include tritium (^{3}H), carbon-14 (^{14}C), and potassium-40 (^{40}K) (Oyeyinka et al 2012).

Radiation has been found to be beneficial on one hand and harmful on the other hand. Some of the harmful effects are: cancer, cataract, gene mutation destruction of bones and blood cells and it can cause the death of an individual (Jwanbot et al, 2012). The level of the natural radioactivity in the soil and in the surrounding environment as well as the associated external exposure due to the gamma radiation depends primarily on the geological and geographical conditions of the region (UNSCEAR, 2000). The geological and geographical definition of an environment dictate to a good degree the radionuclides contained in the soil and rocks there (Tchokossa et al., 2012). However, since radiation is known to cause cancer, it is prudent to monitor the environment for radioactivity (MDH 2008). On the relevance of radiation monitoring, the Office of Radiation Protection (Office of Radiation Protection, 2008) stated that through radiation monitoring, sample collection and data analysis, the environment is protected from hazards associated with ionizing radiation.

There are more than 1,577,000 metric tons of irradiated scrap metals available and these metals come from decommissioned nuclear reactors and nuclear weapons, tons of steel from buildings that contain radioactivity which are part of the 'hot metal' scrap being introduced for recycling (Howdershelt, 2000). Radioactive metals like gold, silver, carbon steel, stainless steel, aluminium, nickel and copper are being made available for recycling (Howdershelt, 2000). Scrap metal can contain sources of radiation with the associated environmental and health risks. Higher levels of radiation are possible and may stem from losses, accidents or the inadvertent disposal of radioactive material (Lenka and Peter, 2010).

Mechanic workshops in most cities in Nigeria could pose serious health hazards to the auto technicians (locally called mechanics). This is as a result of the fact that these mechanics are exposed to metals indiscriminately dumped in the vicinity of the workshop that might have been contaminated by other radioactive metals in the course of production (Nworgu et al., 2012). Studies show that long-term exposure to low levels of radiation can be more hazardous than short term exposure to high levels, resulting in a six to eight times greater cancer risk (Howdershelt, 2000). The proper monitoring and evaluations of the radiation emanating from these mechanic workshops in order to provide accurate data as part of environmental monitoring research for proper assessment of radiation exposure rate in Abuja motivated this study.

MATERIAL AND METHODS

Study Area

Abuja, Nigeria's new capital city is located in the middle of the country. The Federal Capital Territory (FCT) has a land area of 8,000 square kilometres, which is two and halftimes the size of Lagos, the former capital of Nigeria. The FCT is bounded on the north by Kaduna State, on the west by Niger State, on the east and south-east by Plateau State, and on the south-west by Kogi State. Abuja lies at latitude 9°4´0´´N and Longitude 7º29´0´´E. The FCT is presently made up of six (6) Area Councils – Municipal, Abaji, Bwari, Gwagwalada, Kuje and Kwali. The study area covers mechanic workshops in four (4) Area Councils (Abaji, Kwali, Kuje and Gwagwalada). Seventeen (17) locations were strategically selected in the study as shown in Table 1 for adequate coverage of the four Area Councils.

Experimental Method

An in-situ approach of background radiation measurement was adopted and preferred to enable samples maintain their original environmental characteristics. A universal survey meter, RDS-200 was used. The RDS-200 Universal Survey Meter is an excellent, portable multipurpose radiation meter for a wide range of applications. It is especially designed for situations where accurate measurements at low dose rate levels are of importance. The meter has an interface for the external gamma probes GMP-12H/12L or beta/contamination measurement probe GMP-11/15. A connector for the attachment of the meter to a PC is located at the bottom part of the meter and is equipped with protective cover. The RDS-200 utilizes field-proven measurement electronics and can also be used as a local display unit with the RADOS AAM-90 Area Monitoring System. The meter measures γ-radiation and beta radiation with an external probe detector. It also measures equivalent dose rate within 0.05 μSv/h-10 μSv/h. The meter was calibrated by the National Institute of Radiation Protection and Research, University of Ibadan, Ibadan-Nigeria. The monitor was suspended in air at one meter above the ground level. Readings were obtained between the hours of 1200 and 1600 hours since the exposure rate meter has a maximum response to environmental radiation within these hours.

Table 1: The respective descriptions of the various locations

Area Councils	Location	Code
Abaji	Abaji city centre	MW1
Kwali	Yangoji	MW2
Kwali	Kwali	MW3
Kwali	Sheda	MW4
Kwali	Bako	MW5
Kwali	Dabi	MW6
Gwagwalada	Dagiri	MW7
Kuje	Kuje 1	MW8
Kuje	Kuje 2	MW9
Gwagwalada	Angwan Dodo	MW10
Gwagwalada	SDP Junction	MW11
Gwagwalada	UATH Road	MW12
Gwagwalada	Gwako	MW13
Gwagwalada	Giri	MW14
Gwagwalada	Anagada	MW15
Gwagwalada	Tunga Maje	MW16
Gwagwalada	Zuba	MW17

Dose and Risk Estimation
Annual dose equivalent helps to determine the absorbed dose rate per year (μSv/yr). The equation below is used to calculate the annual dose equivalent.

$$D = \sigma \times \mu \times 24 \times 365 \ (\mu Sv/yr) \qquad (1) \text{ (Tayyeb et. al., 2012)}$$

Where:
D = Annual absorbed dose rate in micro sievert per year.
σ = Absorbed dose rate in micro sievert per hour.
μ = Occupancy factor, 0.2

Risk can be defined as the probability of an event occurring multiplied by the severity if it does occur. Occupationally exposed workers are normally exposed to chronic risk of somatic or hereditary damage of human tissues, thus much emphasis is always placed on the reduction of chronic risks. The cancer risk estimates have not greatly changed since 1990. Furthermore, the International Commission on Radiological Protection, ICRP (2007) continues to consider that a dose and dose-rate effectiveness factor (DDREF) of 2 is still appropriate in order to derive nominal risk coefficients for low doses and low dose rates. The nominal lifetime risk coefficients of fatal cancer recommended in the 2007 recommendations of the ICRP are 5.5 x 10^{-2} Sv^{-1} for members of the public and 4.1 x 10^{-2} Sv^{-1} for occupationally exposed workers. For heritable effects, the detriment-adjusted nominal risk coefficient is estimated at 0.2 x 10^{-2} Sv^{-1} for the whole population and 0.1 x 10^{-2} Sv^{-1} for adult workers as stated in ICRP (2007) for stochastic effects after exposure at low dose rates. The total detriment (Cancer + Heritable effects) is 4.2 x 10^{-2} Sv^{-1} for adult workers and 5.7 x 10^{-2} Sv^{-1} for the whole population (ICRP, 2007). All values are nominal in that the new values were based upon data on cancer incidence weighted for lethality and life impairment, whereas the 1990 values were based upon fatal cancer risk weighted for non-fatal cancer, relative life years lost for fatal cancers and life impairment for non-fatal cancer. Thus, the combined detriment from stochastic effects has remained unchanged at around 5% Sv^{-1}. If anything, the total detriments are somehow lower; which is largely a reflection of the reduction in the risk of serious heritable effects

The risk to the auto technicians (occupationally exposed workers) was then estimated using the 2007 recommended risk coefficients in ICRP (2007).

Cancer Risk = Total Annual Effective Dose (Sv) x Cancer Risk Factor (2)
Hereditary Effects = Total Annual Effective Dose (Sv) x Hereditary Effect Factor (3)

RESULTS AND DISCUSSION

The result from the work carried out is tabulated in Tables 2 and 3. A total of two hundred and twenty (220) measurements were taken. Table 2 shows the results of the *in-situ* gamma radiation dose rates measured with the RDS 200 survey meter. The results of the measured dose rates varied from an average of 0.088±0.028 μSv/h to 0.149±0.034 μSv/h. The mean value from MW17 shows the highest dose rate while the dose rate from MW5 was the lowest. The overall mean dose rate in this work is 0.109±0.029 μSv/h. MW9 recorded the second highest in-situ gamma radiation of 0.134±0.035 μSv/h. Furthermore, the dose rates of MW1 to MW8 and MW10 to MW16 are below the Standard Background Radiation (0.133μSv/h). However, MW17 and MW9 are slightly above Standard Background Radiation but far below the maximum allowable limit (0.57 μSv/h) recommended by ICRP [ICRP 2007]. Table 3 illustrates the estimated fatality cancer risk to adult workers per year which ranges from 6.321×10^{-6} to 10.703×10^{-6} with heritable effect risk to adult workers ranged from 0.154×10^{-6}.to 0.261×10^{-6}. Also, the total detrimental risk to adult workers ranges from 6.475×10^{-6} to 10.964×10^{-6}. It could also be inferred that the annual effective dose values is far below the worldwide average of the annual effective dose of 480 μSvy^{-1} or 0.48 $mSvy^{-1}$ as stated in ICRP [ICRP 2007]. Figure 1 shows the comparison of the mean radiation levels with the standard background radiation level of 0.133 μSv/h recommended by ICRP (2007).

Table 2: Mean and Standard Deviation of dose rate values measured at the different location

Location Code	Mean Dose Rate* (uSv/h)	Number of Data Points
MW1	0.120±0.034	14
MW2	0.104±0.017	8
MW3	0.108±0.025	16
MW4	0.089±0.026	8
MW5	0.088±0.028	15
MW6	0.092±0.027	13
MW7	0.101±0.028	21
MW8	0.108±0.036	15
MW9	0.134±0.035	16
MW10	0.112±0.041	9
MW11	0.116±0.027	10
MW12	0.106±0.032	9
MW13	0.111±0.030	10
MW14	0.108±0.037	13
MW15	0.104±0.021	10
MW16	0.108±0.017	15
MW17	0.149±0.034	18
Total	**1.858±0.494**	**220**

*Values represented as Mean ± Standard Deviation.

Table 3: Estimated Average Annual Effective Dose, Cancer Risks and Hereditary Effects of adult workers

Location Code	Annual Absorbed Dose Rate (μSvh^{-1})	Fatality Cancer Risk To Adult Workers Per Year ($x\ 10^{-6}$)	Hereditary Effect in Adult Workers Per Year ($x\ 10^{-6}$)	Total Detriment ($x\ 10^{-6}$)
MW1	210.24	8.620	0.210	8.830
MW2	182.208	7.471	0.182	7.653
MW3	189.216	7.758	0.189	7.947
MW4	155.928	6.393	0.156	6.549
MW5	154.176	6.321	0.154	6.475
MW6	161.184	6.609	0.161	6.770
MW7	176.952	7.255	0.177	7.432
MW8	189.216	7.758	0.189	7.947
MW9	234.768	9.625	0.235	9.860
MW10	196.224	8.045	0.196	8.241
MW11	203.232	8.333	0.203	8.536
MW12	185.712	7.614	0.186	7.800
MW13	194.472	7.973	0.194	8.168
MW14	189.216	7.758	0.189	7.947
MW15	182.208	7.471	0.182	7.653
MW16	189.216	7.758	0.189	7.947
MW17	261.048	10.703	0.261	10.964

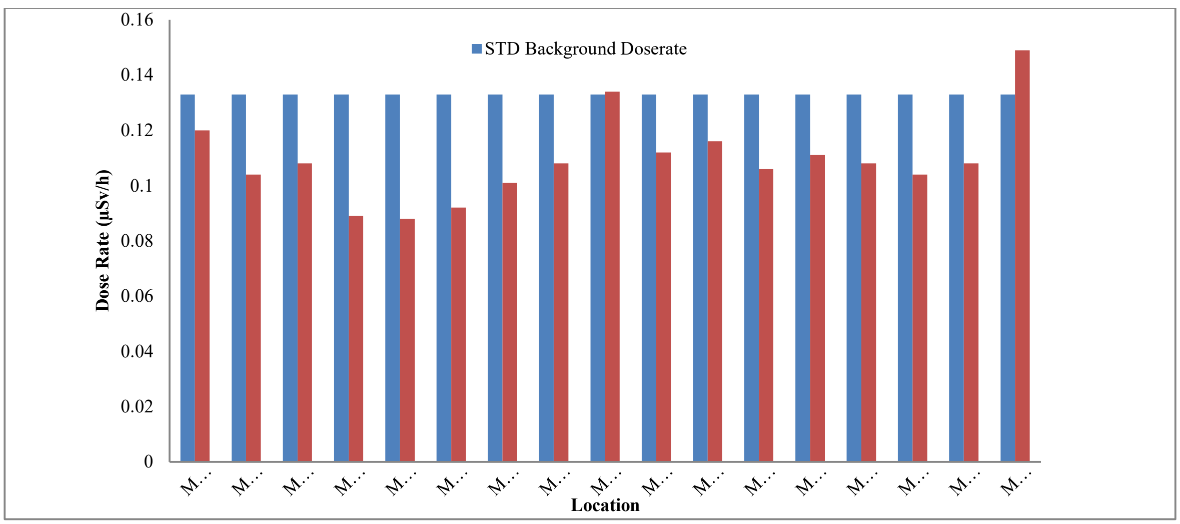

Figure 1: Comparison of dose rate at various locations with Standard Background Radiation

CONCLUSION
The exposure rates have been computed for several mechanic workshops using in situ measurement method. This work revealed that the calculated average annual effective dose is far below the worldwide average annual effective dose. This infers that in the mean time, the mechanics in the area are not at risk of exposure to high levels of radiation. Therefore, there should be no anxiety on the hazards associated with ionizing radiation in the workshops.

REFERENCES
Belivermis, M., Kılıç, Ö., Çotuk, Y., & Topcuoğlu, S. (2010). The effects of physicochemical properties on gamma emitting natural radionuclide levels in the soil profile of Istanbul. *Environmental Monitoring and Assessment*, 163, 15–26.

E. Howdershelt (2000). Radioactive Scrap Metal. Abintra Press

International Commission on Radiological Protection ICRP, (2007). Recommendations of ICRP.*ICRP Publication 103. Ann. ICRP* 37, pp. 54-55

Jwanbot, D. I.; Izam, M. M.; Gambo, M. (2012). Measurement of Indoor Background Ionizing Radiation in some Science Laboratories in University of Jos, Jos- Nigeria. *Science World Journal* Vol. 7, No 2.

Lenka M and Peter E (2010). End-of-waste criteria for iron and steel scrap: technical proposals. *EUR-scientific and technical research series*-ISSN 1018 5593.
.
MDH: Environment Radiation Monitoring (2008). Minnesota Department of Health, Radiation Control Unit, 651-201-4545

Nworgu, O. D., Osahon, O. D., Franca F.E. (2012). Measurement of Gamma Radiation in Automobile Mechanic Workshops in an Area of Benin City, Nigeria. *Advanced Materials Research* Vol. 367 pp 801-805

Oyeyinka, O. D., James, I. U., Akueche, E. C., Shonowo, O. A., Adesanmi. C. A. (2012). Estimation of Radiation Dose Rate Levels around a Nuclear Establishment in Abuja, North Central, Nigeria. *Science and Technology* 2(6): 163-167

Office of Radiation Protection (2008). Division of Environmental Health, Washington State Department of Health.

Orwa J. H; Mohamad A; Aziz B; Odayy Z; Ismail H; Solena A. (2012). Measurements of the Environmental Natural Radiation in the Northern West Bank Governorate of Jenin-Palestine *Journal of Science (JOS)* Vol. 2, No. 1.

Tayyeb A. P; Hamed B; Maryam S. (2012). Evaluation of High Level Environmental Background Radiation Areas and its Variation in Ramsar. *Iranian Journal of Medical Physics* Vol. 9, No. 2, 87-92

Tchokossa, P; Olomo, J. B; Balogun, F. A; Adesanmi, C. A. (2012). Radiological Study of Soils in Oil and Gas Producing Areas in Dealta State, Nigeria. *Radiat. Prot. Dos*. pp 1-6

UNSCEAR (2000). United Nation Scientific Committee on the Effects of Atomic Radiation. Sources and effect of Ionizing radiation. Report to the general assembly with scientific annexes. United Nations; New York.