Science and Technology 2012, 2(6): 163-167
DOI: 10.5923/j.scit.20120206.04

Estimation of Radiation Dose Rate Levels around a Nuclear Establishment in Abuja, North Central, Nigeria

O. D. Oyeyinka*, I. U. James, E. C. Akueche, O. A. Shonowo, C. A. Adesanmi

Nuclear Technology Centre, Nigeria Atomic Energy Commission, Sheda-Abuja, P.M.B O7, Gwagwalada, Abuja

Abstract The radiation monitoring around Nuclear Technology Centre, Nigeria Atomic Energy Commission, Sheda-Abuja has been carried out using RDS-200 Universal Survey meter. Areas monitored included Gamma Irradiation Facility, Central Workshop, Radioactive Waste Management Building under Construction, proposed Radioisotope Plant site, Power Supply Station, SHESTCO Advanced Laboratories, Xechem Pharmaceutical Plc, Staff Housing Estates and NAEC Researchers' Hostel. It was observed that the dose equivalent rate varied from 0.106 ± 0.032 to 0.212 ± 0.036 µSv/h with a mean of 0.149 ± 0.032µSv/h.These results though slightly above the standard background radiation of 0.133 µSv/h, they are below the ICRP maximum permissible limit of 0.57µSv/h and may not pose any danger to the radiation workers, the general public and the environment. This work also revealed that the dose rate at the Nuclear Technology Centre (NTC) is essentially from natural background radiation. This implies that there is adequate shielding for all the radioactive sources. It is safe and there has possibly been no contamination from the activities of the centre on its environment.

Keywords Dose Rate, Environment, Heritable Effect, Nuclear Establishment, Radiation Monitoring

1. Introduction

Radiation, because of the adverse health effect when persons are over exposed to ionizing radiation, is feared by many people worldwide and Nigerians are no exemption. This concern is even much higher with inhabitants living at close proximity to nuclear establishments. What most people do not realize is that radiation is present everywhere, in everything in our environment and even in our bodies. There is cosmic radiation made up of protons, alpha particles and heavy nuclei bombarding the earth from space. They interact with atmosphere resulting into large numbers of gamma rays, neutrons and mesons contributing high radiation dose burden to man even at sea level[1]. Other natural radiation includes the terrestrial gamma rays from land, sea and walls of houses we live. We are also internally exposed from radiation emitted by radio-nuclides absorbed into the body through the food we eat and milk we drink. Examples of such radio-nuclides are potassium -40, heavy elements and carbon-14. Although generally the background radiation contributes more than 60% of the annual radiation dose burden to man, however the radiation levels in most places are too weak to cause any deleterious effects on man. Therefore, there is no need to fear radiation but to understand the properties, make use of it and reduce the exposure to dose level which the society judged as acceptable with minimum associated risk. As long as the contribution from the artificial radio-nuclides does not push the annual dose equivalent level beyond 1mSv, then there is no need to fear radiation. Although the level of dose burden from natural radiation is low, there is still a level of risk, though small, is not zero. It has been reported[2] that averagely the radiation exposure rate lies in the range of 0.08-0.15µSv/hr. According to[3] about 95% of the world's population is assumed to live in areas of normal background radiation with outdoor dose rate ranging from 0.024 to 0.160 µGy/h.

The harmful effects of radiation can be categorized into deterministic radiation (Tissue reaction) and non deterministic radiation risks. Deterministic effects have threshold dose below which effects are not probable such as erythema, radiation dermatitis, alopecia etc whereas non deterministic effects have no threshold dose and include carcinogenesis and genetic effects. The objective of radiation protection is to define how one can protect individual, their descendants and human race in the entirety against the potential risks of ionizing radiation[4]. The public and radiation workers receive various doses of ionizing radiation from both naturally occurring and man made sources. The level of doses received depends on the occupation, level of radiation in the environment and where an individual lives. Depending on where an individual lives, some people receive an exposure in the range of 1mSv per year from cosmic radiation from outer space and from naturally occurring isotopes in the ground, air, food and water[5]. Radiation from many sources is omnipresent on the earth

* Corresponding author:
lanre442003@yahoo.com (O. D. Oyeyinka)
Published online at http://journal.sapub.org/scit

surface, consequently man is continuously irradiated. 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[6]. The geological and geographical definition of an environment dictate to a good degree the radionuclides contained in the soil and rocks there.[7]. Soil contains small quantities of radioactive elements along with their progeny [8].

This paper presents the radiation level and the gamma equivalent dose rate, cancer and heritable risks effects to the radiation workers and the non radiation workers working and living within Sheda Science and Technology Complex, Sheda and the general public living around this nuclear establishment. The values obtained for radiation from this work will form part of the baseline data for environmental radiation in the Federal Capital Territory, Abuja which up till now to the best of our knowledge is not available. The data could also be used (in the future) to assess the impact of research activities on the environment.

2. Materials and Methods

This study was conducted between October and November, 2011, in and around Nuclear Technology Centre (NTC). NTC is situated in Sheda, Abuja. It is also 75 km southwest of the Federal Capital Territory (FCT), Abuja and about 35 km from the Nnamdi Azikwe International Airport, Abuja. NTC is in the vicinity of the National Food Reserve Agency Strategic Grains Reserve Facility, National Agricultural Seeds Council; National Automotive Council site, Nigerian Educational Research and Development Council, Federal Ministry of Works Highway Materials and Geotechnics Testing Laboratories. Also the National Mathematical Centre lies to the South West while National Fire Academy, National Co-operative Management Development Centre and Federal Government College lies to the South East. NTC is in the transitional zone between the basement complex rocks of the North-Central part of Nigeria and the Bida Sand stone basin lying to the South. The rocks consists mainly of granite, are exposed only along river channels[9].

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. Readings were obtained between the hours of 1200 and 1600 hours. Eighteen (18) locations were strategically selected in the study for adequate coverage of the complex. These include Surrounding of Shield (SRDSH), Other Locations within Gamma Irradiation Facility (Other-GIF), Waste Treatment Plant (WTP), Gamma Irradiation Water Treatment Plant (GIF-WTP), Central workshop (CWS), On Top of Irradiation Room (TOPIRRAD), Power Supply Station (PSS), SHESTCO Administration Complex (ADC), SHESTCO Staff Canteen (SSC), Xechem Pharmaceuticals (XECHEM), SHESTCO Physics Advanced Laboratory (PAL), SHESTCO Biotechnology Advanced Laboratory (BAL), SHESTCO Mechanical Workshop (SHESTCO WKSP), SHESTCO Staff Quarters Phase 1(SSQ1), SHESTCO Staff Quarters Phase 2(SSQ2), SHESTCO Staff Quarters Phase 3(SSQ3), NAEC Researcher's Hostel (NAECRH), Natural Background Radiation (BKG). These areas record high population flux throughout the day. The monitor was suspended in air at one meter above the ground level.[10]. At least five readings were taken in each location and the mean values were recorded.

3. Results and Discussion

Data for the mean dose rates of the areas measured are presented in Table 1 below. A total of 125 measurements were taken across the Nuclear Technology Centre and Sheda Science and Technology Complex.

Generally, from the result, the average dose rates for each area ranged between 0.106 ± 0.032 μSv/hr to 0.212 ± 0.036 μSv/hr. The mean value from WTP shows the highest dose rate while the dose rate from PAL was the lowest. The overall mean dose rate in this work is 0.149 ± 0.032 μSv/hr. SSQ2 recorded the second highest in-situ gamma radiation of 0.176 ± 0.027 μSv/hr. Furthermore, the dose rates of TOPSH and PAL are below the Standard Background Radiation (0.133 μSv/hr) while that of XECHEM and GIF-WTP are about the same with the Standard Background Radiation. However, others are slightly above Standard Background Radiation but far below the maximum allowable limit (0.57 μSv/hr) recommended by ICRP. The cancer risk estimates have not greatly changed since 1990. Furthermore, ICRP 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 detriment –adjusted nominal risk coefficient for adult workers after exposure to radiation at low dose rates (10^{-2}/uSv) for cancer is 4.1, Heritable effects, 0.1, and the total detriment (cancer + Heritable effects) is 4.2[11]. 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 effective dose was calculated from absorbed dose rate multiplied by the dose conversion factor of 0.72 and an occupancy factor of 2000hrs/year. Risk can be defined as the probability of an event occurring multiplied by the severity if it does occur. Radiation 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.

Cancer Risk = Total Annual Effective Dose (Sv) x Cancer Risk Factor (1)

Hereditary Effects = Total Annual Effective Dose (Sv) x Hereditary Effect Factor (2)[12].

Figure 1. Shows that the dose rate values of NTC I, SHESTCO academic and Staff Quarters areas are higher than the NTCII (inside the Gamma Irradiation Facility) radiation dose rate value. This implies that inhabitants of those areas are not subjected to increased radiation exposure and higher risks from the radiation facility. The background radiation observed at the surveyed areas could be attributed only to natural sources (cosmic and terrestrial). The geology of the town suggests that the soil in Abuja has a large deposit of granite. It is well known that granites contain high concentrations of uranium, thorium and potassium[13]. The total mean dose rate of the surveyed areas was found to be lower than that of a similar institution at GAEC, Ghana[12]. Also, the dose rate is lower than that reported for Minna which is just about 100 Km away from the study area; this may be due to the fact that they have similar geology[8, 9]. Ilorin and Offa values, 0.132uSv/hr and 0.134 uSv/hr respectively,[14, 15] are found to be comparable with that obtained in this work.

Table 2 illustrates the estimated fatality cancer risk to adult workers per year which ranges from 6.26 X 10^{-6} to 12.50 x 10^{-6} with heritable effect risk to adult workers ranged from 1.53 x 10^{-6}.to 3.05 x 10^{-6}. Also, the total detrimental risk to adult workers ranges from 6.41 x 10^{-6} to 12.80 x10^{-6}. It could be inferred that annual effective dose values compares well with world average of annual effective dose of 480uSv/h[11]. On the average, WTP recorded the highest level of risks to its workers and thus it could be inferred that the likelihood of a worker within WTP transferring heritable effects from a radiation induced to their offspring is high.

Table 1. Mean and Standard Deviation of dose rate values measured at the defined Zones

S/N	Location	RADOS200 (µSv/h)	No of data Points
1	Surrounding of the Shielding (SRDSH)	0.149 ± 0.062	9
2	On Top of the Irradiation Room (TOPIRRAD)	0.128 ± 0.016	5
3	GIF Water Treatment Plant (GIF-WTP)	0.130 ± 0.070	3
4	Other Locations within GIF	0.143 ± 0.027	12
5	Waste Treatment Plant (WTP)	0.212 ± 0.036	6
6	Central workshop (CWS)	0.168 ± 0.037	6
7	Power Supply Station (PSS)	0.167 ± 0.060	6
8	SHESTCO Administration Complex	0.132 ± 0.040	5
9	SHESTCO Staff Canteen (SSC)	0.156 ± 0.065	5
10	Xechem Pharmaceuticals (XECHEM)	0.130 ± 0.029	5
11	SHESTCO Physics Advanced Laboratory(PAL)	0.106 ± 0.032	5
12	SHESTCOBiotechnology Advanced Laboratory (BAL)	0.140 ± 0.035	5
13	SHESTCO Staff Quarters Phase 1(SSQ1)	0.138 ± 0.047	10
14	SHESTCO Staff Quarters Phase 2(SSQ2)	0.176 ± 0.027	9
15	SHESTCO Staff Quarters Phase 3(SSQ3)	0.152 ± 0.032	17
16	NAEC Researcher's Hostel (NAECRH)	0.149 ± 0.038	8
17	Mechanical Workshops (SHESTCO Mech Wksp)	0.138 ± 0.036	5
18	Natural Radiation; Background (BKG)	0.133 ± 0.030	4
		Total number of Points	**125**

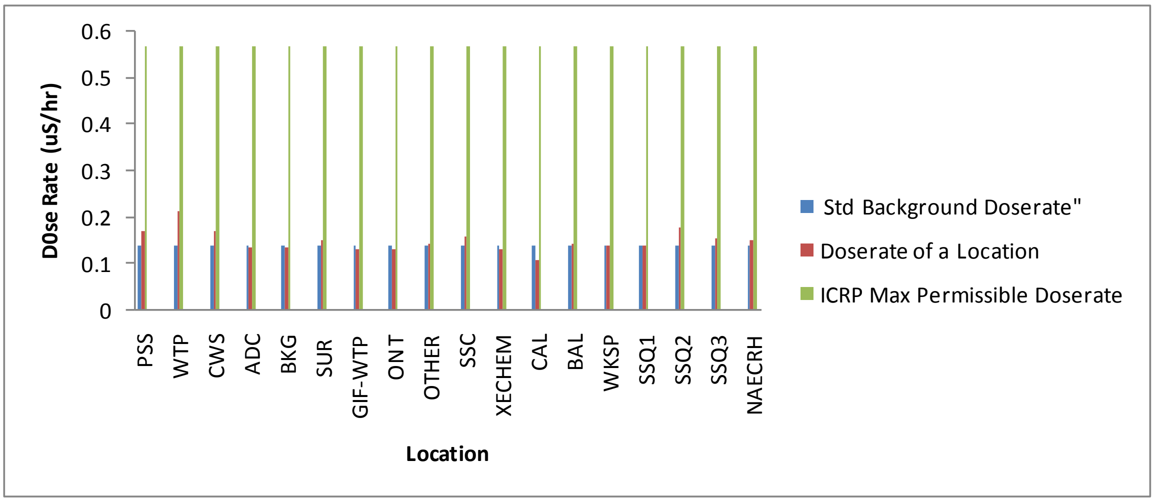

Figure 1. Dose rates of different locations measured

Table 2. Estimated Average Annual Effective Dose, Cancer Risks and Hereditary Effects of adult workers

S/N	Location	Average Annual Effective Dose (μSv/yr)	Fatality cancer risk to adult workers per year (x 10^{-6})	Heritable effects (x10^{-7})	Total detriment (x 10^{-6})
1	Surrounding of the Shielding (SRDSH)	214.56	8.80	2.15	9.01
2	On Top of the Shielding (TOPSH)	184.32	7.56	1.84	7.74
3	GIF Water Treatment Plant (GIF-WTP)	187.20	7.68	1.82	7.86
4	Other Locations within GIF	205.92	8.43	2.06	8.65
5	Waste Treatment Plant (WTP)	305.28	12.52	3.05	12.82
6	Central workshop (CWS)	241.92	9.92	2.42	10.16
7	Power Supply Station (PSS)	240.48	9.86	2.40	10.10
8	SHESTCO Administration Complex	190.08	7.79	1.90	7.98
9	SHESTCO Staff Canteen (SSC)	224.64	9.20	2.25	9.44
10	Xechem Pharmaceuticals (XECHEM)	187.20	7.68	1.87	7.86
11	SHESTCOPhysics Advanced Laboratory (PAL))	152.64	6.26	1.53	6.41
12	SHESTCOBiotechnology Advanced Laboratory (BAL)	201.60	8.27	2.02	8.47
13	SHESTCO Staff Quarters Phase 1(SSQ1)	198.72	8.15	1.99	8.35
14	SHESTCO Staff Quarters Phase 2(SSQ2)	253.44	10.39	2.53	10.64
15	SHESTCO Staff Quarters Phase 3(SSQ3)	218.88	8.97	2.19	9.19
16	NAEC Researcher's Hostel (NAECRH)	214.56	8.80	2.15	9.01
17	Mechanical Workshops (SHESTCO Mech Wksp)	198.72	8.15	1.99	8.35
18	Natural Radiation; Background (BKG)	191.52	7.85	1.92	8.04

4. Conclusions

The exposure rates have been computed for the various Nuclear Technology Centre and Sheda Science and Technology Complex locations using in situ measurement method. This work revealed that the calculated average annual effective dose is comparable to the worldwide average annual effective dose. This explains the acceptable level of safety culture being practiced in the centre. The results from this work will form the baseline data which will be useful in assessing contribution to radiation in the environment from future activities of the Nuclear Technology Centre.

REFERENCES

[1] Maduemezia, A; Coker, AJ; Osaisai, FE; Mshelia, ED; Adesanmi, CA (2008). Biological Effects of Nuclear Radiation on Man and the Environment in: The Physics of Power Reactor, Beaver Publications, Ibadan, Nigeria. : 82-95.

[2] Gordon Linsley (1997). Radiation & the Environment: Assessing effects on Plants and Animals: IAEA Bulletin. 39 (1).

[3] United Nation Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (1993). Sources and effect of Ionizing radiation. Report to the general assembly with scientific annexes. United Nations; New York.

[4] International Commission on radiological Protection (1991). Recommendations of the International Commission on Radiological Protection, Annals of ICRP vol. 21, No 13 Pergamum Press, Elmsford, NY.

[5] Oluwafisoye, PA; Olowookere, CJ; Obed, RI; Efunwole, HO; Akinpelu, JA (2009). Environmental Survey and Quality Control Tests of X-Ray Diagnostic Facility of a large Nigeria Hospital International. Journal of Research and review in applied Sciences Vol.1 (2):157-162.

[6] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (2000) Report to the General Assembly with Scientific Annexes, Vol 1: 2000.

[7] Tchokossa, P; Olomo, JB; Balogun, FA; Adesanmi, CA; (2012) Radiological Study of Soils in Oil and Gas Producing Areas in Dealta State, Nigeria. Radiat. Prot. Dos. Pp 1-6; doi:101093/rpd/ncs101

[8] Olarinoye, IO; Sharifat, I; Baba-Kutigi, AN; Kolo, MT; Aladeniyi, K. (2010). Measurement of Background gamma radiation levels at two Tertiary Institutions in Minna, Nigeria. J. App. Sc. Environ. Management, Vol. 14 (1): 59-62.

[9] Folayan, MA; Agunbiade, JA; Omothoso, DB; Oyewole, GA, Oni, JO; Akinsunmade, T; Oniyide, JO; Ogunsola, IO (1989). SHESTCO Final Land Use Plan, Niger Consultants, Architects and Planners Nigeria, Vol.1.

[10] Environmental Measurement Laboratory (EML). (1983). Procedure manual. New York

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

[12] Amekudzie, A; Emi- Reynolds, G; Kpeglo, DO; Mensah; CK; Gyekye, PK; Lawluvi, H; Gbormittah, SV; Owusu, E (2011). Determination of Dose Rate Levels around Nuclear Installations in Ghana. Int. J. of Sci & Tech. Vol.1. (3): 144-147.

[13] Ivanovich, M and Harmon, RS. (1982). Uranium series disequilibrium in application to environmental problems. Oxford, Clarendon Press, 51-55.

[14] Nwankwo, L I; Akoshile, CO (2005a). Background Radiation study of Offa Industrial area of Kwara State, Nigeria. J. App Sci. Environ. Management 9 (3): 95-98.

[15] Nwankwo, LI; Akoshile, CO (2005b). Monitoring of external Background Radiation Level in Asa Dam Industrial area of Ilorin, Kwara State, Nigeria. J. App Sci. Environmental Management 9 (3):91-94