JASEM ISSN 1119-8362

Full-text Available Online at
www.ajol.info and
www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage. *June 2014*
Vol. 18 (2) 293-298

Measurement of Gamma Radiation in an Automobile Mechanic Village in Abuja, North Central, Nigeria

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***KEYWORDS*:** Radiation Measurement, Apo Automobile Mechanic Village, Background Radiation, Dose Equivalent, Annual Effective Dose, Automobile Technicians

ABSTRACT: Environmental radiation measurement was carried out in an automobile mechanic village, Apo, Abuja, Nigeria. An in-situ measurement approach was adopted using RDS-200 Universal Survey Meter and a handheld Global Positioning System (Garmin GPS 76S) equipment. It was observed that the dose equivalent varied from 0.04 µSv/h to 0.22 µSv/h with a mean of 0.10± 0.03 µSv/h which is below the standard background radiation of 0.133 µSv/h The study also revealed that the average annual effective dose rate is approximately 0.20±0.06 mSv/yr which is lower than the value of 1.0 mSv/yr averaged over five consecutive years according to the dose limit placed by the Basic Safety Standards (BSS) SCHEDULE II and the International Commission on Radiological Protection (ICRP) REPORT 60. This indicates that the automobile technicians, craftsmen and the people living and working within the area are safe and are not exposed to high doses of radiation as a result of activities in the Apo Automobile Mechanic Village. © JASEM

http://dx.doi.org/10.4314/jasem.v18 i2.21

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 (Oyeyinka *et al*., 2012). The earth's atmosphere especially the human populace is exposed to both non-ionizing and ionizing radiation from different sources, which include natural and artificial sources. Prominent among the natural sources are the primordial radionuclides (^{238}U and ^{232}Th and their progenies, and ^{40}K), while the artificial sources include, anthropogenic radionuclide such as ^{137}Cs, ^{90}Sr, etc. (Avwiri et al., 2010).

The basic difference between ionizing radiation and other common types of radiation in the environment such as heat is that it possesses sufficient energy to cause ionization. In water of which cell are largely composed, ionization can lead to molecular changes and to the formation of chemical species of a type which are damaging to the chromosome material. Ionizing radiation injury is dependent on a number of factors including: The nature (alpha (α), beta (β), and gamma (γ)) and energy of the radiation, the dose, time of exposure, homogeneity of dose and shielding (ICRP, 1991). When the dose and dose rate is within the accepted level, the effect of radiation is small and most time no effect is noticed, although the effect of low level radiation are not yet completely understood (Olarinoye *et al*., 2010). Human body is permanently irradiated from two ionizing radiation sources: External and Internal. External radiation sources can either be natural (cosmic, Terrestrial) or artificial (Medical, Commercial and Industrial sources), both of equal risk to man. Small traces of many naturally occurring radioactive materials are present inside 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). 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). Soil contains small quantities of radioactive elements along with their progeny (Olarinoye *et al*., 2010). However, since radiation is known to cause cancer, it is prudent to monitor the environment for radioactivity (MDH 2008).

Environmental Radiation Monitoring is a systematic collection and analysis of certain environmental media such as air, milk and water to determine the level of radioactivity present, in which various levels of radioactivity are compared with safety standards to ensure a safe environment. This is introduced so as to protect the public and the environment from hazards associated with ionizing radiation (MDH 2008).

An in-situ measurement of the background radiation level was carried out at the vicinity of three campuses

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of two major tertiary institutions in Minna, Niger State. The results of the investigation revealed that the average annual effective dose obtained is 0.189 mSv/annum (Olarinoye *et al*., 2010). A study of the background radiation in Akwanga, Nasarawa State showed that the annual mean equivalent doses for indoor and outdoor backgrounds are 1.29±0.13 and 0.31±0.14 mSv/yr respectively (Sadiq and Agba, 2011). In Abuja, Estimation of Radiation Dose Rate Levels was carried out around a Nuclear Establishment in Abuja, North Central, Nigeria. 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 (Oyeyinka *et al*.,2012). Determination of Absorbed and Effective Dose from Natural Background Radiation around a Nuclear Research Facility was carried out in Zaria (Mohammad et al., 2011). It was observed that the estimated total annual effective dose outdoor for the sites range from 27.3-79.9 µSv y^{-1}. A Measurement of Gamma Radiation in Automobile Mechanic Workshops was carried out in an area of Benin City, Nigeria (Nworgu et al., 2012). The study revealed that the average annual effective dose rate from these sites is approximately 0.40 mSv/yr which is lower than the value of 1.0 mSv/yr averaged over five consecutive years according to the dose limit placed by the Basic Safety Standards (BSS) SCHEDULE II and the International Commission on Radiological Protection (ICRP) REPORT 60. However, the external background ionizing radiation exposure within the sites investigated varied between 0.1272 and 0.01411 mR/hr with an average of 0.01314 ± 0.000658 mR/hr in the locality which is relatively higher than the standard background radiation of 0.011 mR/hr recommended by the US Nuclear Radiation Commission. This level of background radiation seems to suggest that there is a possibility of the existence of radio nuclides within the area. Also the natural background radiation dose/dose rate has been investigated by many researchers in other parts of the world and a wide range of results are reported (Amiri et al., 2011). 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).

In Nigeria, automobile mechanic workshops are located or concentrated in areas known as mechanic villages. These places are officially designated for repairs and servicing of motor vehicles (Angela et al., 2011). Automobile 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).

The proper monitoring and evaluation of the radiation emanating from automobile 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.

MATERIALS AND METHODS

Apo Automobile Mechanic village is an industrial/mechanic town located in the suburb of Nigeria's Federal Capital Territory, Abuja. It is known for trade and services in various aspect of motor vehicle. It prides itself as a home of local technology with a cesspool of mechanic activities such as car servicing and all kinds of repairs, motor battery works, panel beating e.t.c.

Abuja, Nigeria's new capital city is located in the middle of the country. The Federal Capital Territory 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.'.

The study was conducted in April, 2013 in and around Apo Automobile Mechanic Village in Abuja, Nigeria. The study area lie within latitude 08^0 57´N and 08^0 58´N and longitude 07^0 29´E. 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 [figure 1] and a Geographical Positioning System (GPS) Garmin 76S [figure 2] were 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/hr-10 μSv/hr. 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. Three readings were taken in each location and the average calculated.

The equation below is used to calculate the annual effective dose rate in milli-sievert per year (mSv/y).
Annual effective dose rate (mSv/yr) = Equivalent dose rate (μSv/hr) × 8760h/yr × 0.2 (occupancy factor) x 10^{-3}(1) (Tayyeb et. al., 2012)

Fig 1: RDS-200 Universal Survey Meter

Fig 2: GPS Garmin 76S

RESULTS AND DISCUSSION

Table 1 shows the average equivalent dose rate and the annual effective dose rate. A total of 133 measurements were taken within and around the Apo Mechanic Village. Figure 3 shows the average equivalent dose rate of different location. Generally, from the result in Figure 3 the average equivalent dose rate ranged between 0.04 μSv/hr to 0.22 μSv/hr with a mean of 0.10± 0.03 μSv/hr which is below the standard background radiation of 0.133 μSv/hr. Of all the locations AMV013 had the highest dose rate value while AMV072 and AMV120 had the least dose rate value.

Table 1: Average Equivalent dose rate and annual effective dose rate of different locations measured

Site Id	Location		Average Equivalent Dose Rate ($\mu Svhr^{-1}$)	Annual Effective Dose Rate ($mSvyr^{-1}$)
	Latitude	Longitude		
AMV001	08^{0}57’304’’N	07^{0}29’864’’E	0.10	0.18
AMV002	08^{0}57’305’’N	07^{0}29’876’’E	0.05	0.09
AMV003	08^{0}57’286’’N	07^{0}29’902’’E	0.15	0.26
AMV004	08^{O}57’776’’N	07^{0}29’898’’E	0.14	0.25
AMV005	08^{0}57’271’’N	07^{0}29’878’’E	0.09	0.16
AMV006	08^{0}57’277’’N	07^{0}29’862’’E	0.13	0.23
AMV007	08^{0}57’263’’N	07^{0}29’856’’E	0.07	0.12
AMV008	08^{0}57’291’’N	07^{0}29’846’’E	0.13	0.23
AMV009	08^{0}57’290’’N	07^{0}29’833’’E	0.12	0.21
AMV010	08^{0}57’281’’N	07^{0}29’821’’E	0.11	0.19
AMV011	08^{0}57’313’’N	07^{0}29’823’’E	0.12	0.21
AMV012	08^{0}57’341’’N	07^{0}29’836’’E	0.18	0.32
AMV013	08^{0}57’345’’N	07^{0}29’847’’E	0.22	0.39
AMV014	08^{0}57’341’’N	07^{0}29’851’’E	0.13	0.23
AMV015	08^{0}57’352’’N	07^{0}29’856’’E	0.08	0.14
AMV016	08^{0}57’419’’N	07^{0}29’880’’E	0.12	0.21
AMV017	08^{0}57’032’’N	07^{0}29’894’’E	0.10	0.18
AMV018	08^{0}57’400’’N	07^{0}29’900’’E	0.13	0.23
AMV019	08^{0}57’399’’N	07^{0}29’807’’E	0.12	0.21
AMV020	08^{0}57’391’’N	07^{0}29’901’’E	0.09	0.16
AMV021	08^{0}57’384’’N	07^{0}29’898’’E	0.09	0.16
AMV022	08^{0}57’388’’N	07^{0}29’908’’E	0.07	0.12
AMV023	08^{0}57’401’’N	07^{0}29’911’’E	0.07	0.12
AMV024	08^{0}57’406’’N	07^{0}29’866’’E	0.07	0.12
AMV025	08^{0}57’395’’N	07^{0}29’870’’E	0.14	0.25

AMV026	08^{0}57’387’’N	07^{0}29’874’’E	0.10	0.18
AMV027	08^{0}57’387’’N	07^{0}29’873’’E	0.09	0.16
AMV028	08^{0}57’382’’N	07^{0}29’876’’E	0.09	0.16
AMV029	08^{0}57’270’’N	07^{0}29’870’’E	0.11	0.19
AMV030	08^{0}57’363’’N	07^{0}29’869’’E	0.15	0.26
AMV031	08^{0}57’371’’N	07^{0}29’851’’E	0.17	0.30
AMV032	08^{0}57’372’’N	07^{0}29’842’’E	0.13	0.23
AMV033	08^{0}57’379’’N	07^{0}29’845’’E	0.08	0.14
AMV034	08^{0}57’377’’N	07^{0}29’845’’E	0.06	0.11
AMV035	08^{0}57’372’’N	07^{0}29’823’’E	0.09	0.16
AMV036	08^{0}57’370’’N	07^{0}29’831’’E	0.09	0.16
AMV037	08^{0}57’384’’N	07^{0}29’818’’E	0.11	0.19
AMV038	08^{0}57’408’’N	07^{0}29’819’’E	0.11	0.19
AMV039	08^{0}57’408’’N	07^{0}29’818’’E	0.08	0.14
AMV040	08^{0}57’411’’N	07^{0}29’831’’E	0.10	0.18
AMV041	08^{0}57’448’’N	07^{0}29’810’’E	0.07	0.12
AMV042	08^{0}57’456’’N	07^{0}29’812’’E	0.06	0.11
AMV043	08^{0}57’455’’N	07^{0}29’822’’E	0.05	0.09
AMV044	08^{0}57’453’’N	07^{0}29’830’’E	0.09	0.16
AMV045	08^{0}57’449’’N	07^{0}29’830’’E	0.12	0.21
AMV046	08^{0}57’450’’N	07^{0}29’839’’E	0.10	0.18
AMV047	08^{0}57’456’’N	07^{0}29’843’’E	0.07	0.12
AMV048	08^{0}57’453’’N	07^{0}29’866’’E	0.08	0.14
AMV049	08^{0}57’458’’N	07^{0}29’866’’E	0.08	0.14
AMV050	08^{0}57’472’’N	07^{0}29’866’’E	0.09	0.16
AMV051	08^{0}57’478’’N	07^{0}29’854’’E	0.08	0.14
AMV052	08^{0}57’473’’N	07^{0}29’850’’E	0.10	0.18
AMV053	08^{0}57’464’’N	07^{0}29’836’’E	0.11	0.19
AMV054	08^{0}57’475’’N	07^{0}29’827’’E	0.12	0.21
AMV055	08^{0}57’481’’N	07^{0}29’828’’E	0.11	0.19
AMV056	08^{0}57’484’’N	07^{0}29’837’’E	0.10	0.18
AMV057	08^{0}57’497’’N	07^{0}29’818’’E	0.07	0.12
AMV058	08^{0}57’496’’N	07^{0}29’828’’E	0.07	0.12
AMV059	08^{0}57’500’’N	07^{0}29’835’’E	0.06	0.11
AMV060	08^{0}57’499’’N	07^{0}29’862’’E	0.06	0.11
AMV061	08^{0}57’500’’N	07^{0}29’846’’E	0.06	0.11
AMV062	08^{0}57’500’’N	07^{0}29’848’’E	0.06	0.11
AMV063	08^{0}57’505’’N	07^{0}29’851’’E	0.05	0.09
AMV064	08^{0}57’502’’N	07^{0}29’860’’E	0.06	0.11
AMV065	08^{0}57’492’’N	07^{0}29’865’’E	0.13	0.23
AMV066	08^{0}57’487’’N	07^{0}29’867’’E	0.12	0.21
AMV067	08^{0}57’494’’N	07^{0}29’869’’E	0.08	0.14
AMV068	08^{0}57’495’’N	07^{0}29’865’’E	0.11	0.19
AMV069	08^{0}57’500’’N	07^{0}29’868’’E	0.12	0.21
AMV070	08^{0}57’505’’N	07^{0}29’866’’E	0.08	0.14
AMV071	08^{0}57’508’’N	07^{0}29’880’’E	0.05	0.09
AMV072	08^{0}57’516’’N	07^{0}29’878’’E	0.04	0.07
AMV073	08^{0}57’513’’N	07^{0}29’872’’E	0.05	0.09
AMV074	08^{0}57’512’’N	07^{0}29’825’’E	0.06	0.11
AMV075	08^{0}57’509’’N	07^{0}29’835’’E	0.05	0.09
AMV076	08^{0}57’637’’N	07^{0}29’788’’E	0.05	0.09
AMV077	08^{0}57’637’’N	07^{0}29’788’’E	0.12	0.21
AMV078	08^{0}57’651’’N	07^{0}29’797’’E	0.11	0.19
AMV079	08^{0}57’645’’N	07^{0}29’766’’E	0.14	0.25
AMV080	08^{0}57’659’’N	07^{0}29’763’’E	0.11	0.19
AMV081	08^{0}57’670’’N	07^{0}29’766’’E	0.11	0.19
AMV082	08^{0}57’675’’N	07^{0}29’777’’E	0.13	0.23
AMV083	08^{0}57’672’’N	07^{0}29’789’’E	0.07	0.12
AMV084	08^{0}57’674’’N	07^{0}29’818’’E	0.07	0.12
AMV085	08^{0}57’679’’N	07^{0}29’829’’E	0.08	0.14
AMV086	08^{0}57’689’’N	07^{0}29’842’’E	0.10	0.18
AMV087	08^{0}57’697’’N	07^{0}29’843’’E	0.09	0.16
AMV088	08^{0}57’706’’N	07^{0}29’861’’E	0.11	0.19
AMV089	08^{0}57’702’’N	07^{0}29’880’’E	0.18	0.32
AMV090	08^{0}57’700’’N	07^{0}29’898’’E	0.15	0.26
AMV091	08^{0}57’714’’N	07^{0}29’895’’E	0.11	0.19
AMV092	08^{0}57’712’’N	07^{0}29’906’’E	0.07	0.12
AMV093	08^{0}57’707’’N	07^{0}29’911’’E	0.06	0.11
AMV094	08^{0}57’705’’N	07^{0}29’916’’E	0.14	0.25
AMV095	08^{0}57’699’’N	07^{0}29’912’’E	0.13	0.23
AMV096	08^{0}57’694’’N	07^{0}29’090’’E	0.12	0.21
AMV097	08^{0}57’689’’N	07^{0}29’899’’E	0.08	0.14
AMV098	08^{0}57’692’’N	07^{0}29’885’’E	0.10	0.18
AMV099	08^{0}57’688’’N	07^{0}29’873’’E	0.09	0.16
AMV100	08^{0}57’689’’N	07^{0}29’863’’E	0.11	0.19

AMV101	08⁰57'664''N	07⁰29'831''E	0.12	0.21
AMV102	08⁰57'662''N	07⁰29'843''E	0.14	0.25
AMV103	08⁰57'659''N	07⁰29'856''E	0.18	0.32
AMV104	08⁰57'655''N	07⁰29'655''E	0.16	0.28
AMV105	08⁰58'729''N	07⁰29'820''E	0.20	0.35
AMV106	08⁰58'076''N	07⁰29'837''E	0.09	0.16
AMV107	08⁰58'081''N	07⁰29'846''E	0.13	0.23
AMV108	08⁰58'082''N	07⁰29'860''E	0.08	0.14
AMV109	08⁰58'113''N	07⁰29'865''E	0.09	0.16
AMV110	08⁰58'118''N	07⁰29'856''E	0.12	0.21
AMV111	08⁰58'116''N	07⁰29'827''E	0.12	0.21
AMV112	08⁰58'121''N	07⁰29'729''E	0.11	0.19
AMV113	08⁰58'131''N	07⁰29'809''E	0.08	0.14
AMV114	08⁰58'143''N	07⁰29'810''E	0.07	0.12
AMV115	08⁰58'154''N	07⁰29'817''E	0.05	0.09
AMV116	08⁰58'162''N	07⁰29'815''E	0.06	0.11
AMV117	08⁰58'176''N	07⁰29'823''E	0.08	0.14
AMV118	08⁰58'180''N	07⁰29'837''E	0.12	0.21
AMV119	08⁰58'174''N	07⁰29'859''E	0.08	0.14
AMV120	08⁰58'186''N	07⁰29'869''E	0.04	0.07
AMV121	08⁰58'121''N	07⁰29'835''E	0.14	0.25
AMV122	08⁰58'081''N	07⁰29'809''E	0.08	0.14
AMV123	08⁰58'089''N	07⁰29'812''E	0.13	0.23
AMV124	08⁰58'508''N	07⁰29'817''E	0.12	0.21
AMV125	08⁰58'480''N	07⁰29'806''E	0.06	0.11
AMV126	08⁰58'443''N	07⁰29'819''E	0.06	0.11
AMV127	08⁰58'424''N	07⁰29'828''E	0.07	0.12
AMV128	08⁰58'417''N	07⁰29'827''E	0.12	0.21
AMV129	08⁰58'408''N	07⁰29'823''E	0.10	0.18
AMV130	08⁰58'408''N	07⁰29'810''E	0.14	0.25
AMV131	08⁰58'418''N	07⁰29'805''E	0.10	0.18
AMV132	08⁰58'430''N	07⁰29'798''E	0.08	0.14
AMV133	08⁰58'479''N	07⁰29'789''E	0.12	0.21
		Mean ±SD	**0.10± 0.03**	**0.20±0.06**

From the results of the measurements presented in **Table 1**, location AMV013 has the highest annual effective dose rate of 0.39 mSv/yr. Locations AMV105, AMV012, AMV089 and AMV103 have annual effective dose rate of 0.35mSv/yr, 0.32 mSv/yr, 0.32 mSv/yr and 0.32 mSv/yr respectively. Locations AMV072 and AMV120 have the least annual effective dose rate of 0.04 mSv/yr. However, these values are seen to be lower than the recommended value of 1.0 mSv/yr for public exposure placed by the Basic Safety Standards (BSS) SCHEDULE II and the International Commission on Radiological Protection (ICRP) REPORT 60 (ICRP, 1991). This indicates that the automobile mechanics and the people working and living around the area are not exposed to high doses of radiation as a result of the activities taken place in the mechanic village.

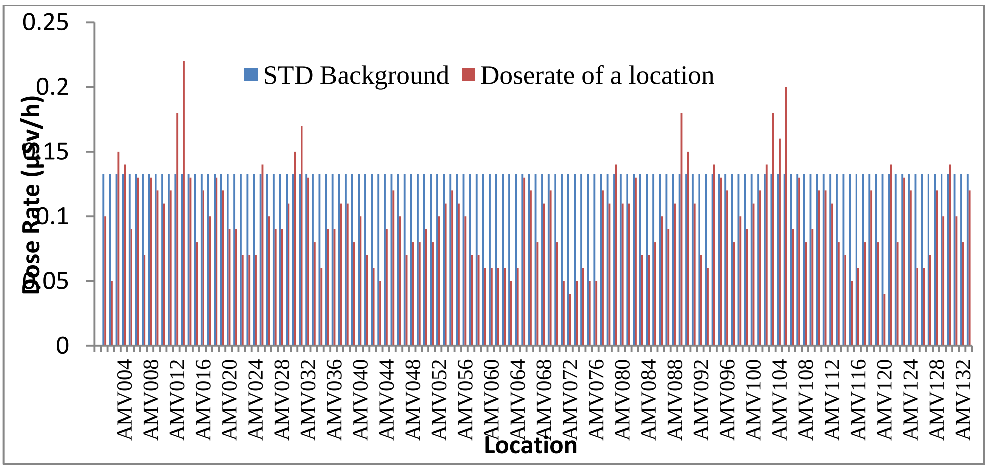

Fig 3: Average Equivalent Dose Rate of different location

Conclusion: The environmental monitoring of radiation dose rates has been computed in and around the Apo Automobile Mechanic Village, Abuja using in-situ measurement method. This work revealed that the average dose equivalent varied from 0.04 µSv/h to 0.22 µSv/h with a mean of 0.10± 0.03 µSv/h which is below the standard background radiation of 0.133 µSv/h. The study also revealed that the average annual effective dose rate is approximately 0.20±0.06 mSv/yr which is lower than the value of 1.0 mSv/yr averaged over five consecutive years according to the dose limit recommended by the Basic Safety Standards (BSS) SCHEDULE II and the International Commission on Radiological Protection (ICRP) REPORT 60. This indicates that the automobile technicians, craftsmen and the people living and working within the area are safe and are not exposed to high doses of radiation as a result of activities in the Apo Automobile Mechanic Village. 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 Automobile Mechanic Village.

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