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Assessment of Gamma Dose Rate within Idu Industrial Area of the Federal Capital Territory (FCT) Abuja, Nigeria

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ABSTRACT
The gamma dose rate within Idu Industrial Area of the Federal Capital Territory, Abuja has been carried out using Atomtex 1117M Radiation Monitor. Readings were taken in twenty three different locations. Five different readings were taken at each location and the mean equivalent dose rate was used to calculate the annual equivalent dose rate. It was observed that the average dose equivalent varied from 0.106±0.001 µSv/h to 0.139±0.004 µSv/h with a mean of 0.117±0.006 µSv/h which is below the standard background radiation of 0.133 µSv/h. The study also revealed that the average annual equivalent dose rate is 0.205±0.017 mSv/y which is lower than the value of 1.0 mSv/yr averaged over five consecutive years according to the dose limit recommended by the International Commission on Radiological Protection (ICRP). This indicates that 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 Idu Industrial Area.

Keywords: *Background Radiation, Dose Limit, Equivalent Dose, Industrial Area, Radiation Monitor*

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I. INTRODUCTION

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. [1, 2]. Naturally occurring radioactive materials (NORM) which may be technologically enhanced generate radioactive isotopes of uranium, thorium, carbon, polonium, lead, radon and potassium. These radioactive isotopes are present in rocks, solid minerals, and soil, building materials, consumer products, foods and human bodies [2].

Terrestrial radiations, which comprise ionizing radiation from rocks, solid minerals and soil, vary significantly depending on geographical locations [3]. The determination of ionizing radiation levels at the premises of industrial plants and buildings is receiving greater attention as the nation places emphasis on environmental standards required by the industries for their operations [4]. Scientists and environmental professionals make critical, objective and what can be considered legally defensible use of analytical data. These data are obtained from sound laboratory and in-situ techniques with adequate understanding of the theory and practice of toxicity testing and proven competence in calculating the risk that a given level of contamination may present to an ecosystem [5].

Environmental radiation monitoring has been carried out in some industries and industrial areas in Nigeria [4-8]. The importance of the estimation of the natural gamma radiation level in an environment lies not only in its epidemiological and dosimetric usefulness but also in its forming a basis for the assessment of the degree of radioactive contamination or pollution in the environment in the future [9]. Hence this study has been undertaken to assess the significance of the level of gamma radiation in an industrial area in the Federal Capital Territory (FCT), Abuja.

The Federal Capital Territory (FCT) is a relatively new creation of the Federal Government of Nigeria sequel to a decision in 1975 to relocate the seat of the central government to Abuja, a city within the FCT, from the former capital city of Lagos. The seat of government formally moved to the area in the December of 1991. In-between when the idea was born until the first phased movement, the FCT much like other modern new cities was elaborately planned to house and host all expected paraphernalia of the Federal Government and supporting
infrastructure including industrial development. The Territory is still in its formative stage as infrastructural development is carried out through a planned and step wise implementation of approved master plan. So, area layouts mapped for hosting industrial infrastructure are also being gradually inhabited. With a land area of 8,000 square kilometres and located within latitude 7º25' N and 9º20' North of the Equator and longitude 5º45' and 7º39', there are two main types of soils in FCT; the sedimentary belt in the southern and south-western extremities of the territory and the pre-Cambrian Basement complex rock country which accounts for more than 80 percent of the territory. Fig. 1 is a map of the Abuja Phase III General Land Use showing the (Idu) Industrial District area of FCT.

The Idu Industrial area is located in the suburb of Nigeria's Federal Capital Territory, Abuja. It is a well-planned industrial zone with a functional road network and functional sewage system. The Idu industrial layout covers about 588 hectares of land that is demarcated into 208 commercial plots and is the government's approved industrial cluster for the Federal Capital Territory. The present study was conducted to monitor and quantitatively document the background radiation levels within Idu Industrial Area of the Federal Capital territory, Abuja using a radiation monitor.

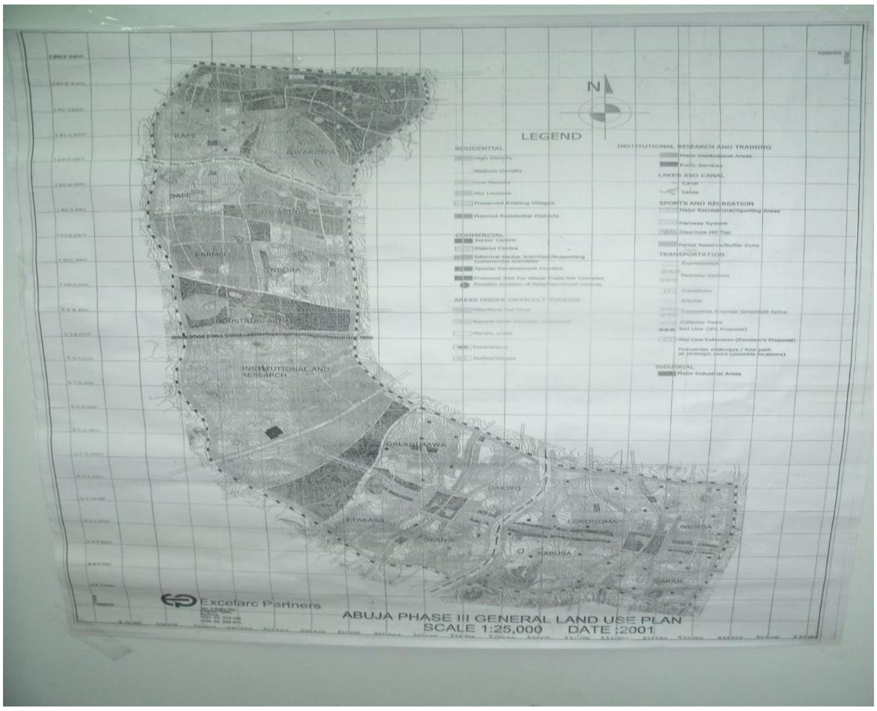

Fig 1. Abuja phase III general land use showing the industrial area 1 of FCT

II. MATERIAL AND METHODS

An in-situ approach of background radiation measurement was adopted and preferred to enable samples maintain their original environmental characteristics. A radiation monitor, Atomtex AT 1117M with serial no 14199 was used. The Atomtex AT 1117M is a portable combined multifunction radiation monitor with digital readout, designed for measuring X-ray, gamma and neutron radiation ambient dose equivalent, density of alpha and beta radiation flux density from contaminated surfaces, alpha and beta radiation surface activity and neutron flux density. The AT1117M radiation monitor consists of a processing unit and a set of detection units. Radiation monitor operation algorithm provides measurement continuity, calculation moving average values, real time display of detection unit data on integrated display, statistical processing of measurement results, real-time statistical fluctuation estimation and rapid accommodation to changes in radiation level. 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. Five readings were taken at each location and the mean values were recorded.

The equation below is used to calculate the annual effective dose equivalent received outdoor.

Annual Dose Equivalent (mSv/y) = Equivalent dose rate (μSv/h) × 8760 (h/y) × 0.2 (occupancy factor) × 0.001 (μSv/mSv) (1) [10]

III. RESULTS AND DISCUSSION

Data for the average equivalent dose rates of the areas measured and the annual effective dose rate are presented in Table 1 below. A total of 115 measurements were taken across the 23 locations in the Idu Industrial Area. Generally, from the result, the average equivalent dose rates for each area ranged between 0.106±0.001 μSv/h to 0.139±0.004 μSv/h. The mean value from INDY 23 shows the highest equivalent dose rate while the equivalent dose rate from INDY 13 was the lowest. The total equivalent mean dose rate in all the twenty three locations is 0.117±0.006 μSv/h. INDY 2, INDY 1 and INDY 22 recorded the second, third and fourth highest in-situ gamma radiation of 0.134±0.001 μSv/h, 0.133±0.011 μSv/h and 0.132±0.026 μSv/h respectively.

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

S/n	Location	Location code	Average Equivalent Dose Rate* (μSvh^{-1})	Annual Dose Equivalent ($mSvy^{-1}$)
1	Authentic Plast Ltd	INDY 1	0.133±0.011	0.233
2	Omnia Nig Ltd	INDY 2	0.134±0.001	0.235
3	Sunny Patze Aluminium Industry	INDY 3	0.121±0.002	0.211
4	NASENI	INDY 4	0.113±0.002	0.198
5	NIPRD	INDY 5	0.109±0.002	0.191
6	Oyi Shelter & Allied Services Ltd	INDY 6	0.115±0.001	0.201
7	Interstate Contractors Ltd	INDY 7	0.115±0.001	0.201
8	Pharmaceutical Council Of Nig	INDY 8	0.114±0.001	0.199
9	NEIC Ltd Main Yard	INDY 9	0.112±0.001	0.196
10	Korsten Muller Ltd (Nig)	INDY 10	0.112±0.001	0.196
11	Eagle Aluminium Industries Ltd	INDY 11	0.111±0.002	0.194
12	Banrut Rolls Nig Ltd	INDY 12	0.109±0.002	0.190
13	Lingo Gas	INDY 13	0.106±0.001	0.186
14	Bouygues Construction (Nig) Ltd	INDY 14	0.109±0.004	0.192
15	Safari Petroleum Products Ltd	INDY 15	0.109±0.002	0.190
16	A-Z Petroleum Gas Plant	INDY 16	0.108±0.005	0.190
17	Polystyrene Industries Ltd	INDY 17	0.109±0.004	0.191
18	Dumez Nig Plc	INDY 18	0.120±0.015	0.210
19	ITEX	INDY 19	0.114±0.011	0.200
20	Julius Berger Yard	INDY 20	0.122±0.028	0.214
21	Artco Industries Ltd	INDY 21	0.122±0.013	0.214
22	Nigeria Bottling Company	INDY 22	0.132±0.026	0.231
23	Seven-Up Bottling Company	INDY 23	0.139±0.004	0.243

*Values represented as Mean ± Standard Deviation

Fig 2 shows the comparison of the mean equivalent dose rate radiation levels with the standard background radiation level of 0.133 µSv/h recommended by ICRP [11]. The result shows that the entire equivalent dose rates of all the locations, except INDY 23 and INDY 2, where below or exactly the value of the Standard Background Radiation (0.133 µSv/h). Equivalent dose rate is the measure of the amount of radionuclides absorbed by the human body for a given period. To avoid any somatic, epidemiological and radiological health side effect, ICRP recommended and consequently set the maximum permissible limit for non–radionuclide industrial worker and the public as 1.0 $mSvy^{-1}$. Fig 3 shows the comparison of the annual dose equivalent with ICRP maximum permissible limit. The results revealed that the dose levels in all of the locations were below the maximum permissible limit for the public.

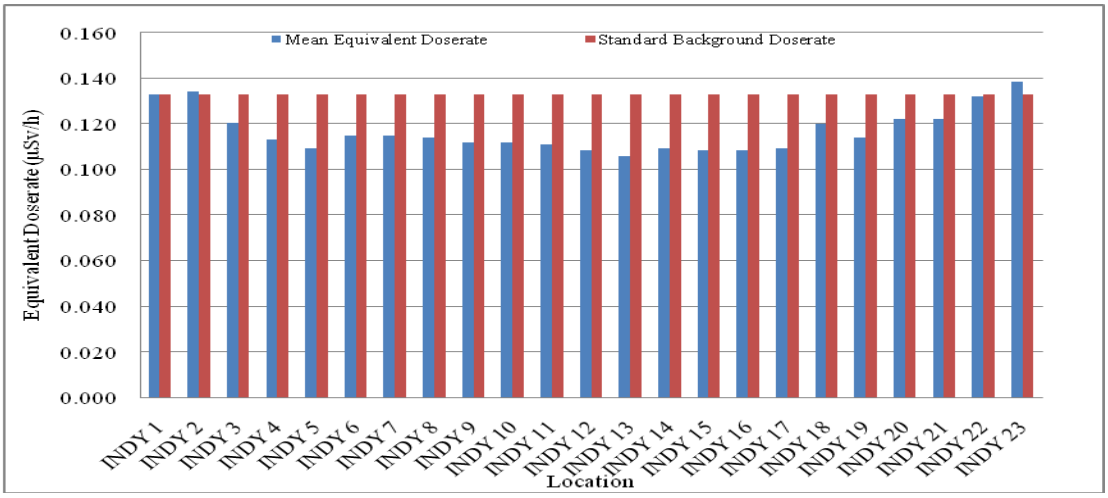

Fig 2: Comparison of different locations mean equivalent dose rate with standard background dose rate

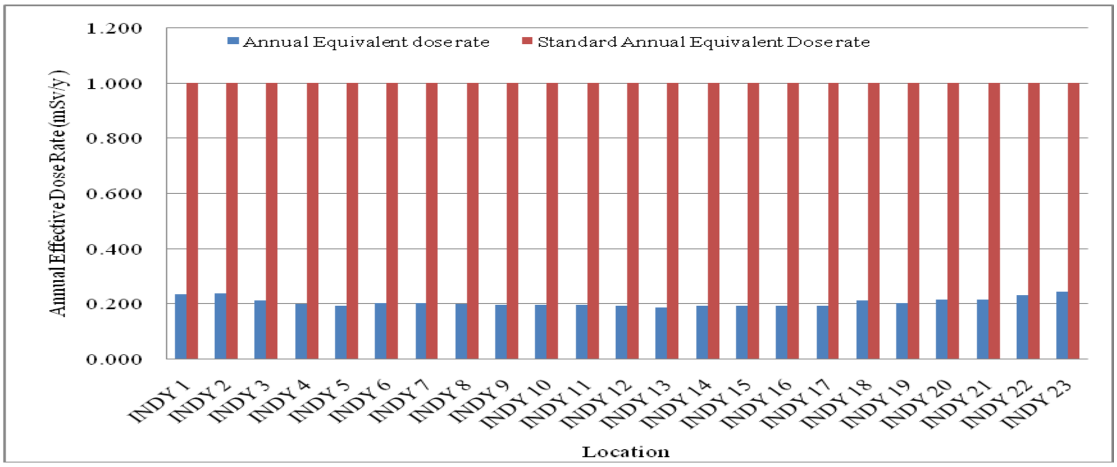

Fig 3: Comparison of different locations mean annual dose rate equivalent with standard annual equivalent dose rate

IV. CONCLUSIONS

The environmental monitoring of radiation dose rates has been computed in and around the Idu Industrial Area of the Federal capital Territory, Abuja using in-situ measurement method. This was meant to determine the background ionization radiation level of the study area. The study revealed a radiation level within the acceptable limit for the general public. The annual equivalent dose rate obtained for all the locations sampled did not exceed the safe limit recommended by the international bodies on radiation protection. This work revealed that the average dose equivalent varied from 0.106±0.001 μSv/h to 0.139±0.004 μSv/h with a mean of 0.117±0.006 μSv/h which is below the standard background radiation of 0.133 μSv/h. The study also revealed that the average annual equivalent dose rate is 0.205±0.017 mSv/y which is lower than the value of 1.0 mSv/yr averaged over five consecutive years according to the dose limit recommended by the International Commission on Radiological Protection (ICRP). This indicates that 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 Idu Industrial Area. 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 Industrial Area.

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