

INDUSTRIAL RADIATION MONITORING AROUND KADUNA METROPOLIS

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ABSTRACT

Apart from the amount of radiation, which may be encountered due to radioactive substances, individuals are also exposed to radiation because of the nature of the environment. This natural source of exposure is often referred to as background radiation and studies have revealed two main components, viz: radioactivity in the earth crust and extraterrestrial radiation called cosmic rays. The amount either of these radiation sources contributes varies with locations. To examine this, both LiF: Ti and CaSO₄: Mn phosphor chips were investigated and the CaSO₄ dosimeter chosen because of annealing and contamination problems associated with LiF. The CaSO₄ TLD was calibrated using ⁹⁰Sr beta source as standard. A low level standard deviation of 4% was recorded around 25mR region. It was established that among the sampled areas, the NNPC and Panteka recorded high radiation levels. Measurements of photoemission produced around these industrial areas of Kaduna were also determined and compared with standards. Results established that apart from NNPC and Panteka, other locations were uncontaminated. However, locations below ground level at various depths around metallic waste dumps of Panteka and NNPC recorded large exposure rate, which increased with depth until a plateau is attained.

KEY WORDS: Radiation, dosimeter, photoemission, radioactivity, irradiation,

INTRODUCTION

Basically, the techniques of geophysical exploration rest on the fact that mineral deposits and geological strata possess distributive physical properties. Chief among these are density, magnetism, elasticity, electrical conductivity, and radioactivity. The deposits, and strata have acquired these properties by chemical or mechanical processes in the course of their geological history. In general, an ore body or stratum can be detected if one of its dimensions is comparable in magnitude with its depths in the earth and if sufficiently large differences in properties occur between the body in question and its surroundings. Radiation monitoring which is one of the techniques used in such detection also provides information on natural and polluted environments. Such radiations may be natural through cosmic radiation, the earth crust and building materials. Others are through artificial radioactivity (diagnostic and radiological X-rays); nuclear energy industries and laboratories or radioactive fallouts; and industrial wastes. It is very useful in providing knowledge on health hazards of radiation exposure. It may also serve as a valuable index in uranium and thorium exploration programmes. The general effects of radiation on life can be summarized as in figure 1 below.

Figure 1 shows that except some threshold whole body radiation is reached, the short term effects may not be fatal. Above such threshold values, such as between 500-1000 rads, chemical or enzymatic misrepair may occur resulting in death, mutagenesis or total reproductive damage. This work is essentially to monitor for any possible environmental contamination around Kaduna metropolis, which is a good basis for assessing and receiving the various radiation protective measures.

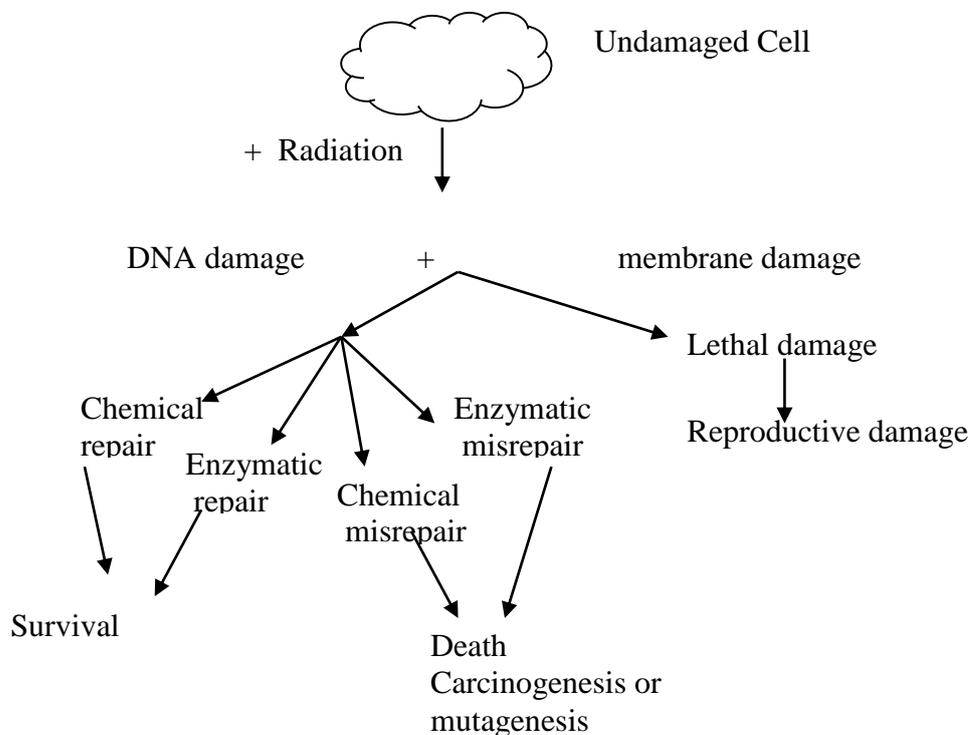


Figure 1 Possible pathways for cellular response to ionized radiation (Kathren, 1985)

MONITORING

The study area is Kaduna metropolis which is the capital city of Kaduna state, Nigeria. Kaduna is an urban center with characteristic low and high population density areas as well as marked out Industrial layouts. Kaduna town is situated $7^{\circ} 23'N$ and $07^{\circ} 40'N$ of the equator and $10^{\circ} 25'E$ and $10^{\circ} 40'E$ of the Greenwich Meridian (Oluwafemi, 1994). Figure 2 shows the map of Kaduna metropolis with industrial sectors. Kaduna is the second most industrialized city (after Kano) in Northern Nigeria. The choice of location for monitoring is therefore informed by her population and level of industrialization. The instruments used were the bond digital Geiger Counter, the portable, Radiological Survey Dosimeter model 3700 and the universal Toledo 654D TLD detector of the Federal Radiation Protection service of the University of Ibadan.

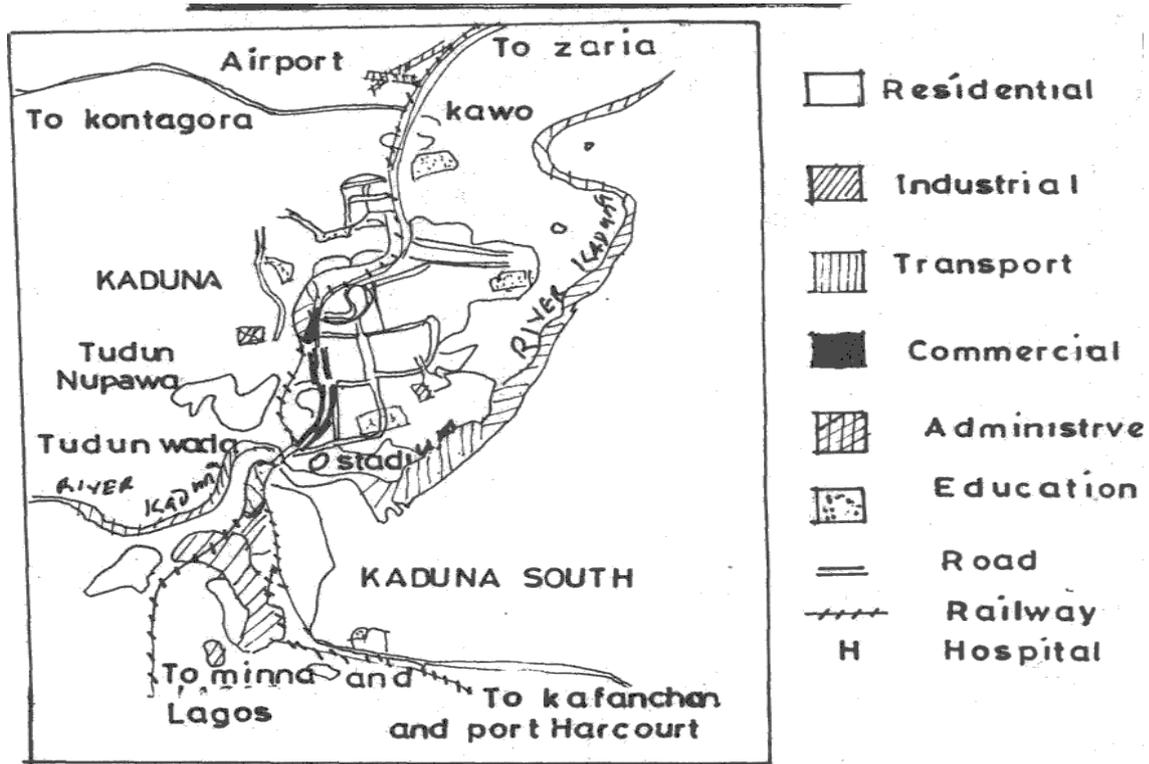


Figure 2 Map of Kaduna metropolis with industrial sectors.

The monitoring was carried out in two stages viz. surface monitoring employing the Geiger Counter and the Radiological Survey Dosimeter and underground measurement using the sophisticated detector, Toledo 654D for better accuracy. In each case, many readings were taken and averages calculated.

For the survey measurement, the Physics laboratory of the Nigerian Defence Academy old site was used as the main background reference point and the mean readings were taken at various days and locations over a period of about 6 months (Nov.2005 – April 2006). Background readings using the Radiological Survey Dosimeter are given in Tables I to III and Figs I to III represent their plots.

Table I Mean background Radiation for NDA at various points.

Location	Distance from Physics laboratory (m)	Mean Background Reading (mR/Hr).	Calculated whole body radiation/year (rem/yr)
Laboratory (a)	0	0.037	0.077
Magazine (b)	200	0.070	0.145
Cadets mess (c)	250	0.040	0.083
Mammy market (d)	700	0.043	0.089
Kurumi Marshi Officers Quarters (e)	1,200	0.037	0.077
Air force wing (f)	100	0.027	0.056

Table II Mean Background Radiation for densely populated areas.

Location	Distance from NDA (km)	Mean background Radiation (mR/hr).	Calculated whole body radiation/year (rem/yr)
NDA (a)	0	0.037	0.077
Kawo (b)	3.0	0.027	0.056
Kakuri (c)	8.0	0.040	0.083
U/Rimi (d)	4.5	0.023	0.048
Abakpa (e)	1.2	0.027	0.056
Sabo (f)	9.0	0.036	0.075

Table III: Mean Background Radiation for Industrial areas.

Location	Distance from NDA (km)	Mean background Radiation	Calculated whole body radiation/year (rem/yr)
NDA (a)	0	0.039	0.081
FCFC (b)	8.6	0.053	0.110
NNPC (c)	15.0	0.070	0.145
NBL (d)	8.1	0.040	0.083
UNTL (e)	8.4	0.030	0.062
Old Pantaka (f)	5.0	0.070	0.145

Columns three of tables I, II and III were calculated on the basis that, an average worker reports for duty eight working hours per day for five days per week. This is the presently accepted norms of the Nigerian Civil Service. Therefore, for whole body irradiation of 0.03mR/Hr, we have $0.03 \times 8 \times 5 \times 52$ mRem per year of 52 weeks. This will be equal to 0.062 Rem per year. The locations in the figures are labeled alphabetically in consonance with the correct positioning in each of the tables.

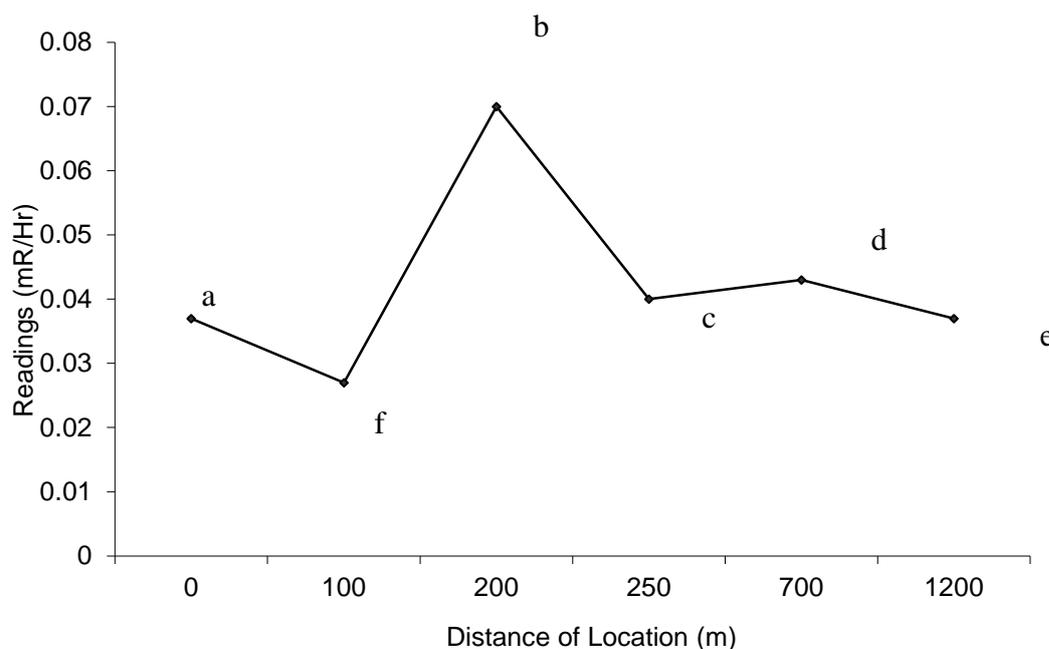


Fig. 1 Mean Background at Different Locations around NDA

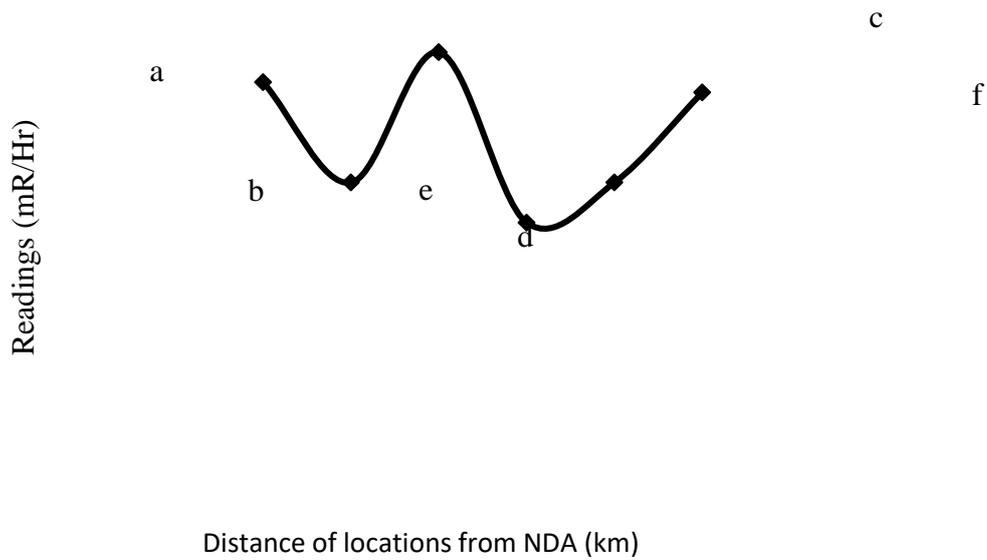


Fig. II Mean Background Radiation at different locations around Kaduna

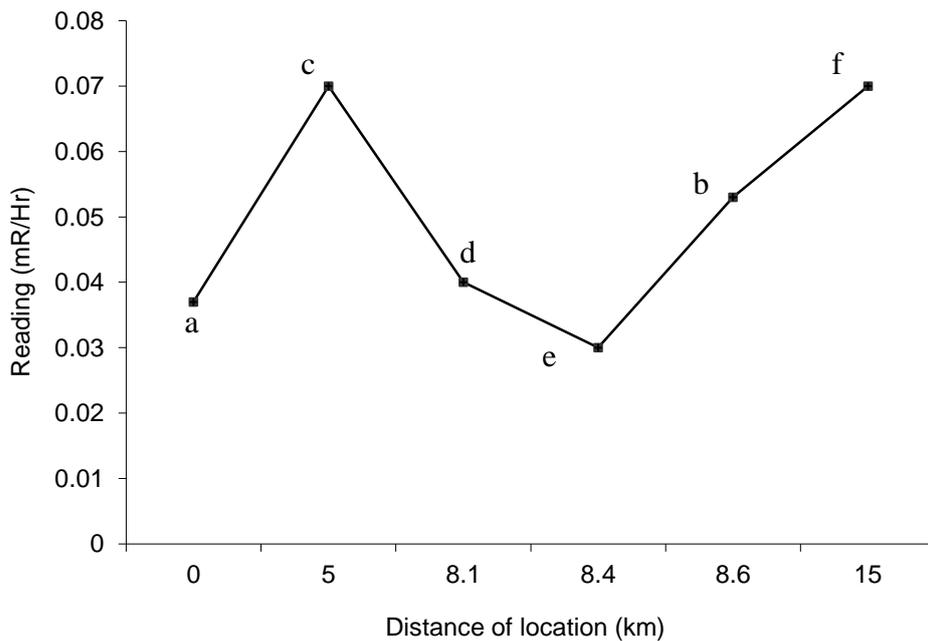


Fig. III Mean Background Radiation for Industrial Areas using the detector Toledo 654D

Two dosimetry phosphors of Lithium fluoride doped with magnesium and Titanium (Li:F:Mg:Ti) and calcium sulphate doped with Dyspronium (CaSO₄:Dy) were investigated during the monitoring and the later chosen due to its advantages over the former. CaSO₄:Dy has very slow fading rate of about 1.5% per week compared with 10% for LiF. The minimum detectable dose for CaSO₄:Dy and LiF are 0.1 mRad and 10 mRad respectively which makes CaSO₄:Dy more suitable in areas of low background. Although CaSO₄:Dy is not as sensitive

to contaminations due to oil and dust as LiF thereby making LiF more suitable for personnel monitoring because of its tissue equivalence, generally speaking, its sensitivity is 30 times more than LiF and is therefore better for environmental monitoring and has accordingly been selected for this work.

A sample of CaSO_4 dosimeter was annealed at 400°C for 1 hour. Portions of this freshly annealed phosphor were irradiated to 12.5mR, 25mR, 37.5mR, 50mR and 75mR from a Beta source irradiator (^{90}Sr) for the calibration of the detector. 20mg of each portion was read on the TL detector four times and the mean recorded representing the TLD residual response after annealing. These readings and their standard deviation curves are as shown in Figs IV and V.

Environmental doses were measured using plastic bags in which portions of the dosimeter were contained. These were suspended at a height of at least one meter from the floor of the FRPS and at least 0.8m from the wall for some days Fig. VI (as in Farai 1984). 20mg of these portions from different rooms of the center were read for the various positions. This positioning method was to ensure that scattered radiation from the walls was excluded.

Dosimeter in plastic bags was buried at different depths of approximately 13cm, 26cm, 52cm and 68cm respectively for approximately the same length of time, that is, 3 weeks. Readings were also taken for these locations and such readings converted to doses using the Beta source strontium-90 calibration and recorded as depicted in Fig. VI. The calculated standard deviation is shown in Fig. V.

The positioning of the plastic bags in the FRPS building for background radiation monitoring serves as a simulation of the monitoring of running industrial sites (FRPS, 1981). The result of such simulation is shown in figure VI. It shows that radiation from the earth itself increases with depth until a plateau is attained. This is as a result of radiation from mineral deposits which decreases vertically upwards and such decreases downwards. From the same simple conversion, it was observed that, just a few centimeters below the surface the per annum radiation dose is 0.164 rem/yr, which is almost equivalent to the maximum permissible dose. This increases rapidly with depth and can filter back to increase the surface dose around the factory thereby posing health hazard.

The calculation is based on the simple logic that the dosimeter badges were mounted for three weeks out of 52 weeks of the year. Therefore for 20mR/3weeks, the per annum dose for an eight hour worker would be 0.113rem/yr.

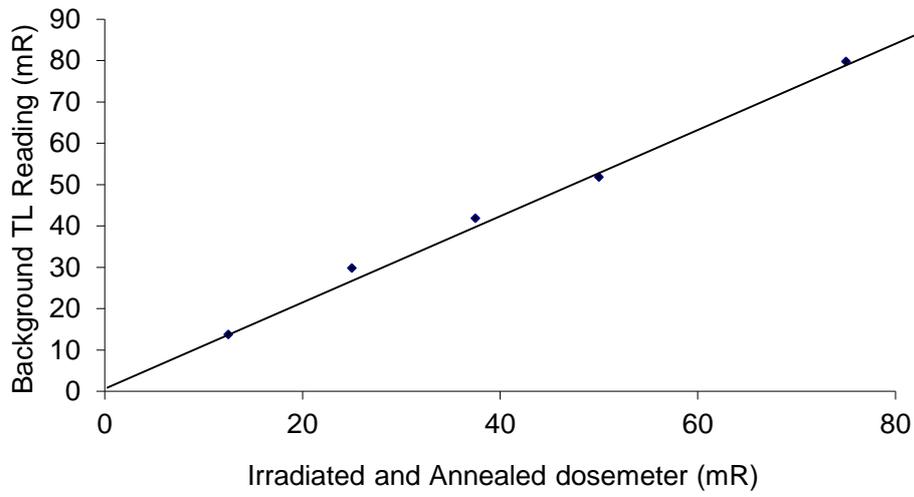


Fig. IV TL Residual Response after Annealing

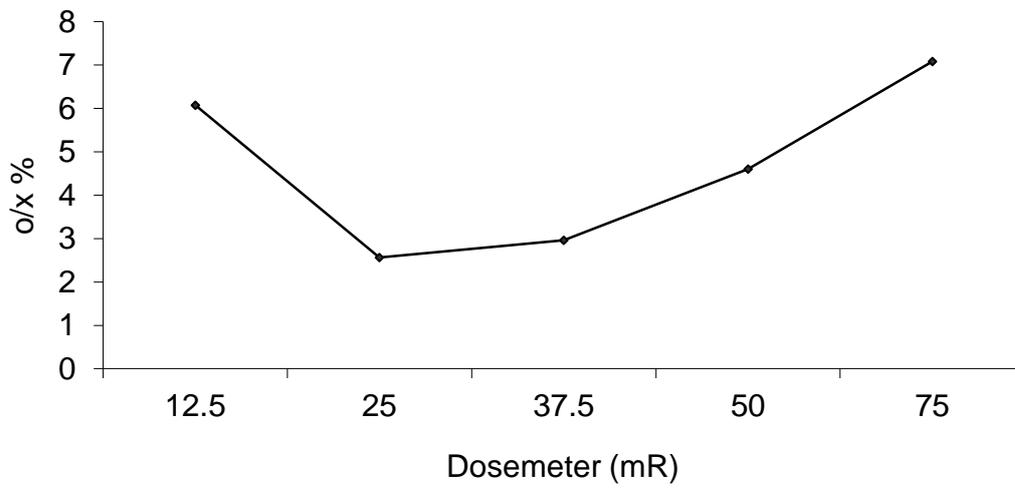


Fig. V Percentage Standard Deviation Curve

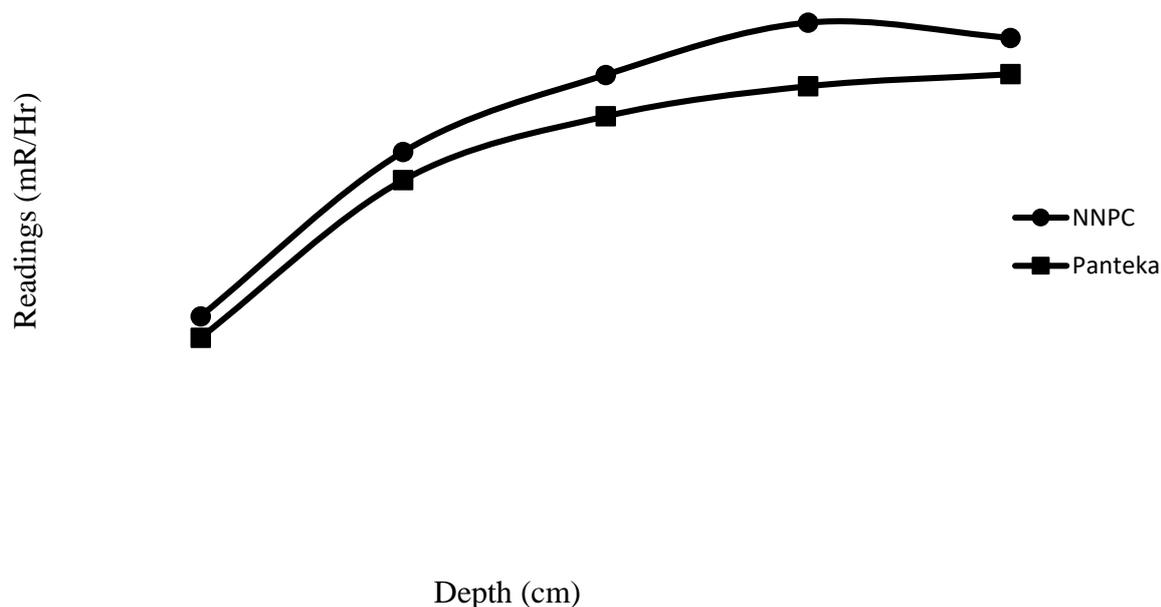


Fig VI Radiation dose for NNPC and Panteka at various burial time – 3 weeks

DISCUSSION

From readings recorded for Kaduna metropolis and its industrial set ups, (Tables I-III), one can rightly conclude that the radiation level at all points are purely background except in the industrial areas of Pantaka and the NNPC as well as the magazine area of the Nigerian Defence Academy. Though the Physics laboratory is equipped with radioactive material sources, radiation is low because the sources are very weak laboratory sources. But around the cadet mess and magazine areas, the radiation level is high perhaps due to the presence of modern ammunitions whose contents are unknown to these investigators. Kawo and U/Rimi fairly average radiation levels were recorded mainly due to human activities, while Kakuri, an industrialized area, showed high radiation level.

The CaSO_4TLD Calibrated using ^{90}Sr beta source showed a low level standard deviation of 4% around 25mR region making it more suitable for environmental monitoring over LiF. TLD readings recorded within 2m of the source pit of the FRPS building were as high as those of the magazine area and Pantaka of Kaduna. Apart from the natural radiation source, the high level of radiation around NNPC might be due to the contribution from the earth as indicated by the buried dosimeters. Except for these areas, other areas of Kaduna that were investigated can therefore be considered safe for workers and members of the public. Workers of the FRPS are not usually allowed to stay beyond 5minutes within the polluted source pit.

The NNPC workers should follow general code of working ethics. By the US guidelines of 1969, an average dose to the general population should not exceed 0.17 rem/yr. NNPC and Pantaka are already recording averagely the same 0.145 rem/yr. With continuous diurnal and yearly variation in climatic conditions vis-à-vis extremely provocative pollution of the environment, an average worker in this vicinity is gradually being exposed to radiation danger. Such workers are therefore exposed to high mortality rate by stealth.

CONCLUSION

The environment, as at the period of this work, in Kaduna is considered safe for both workers and members of the public. However, it is recommended that this environmental monitoring be applied to those areas like the mine fields, cement factories, radiotherapy units etc from time to time.

In particular, NNPC workers should be made to wear thick fabrics around laboratories, take their annual leaves and go for daily break hours away from the plant vicinity. Good food alone cannot absorb all acquired radiation; hence these workers should observe periodic medical checkups. Above all, management of such organization should eschew the culture of inviting experts to monitor the factory environment from time to time.

Companies should be enlightened about the importance of this monitoring exercise as some industrial organizations were hostile to this investigator out of ignorance. On the other hand, the acquired sophisticated equipment of our Energy and Research centers should be commissioned on time for in depth and more accurate monitoring of the environment.

Simple calculation and projection would have rated the industrial sites to be high-risk zones but for non-linearity in absorption due to break times, leave periods etc.

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