Radiation levels of dumpsites within Imo State University, Owerri, Imo State, Nigeria

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ABSTRACT

With increasing population and human activities, dumpsites experience diverse sources of waste with potential radiation hazards. Ionizing radiations have often been overlooked amongst researchers in third world countries, hence, information in this regard is lacking. In this study, nine dumpsites within Imo State University (IMSU) grounds were assessed for radiation levels using Geiger Muller counter Tube Mullard type ZP 1481 with assisted scalar and stopwatch. After calibration, the instrument was placed one meter above ground level and count rates recorded at 10 minutes interval for each location once in the morning, the afternoon and the evening for seven days. Results reveal higher dose equivalents in some morning periods than in the afternoon and evening. Site ETF2 had highest value of 0.69 ± 0.08 mSv·yr^{-1}, while Extension gate had lowest value of 0.56 ± 0.01 mSv·yr^{-1}. Compared to National Council for Radiation Protection maximum permissible level, these values are quite low. In conclusion, ionizing radiations levels at the studied dumpsites in Imo State University grounds are low and may not pose a threat to persons within the university.

Keywords: Environmental monitoring, Ionizing, Public health, waste

1. INTRODUCTION

Radiation, obtained during radioactivity is the energy that comes from a source and travels through some materials and through space. This energy is in form of high speed

particles and electromagnetic waves (Faiz, 1994 and Temaugee et al, 2014). It is often categorized as either ionizing or non-ionizing depending on the energy of the radiated particles. Ionizing radiation carries more than 10 electron Volts, which is enough to ionize atoms and molecules, and break chemical bonds. This is an important distinction due to the large difference in harmfulness to living organisms (Kwan-Hoong, 2003).

Ionizing radiation is a form of radiation with sufficient energy to remove electrons from their atomic or molecular orbital shells in the tissues they penetrate (Borek, 2004). This is the major source of worry for public health. However, the main contribution is the gamma ray absorbed dose arising from ~55% terrestrial radon, 8% cosmic ray, natural radioactivity of environmental rocks (containing uranium, actinium, radium and thorium) and the potassium - 40 activity within our own bodies (Klement et al, 1972; Sigalo and Briggs-Kamara, 2004 and Alaamer, 2008). A common source of ionizing radiation is radioactive materials that emit α, β, or γ radiation, consisting of helium nuclei, electrons or positrons, and photons, respectively. Other sources include X-rays from medical radiography examinations and muons, mesons and other particles that constitute the secondary cosmic rays that are produced after primary cosmic rays interact with Earth's atmosphere (IAEA, 2011).

Radioactivity in the environment has received the attention of researchers in the present times worldwide, due to the health hazard they constitute when absorbed into the body (Temaugee et al, 2014). Human beings are exposed to radiation from sources outside their bodies; mainly cosmic rays and gamma ray emitters in soils, building materials, water, food, air (Alaamer, 2008) and dumpsites (Ugochukwu et al, 2015). These waste dumpsites pose serious threat to the environment through their odor, presence of disease causing micro-organism, as well as the radiation emanating from them (Faweya, et al, 2010; Olubosede et al, 2012; Odeyemi et al, 2012 and Ugochukwu et al, 2015). These ionization radiations, received in sufficient quantities over a period of time, can result in tissue damage and disruption of cellular function at the molecular level. The natural level of background ionizing radiation is generally between 1 and 2 mSv·yr^{-1} (Hunt, 1987; Sigalo and Briggs-Kamara, 2004). High doses of ionizing radiation can lead to various effects, such as damage to living tissue, and can result in mutation, radiation sickness, skin burns, hair loss, birth defects, illness, cancer, and death (Adams et al, 2003 and UNSCEAR, 2008).

The University campus is traditionally the land on which a college or university and related institutional buildings are situated. Usually a college campus includes libraries, lecture halls, residence halls, food canteens, business centres and park-like settings (Wikipedia, 2017). Activity carried out in these various locations within the university campus generates a lot of waste and enhance ionizing radiations. The possible effect of ionization radiation on workers and students in a university campus cannot be detected except by testing. It has therefore become necessary to investigate work environment for elevated ionization radiation levels. As far as the published scientific literature is concerned, no study has been conducted on the threat that ionizing radiation level pose to public health in university campus in Nigeria. However, a study on the radon level in a Nigerian university campus has been conducted in Obafemi Awolowo University, Ile-Ife (Afolabi *et al.* 2015) and indoor background ionizing radiation profile of a physics laboratory in the Rivers State College of Education, Port Harcourt, Nigeria (Yehuwdah et al., 2006). Therefore, this will be the first study conducted on the possible threats of ionizing radiation levels within Imo State University campus. However, a study conducted on exposure dose rate from waste dumpsites within Owerri, Imo state, Nigeria showed that all the waste dumpsites emit radiation that

exceeds the International Commission on Radiation Protection (ICRP) recommended maximum permissible limit of 11.4 µR hr^{-1} for members of the public (Ugochukwu et al, 2015).

It cannot be over-emphasized that ionization radiations is harmful at higher levels and that many lung cancers could be initiated by exposures (Darby et al, 2005 and Afolabi *et al.* 2015). There is, therefore, need to assess the vulnerability of people who operates in areas that may have high levels of radiation concentration such as the Imo State University (IMSU) campus with indiscriminate dumpsites.

The objectives of this study are (1) to determine the dose rates emanating from the dumpsites located within the university campus. (2) To also show the relationship between the dose equivalents at different periods of the day (3) to check for the relationship between the ambient temperature and dose. For this, the following hypothesized (H_0: The dose equivalent at different periods is the same, H_1: The dose equivalent at different periods is not the same) were tested and to enlightens the workers and students who operate within the Imo State University campus. It is noteworthy that the scope of this work does not include the nature of the radiation from the various points.

2. METHODOLOGY

2. 1. Study area

The study area is Imo State University, Owerri campus which is located geographically between latitude 5.4869° N and longitude 7.0157° E. The university is located in Owerri city, which is one of the largest city in Imo state and has rain forest vegetation, which shows trend of increasing monthly rainfall variability with mean annual rainfall and global solar power of about 2400 mm/yr and 4.82 kW h respectively (Ugochukwu et al, 2015). The university was established in 1981. Like some other state universities in Nigeria, different activities are been carried out within the university campus such restaurants or food canteens which involves cooking, business centers which involves generator use, church, halls to host events etc. The University population is estimated to be more than 10,000 including students and workers. The university does not have any legislative or laws that regulate the position of dumpsites with respect to the various activities carried out within the university, more so these laws are poorly enforced.

2. 2. Site description

Table 1. The selected waste dumpsites and locations, their coordinate and associated wastes

Dumpsites number	Location	Coordinates	Comments
1	Front gate/security post (F/SP)	5° 30' 20.2'' N 7° 02' 43.1'' E	Generally, the various dumpsites contain similar waste materials which include paper, tins, polythene, plastics,
2	ETF 1	5° 30' 16.7'' N 7° 02' 45.2'' E	
3	University Library (UL)	5° 30' 19.2'' N 7° 02' 42.0'' E	

4	ETF 2	5º 30' 22.6'' N 7º 02' 41.4" E	glass, decomposing vegetables and some unidentified burnt materials etc. However, in some waste dumpsite decomposing human excreta are present notably at ETF 2.
5	Law Faculty (L/F)	5º 30' 16.7'' N 7º 02' 45.2" E	
6	St. Joseph Chaplaincy (St.J/C)	5º 30' 16.4'' N 7º 02' 22.1" E	
7	Extension gate (Ext. G)	5º 30' 16.2'' N 7º 02' 20.1" E	
8	Chemistry lab (CL)	5º 30' 28.2'' N 7º 02' 42.2" E	
9	Medical college (MC)	5º 30' 29.2'' N 7º 02' 43.1" E	

The nine waste dumpsites selected for this study duly represent the Imo State University Owerri campus as shown on Table 1. The choices of these dumpsites were due to heavy human activities (both students and workers) around them. The constituent of these waste dumpsites and the nature of emitted radiation is not the scope of the study. Plate 1 shows photographs of the various dumpsites.

Nine dumpsites (Plate 1) were selected and indentified by the closeness to the following point (i.e the frontgate/security post,(FS) ETF1, Chemistry laboratory, (CL) St. Joseph Chaplaincy, (SJC), ETF2, extension gate,(EG) law faculty (LF), the University library (UL) and medical college all within the university campus.

2. 3. Measurement procedure

The ionizing radiations were measured according to the method of Ebong & Aloga, (1992), Aten & Dejong, (1961) and most recently by (Sigalo and Briggs-kamara, 2004). The data of radiation emissions from the waste dumpsites were acquired using the Gieger Muller (GM) Counter (which consists of the Geiger Muller (GM) Tube Mullard type ZP 1481 with associated scaller and stop watch). The GM counter is non-energy dissipative, hence effectively useful for environmental monitoring of radiation levels.

The GM model used here is an exceptionally robust cylindrical tube of internal diameter 20 mm, a length of 65 mm with mica end window having protective open mesh plastic guard giving increased sensitivity. The mean dead time for the tube is 208 ±40 is (Sigalo, 2000).

Following an initial laboratory calibration, Cs-137 and Co-60 which emit gamma radiation of 0.662 MeV and combination of 1.17 and 1.33 MeV respectively were exposed to a standard dosimeter calibration in absorbed dose (ranging from 0 to 200 Ir). The dosimeter was placed one meter away from the source, and the dose rate determined for times varying from 1 to 24 hours. The GM Counter then replaced the dosimeter and the corresponding count rates taken. In this way count were translated to absorbed doses, after some calculations involving the tube dimensions (National Council on Radiation Protection, 1976). By this estimation (Sigalo and Briggs-kamara, 2004) 1 cpm = 0.0438 milli-Sievert/year (mSv/yr).

The GM tube was placed one meter above ground level and count rates taken at 10-minute intervals for one hour at each location and a mean of triplicate determination recorded. The readings were taken for morning, afternoon and evening for seven days. These hours were chosen based on the fact that they are meteorological hours recommended for weather

observation by world meteorological organization. Count rates obtained were converted to dose equivalents in milli-sievert per year for man.

2. 4. Data analysis

Correlation analysis and one factor Analysis of variance (ANOVA) was used to test for significant difference between the ionizing radiation levels at different periods at 5% significance level. Co-efficient of variation (CV %) was used to determine the variability in dose equivalents in seven days according to Verla et al, 2015.

3. RESULTS AND DISCUSSION

Table 2 below show the period, temperature, counts per minute (CPM) and the dose equivalents for the ionizing radiation level for the various dumpsites within Imo State University for seven days.

Table 2. Count rates and dose equivalents for dumpsites in Imo State University campus.

Location	Period	Temperature °C	Counts per minutes (cpm)	Dose equivalent (mSv·yr⁻¹)	Mean ±SD	Mean Variability
FS	Morning	25.1±0.48	11.9±1.06	0.52±0.05		
	Afternoon	34.4±2.60	14.1±1.35	0.62±0.06	0.59±0.08	13.55
	Evening	27.9±2.88	14.4±2.69	0.63±0.12		
ETF1	Morning	25.2±0.38	14.6±2.37	0.64±0.11		
	Afternoon	34.2±1.12	13±1.83	0.57±0.08	0.61±0.09	15.30
	Evening	28.9±0.81	14±2.00	0.61±0.09		
UL	Morning	25.4±0.56	13.1±1.77	0.58±0.08		
	Afternoon	34.4±1.0	13.3±1.89	0.58±0.08	0.59±0.08	13.55
	Evening	26.8±2.55	13.6±2.07	0.60±0.09		
ETF2	Morning	25.5±0.68	15.1±1.86	0.70±0.08		
	Afternoon	34.1±1.26	14.7±1.11	0.67±0.05	0.69±0.08	13.55
	Evening	25.1±0.51	15.1±2.27	0.70±0.10		
LF	Morning	26±1.04	12.1±1.00	0.53±0.04		
	Afternoon	36.7±1.32	13.3±1.50	0.58±0.06	0.57±0.06	10.17
	Evening	25.2±0.67	13.7±2.14	0.60±0.09		
SJC	Morning	25.9±0.84	14±2.31	0.61±0.11		
	Afternoon	34.8±1.03	13.7±1.11	0.60±0.05	0.59±0.08	13.55
	Evening	25±0.89	12.9±2.12	0.56±0.10		
EG	Morning	25.5±0.80	12.7±1.98	0.55±0.12		
	Afternoon	35.8±1.18	12.6±2.64	0.54±0.12	0.56±0.10	16.95
	Evening	25.1±0.76	13.6±1.62	0.59±0.08		
CL	Morning	25.7±0.82	13.3±1.11	0.58±0.05		
	Afternoon	36.1±0.73	12.6±1.90	0.54±0.10	0.57±0.07	17.86

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	Evening	24.9±0.55	13.3±1.38	0.58±0.06		
MC	Morning	25.5±0.95	14.4±1.72	0.63±0.07		
	Afternoon	36.3±1.22	12.6±1.51	0.54±0.08	0.58±0.08	13.55
	Evening	24.6±0.40	13.1±1.86	0.58±0.08		

*Mean ±SD reported for readings taken for seven days for n=3.

The maximum dose accepted internationally by NCRP (National Council on Radiation Protection, 1976) is 5 mSv·yr^{-1}, which is about three times the Average background of between 1 and 2 mSv·yr^{-1} (Hunt, 1987; Sigalo and Briggs-kamara, 2004). However, from the result presented (Table 2) values range from 0.52±0.05 mSv/yr at Front gate/Security post to 0.70±0.08 mSv/yr at ETF 2 in the morning period, 0.54±0.08 mSv/yr at the Medical College to 0.67±0.05 mSv/yr at ETF 2 in the afternoon period and the evening ranged from 0.56±0.10 mSv/yr at St. Joseph chaplaincy to 0.70±0.10 at ETF2, all falling below the maximum dose. These suggests that the ionizing radiation level within the university campus hasn't been raised above the natural background level of 1 mSv/yr for all persons occupationally exposed at the European Council for Nuclear Research, CERN (1995). This is similar to result obtain in other studies conducted in Nigeria (Sigalo and Briggs-Kamara, 2004; Yehuwdah et al., 2006; Bamidele, 2013 and Adewale et al, 2015). However, NCRP recently released a report which states that radiation's effects should be considered to be proportional to the dose an individual receives, regardless of how small the dose is. Therefore the present work is important as most radiations were significant.

The variability calculated was categorized as little variation (CV % < 20), moderate variation (CV % = 20 – 50) and high variation (CV % > 50) (Verla et al, 2015). The result obtained in this study showed little variability as the lowest variation recorded was 8.33 % in the evening of day two and highest variation recorded 19.64 % in the morning of the sixth day. Mean variability revealed a range of 10.17 at Law faculty to 17.80 at Chemistry lab. Six sites had same variability i.e ETF1, University library, ETF2, Law faculty, St. Joseph Chaplaincy and Medical College. All site showed little variations.

The figure 1 above shows the dose equivalent (mSv/yr) from the various dumpsites at different periods of the day within the university campus. Ranking the order of ionizing radiation level at different periods; morning – ETF2 > ETF 1> Medical college > Chemistry lab > Library > Extension gate >Law faculty > Front gate/Security post. Afternoon- ETF 2> Front gate/Security post > St. Joseph Chaplaincy >Library > Law faculty > ETF1> Chemistry lab > Medical college > Extension gate and evening- ETF2> Frontgate/Security post > ETF1 > Library > Law faculty > Extension gate > Chemistry lab> Medical college > St. Joseph Chaplaincy.

The slight variation would be attributed to latitude and longitude (National Research Council, 1972). Generally, ETf 2 (0.69 mSv/yr) has the highest ionizing radiation level while lowest value was recorded at the Extension gate (0.56 mSv/yr). The high value recorded at ETF2 could be due to the closeness of the dumpsite to the ETF building as some building material is known to emit gamma rays (Alaamer, 2008).
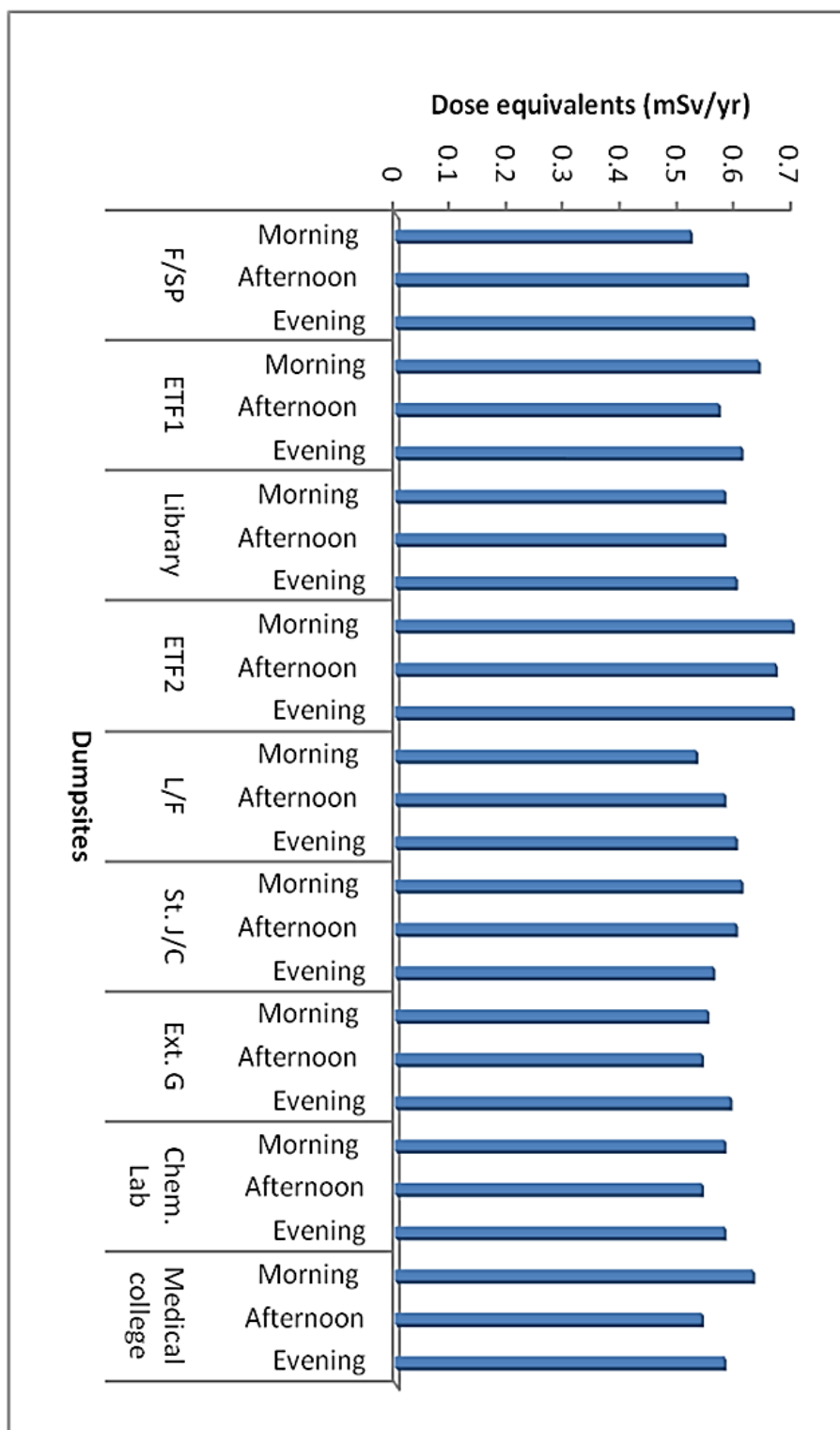
*F/SP = Front gate/Security post, L/F = Law faculty, St. J/C = St. Joseph Chaplaincy, Ext. G = Extension Gate

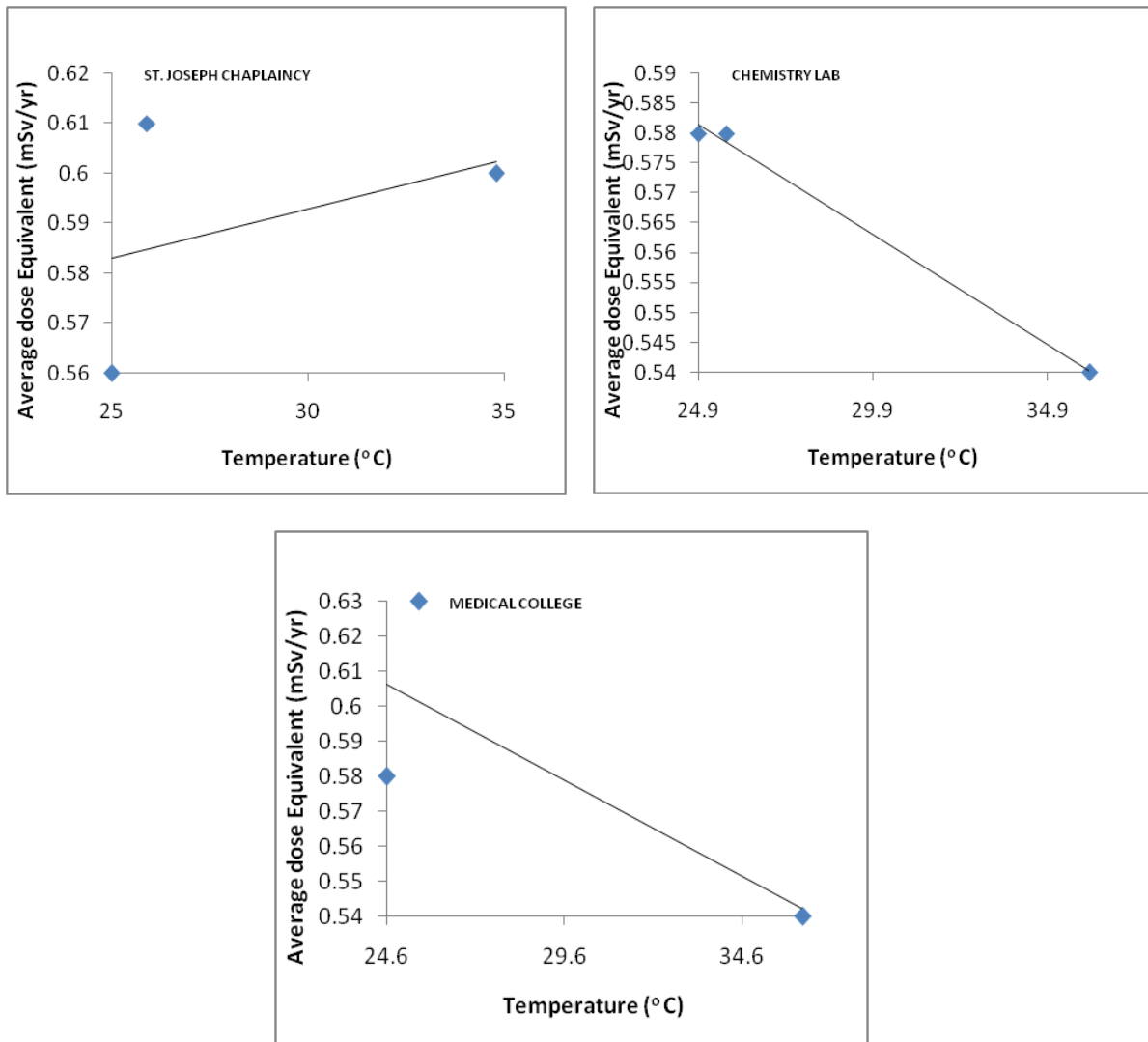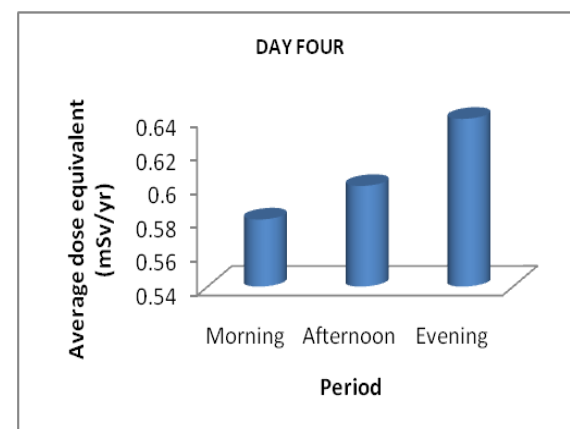**Figure 1.** Dose equivalent (mSv/yr) from the various dumpsites at different periods of the day
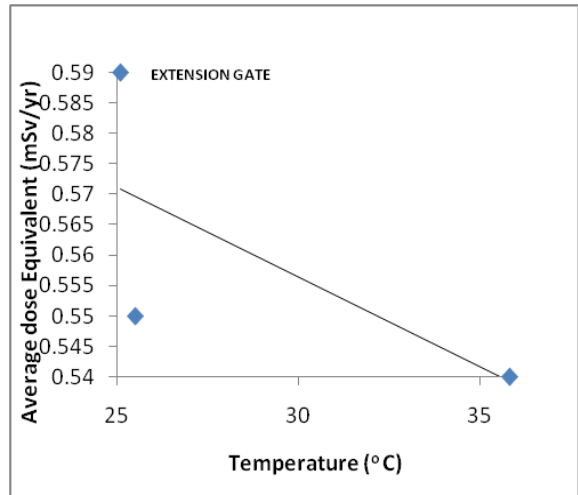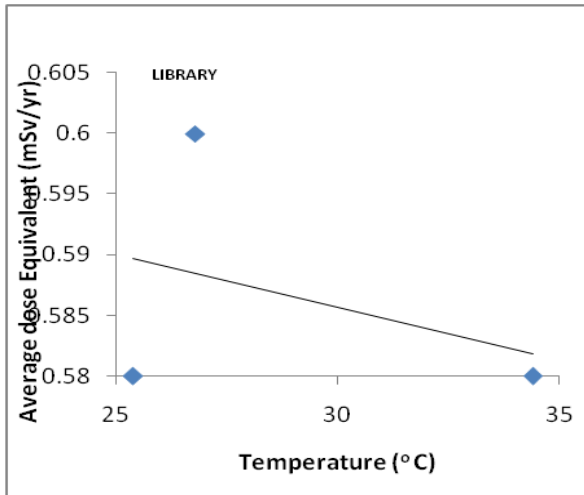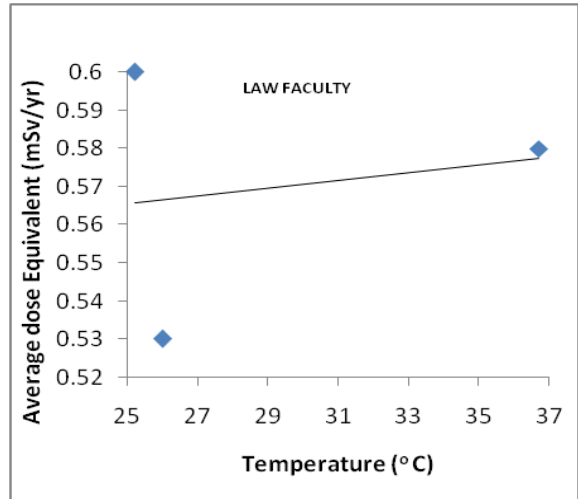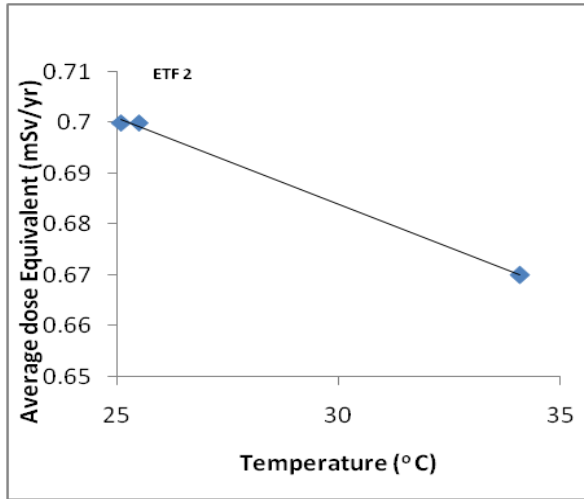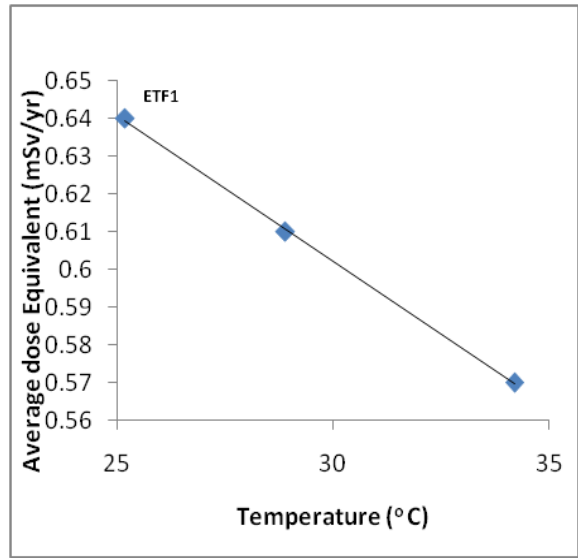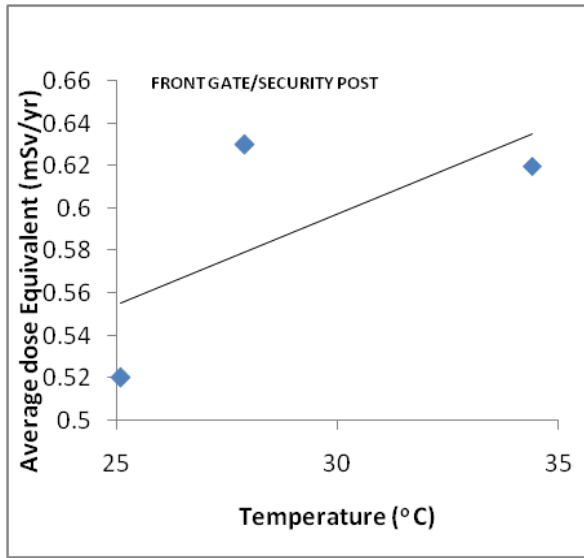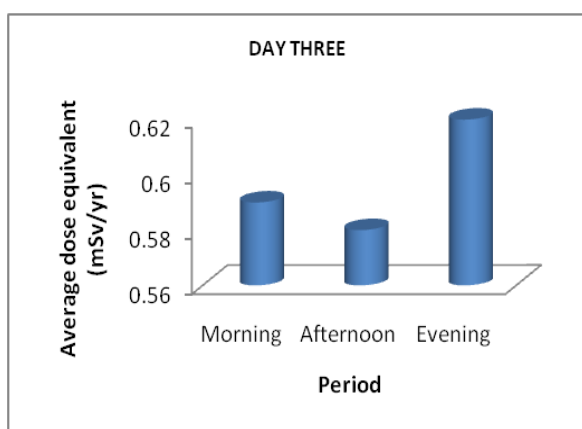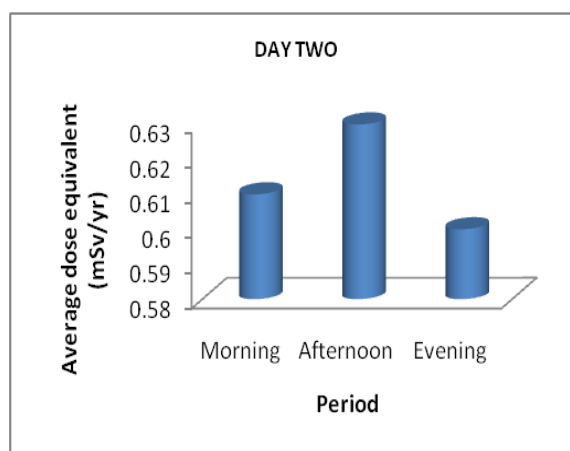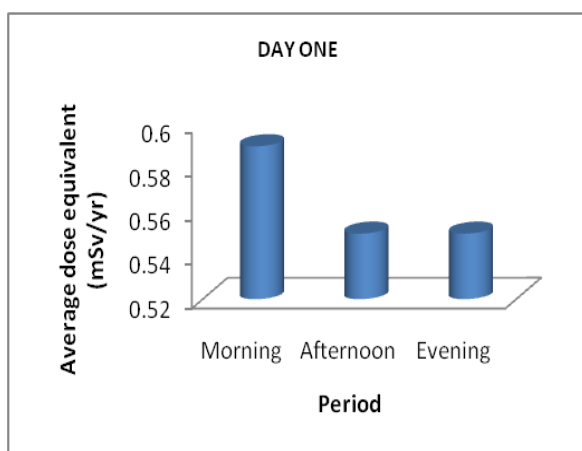
Figure 2. Plots of average dose equivalent (mSv/yr) against the ambient temperature (°C) at various dumpsites.

Table 3. Linear regression equations of average dose equivalent and temperature

Location	Equation (Y = mx + c)	R^2 Value	r (%)	Comment
F/SP	Y = 0.008x + 0.339	0.453	67.3	Positive
ETF 1	Y = -0.007x + 0.835	0.999	99.98	Negative
Library	Y = -0.000x + 0.612	0.136	36.88	Negative

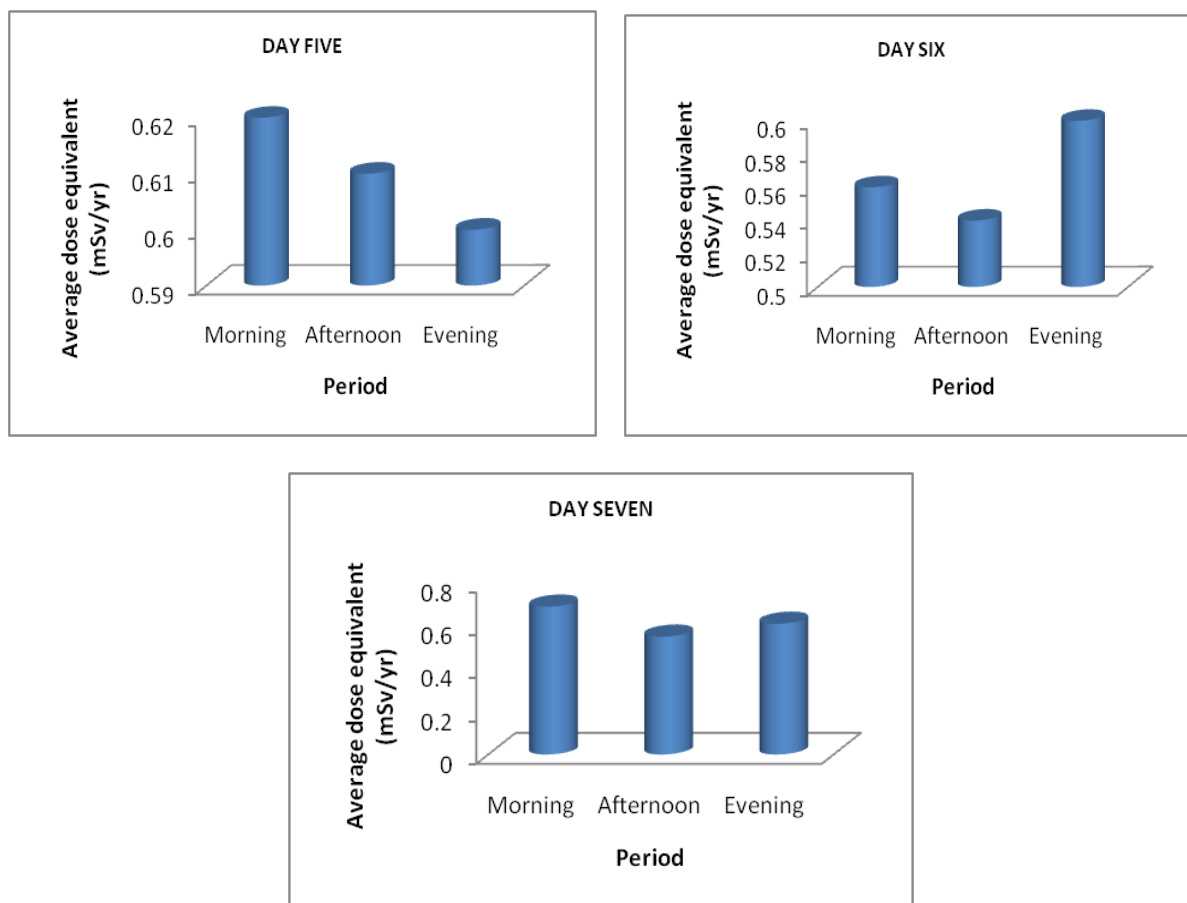| ETF 2	Y = -0.003x + 0.786	0.998	99.89	Negative
Law Faculty	Y = 0.001x + 0.540	0.032	17.88	Positive
St. J/C	Y = 0.002x + 0.533	0.163	40.37	Positive
Extension gate	Y = -0.003x + 0.645	0.461	67.89	Negative
Chemistry lab	Y = -0.003x + 0.673	0.995	99.75	Negative
Medical college	Y = -0.005x + 0.741	0.627	79.18	Negative

Figure 3. Barchart of average dose equivalent (mSv/yr) at different periods for seven days

The various dose equivalents at different periods of the day in seven days were compared using bar chart as shown in figure 3 above. Generally, there is no definite trend in the dose equivalents in seven days, since, at some days morning recorded highest (day 1,5 and 7), afternoon recorded highest in day 2 and evening recorded highest in days 3,4 and 6. However, the order of decreasing mean dose equivalent were recorded in the morning (0.61) > evening (0.60) > afternoon (0.58). This suggests that with time higher exposure could be obtained in the morning hours. Most persons working or studying in the university are mostly present in the morning hours. Thus morning hours could present problems of exposure to ionizing particle to many persons.

The daily trend average dose equivalent (mSv/yr) of the ionizing radiation within the Imo State University campus at different periods in seven days are presented in figure 3 and 4 above. The morning period showed values ranging from 0.56 ± 0.11 (mSv/yr) to 0.69 ± 0.11 (mSv/yr), afternoon ranged from 0.54 ± 0.06 mSv/yr to 0.63 ± 0.10 mSv/yr and evening ranged from 0.55 ± 0.09 mSv/yr to 0.64 ± 0.08 mSv/yr respectively. These values are well below the 1 mSv/yr which is the threshold. However, the highest mean value was recorded in day seven $(0.62\pm0.09$ mSv/yr) and least recorded in day one $(0.56\pm0.08$ mSv/yr). Furthermore, the variations didn't obey exponential distributions as shown in figure 4 above. Although, there

were positive correlations between the morning and evening periods (0.041), afternoon and evening periods (0.35), while morning and afternoon periods correlated weak negatively (-0.012). In statistics, a perfect negative correlation is represented by value -1.00, while 0.00 indicates no correlation and a +1.00 indicates positive correlation. The negative correlation between the morning and afternoon suggests that as there is an increase in the ionizing radiation in the morning, there will be a decrease in the ionizing radiation level in the afternoon.
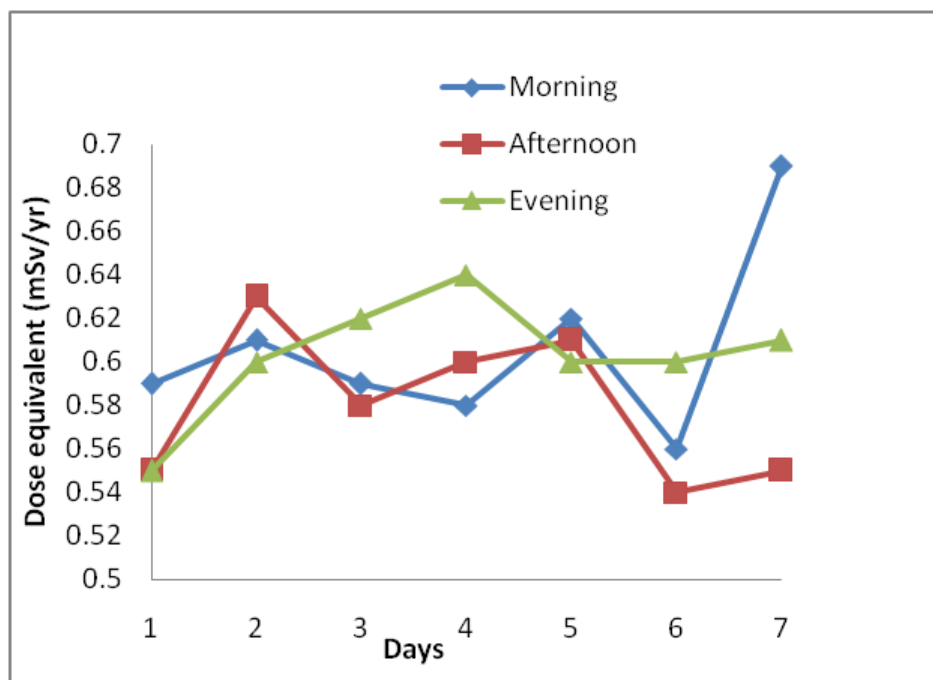

Figure 4. Trend of average dose equivalent at different periods with days

The periods do not have any significant difference on the ionizing radiations level within the campus at $p < 0.05$. The calculated value of F-ratio (1.122) < Critical value (F-critical) 3.55 at 5% significant level. Therefore, H_0 (the dose equivalent at different periods is the same) is accepted. These indicate that at any period of the day (i.e morning, afternoon and evening) the risk of exposure or dose equivalents would still be the same. The various dumpsites have practically the same waste with similar releasing rates of ionizing particles. The Analysis of variance lest agree with the variability characteristics in which variability was low (CV < 20) for all sample sites. It has been established that chronic exposure to an even low dose and a low dose rate of nuclear radiations from an irradiated building has the potential to induce cytogenetic damage in human beings (Chang et al., 1997).

4. CONCLUSION

The various dumpsites have the similar ionizing particles and had no significant differences with mean of various sites. Also, within the limits of calibration and field

measurement errors, the value obtained showed that the students and workers operating within the campus are safe, since it is below the natural background level of 1 mSv/yr. However, there will be need for regular and periodic monitoring of the ionizing radiation level to be carried out to assess the health risks for both staff and students may be exposed to in the future. Furthermore, the University management should enhance awareness on radiation exposure and the effects to the general public as to reduce effects that could be arising due to ignorance by the public. It should also take precaution on how waste materials are deposited to reduce effect to people leaving and those working around the dumpsites.

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Plate 1. Photographs of the various dumpsites selected for this study

a. Front gate/Security post

b. ETF 1

c. Library

d. ETF 2

e. Law faculty

f. St. Joseph Chap.

g. Extension gate

h. Chemistry lab

i. Medical college