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TERRESTRIAL RADIATION PROFILE OF A NIGERIAN UNIVERSITY CAMPUS: IMPACT OF COMPUTER AND PHOTOCOPIER OPERATIONS

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Abstract. *Most universities in Nigeria have high concentrations of photocopiers and computers positioned all over their campuses, often indiscriminately and without regard for the environmental health implications of the radiations emanating from these machines. We study here the impact of the presence of such machines on the terrestrial radiation profile of a Nigerian University, the Rivers State University of Science and Technology, Port Harcourt. The campus was delineated into five study areas. Using the Radalert 50 specialized G-M tube and a model of 7 working hours per day for 7 days per week in each location, the lowest dose equivalent of 0.011 ± 0.003mSv/week was obtained for the Living Quarters while a dose equivalent of 0.016 ± 0.004mSv/week was found at the Business Centre of the campus where the highest concentration of photocopiers and computers is found. Though all the values obtained are within the ICRP prescribed 0.02mSv/week, there is evidence indicating that radiations of photocopier and computer origin result in elevation of the environmental radiation profile.*

Key Words: *Terrestrial radiation, photocopiers, computers, dose equivalent, absorbed dose, health hazards, ozone*

1. INTRODUCTION

Technology, no doubt, has made life much easier. The computer and photocopier for example are now indispensable tools in offices, businesses, schools and even homes. But concomitantly, technology has also spawned many challenges (Lee, 1994) including health hazards, environmental pollution and degradation. The negative impact is enhanced by the increasing demand for such technological innovations as computers, photocopiers, fax machines and GSM handsets.

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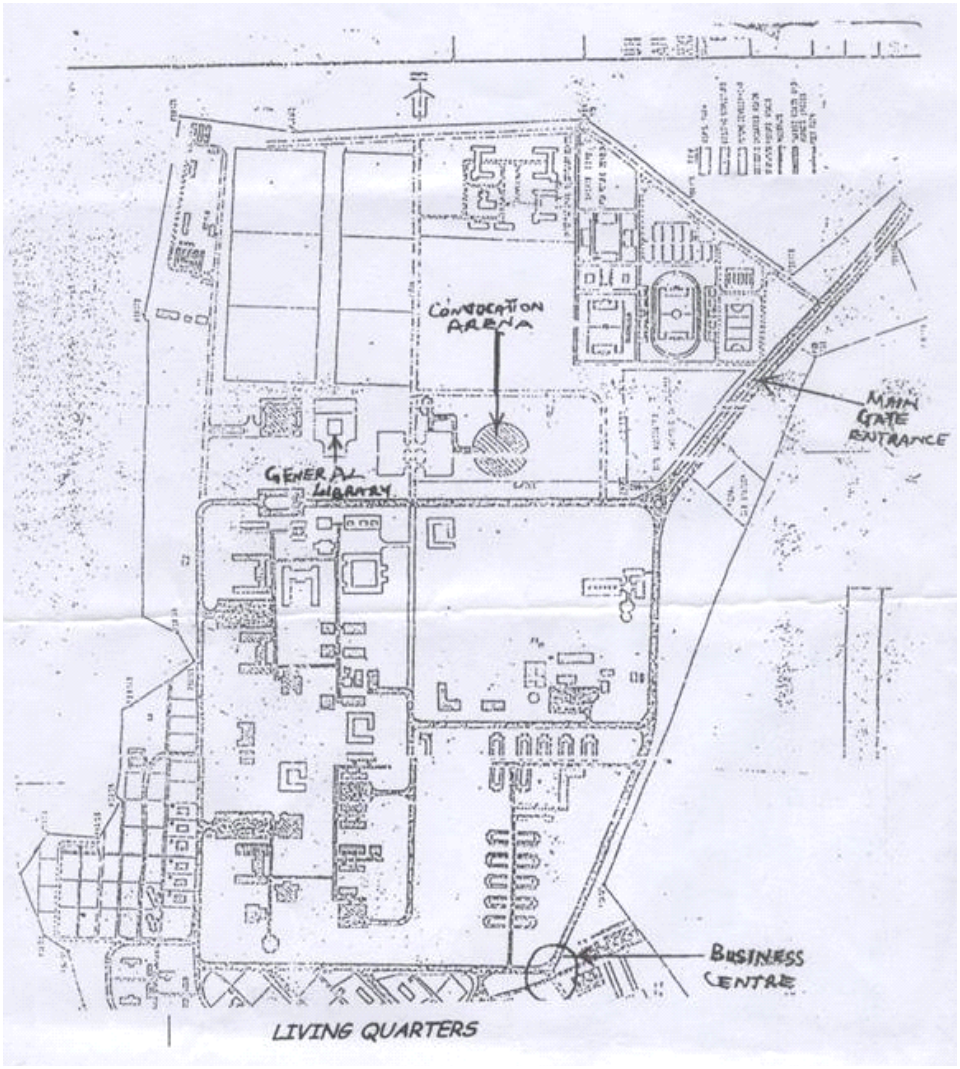

Fig. 1. Map of rivers state university of science and technology showing the surveyed areas (estate works, rsust)

For example, the highly toxic gas, ozone, O_3, is produced during the photocopying process. Ozone is a normal constituent of the earth's atmosphere and is produced both naturally and artificially. It is an incidental by-product in the operating of high voltage equipment and electric arc welding (www.safety.ed.ac.uk/resources/General/printers.strn; www.unionsafe.net.au/hazards/10482038912017.html).

Photocopiers also contribute to environmental noise pollution with noise levels as high as 80dB (www.workershealth.com.au/facts011.html). Also generated during the photocopying process is heat. Consequently, in environments where ventilation and heat disper-

sal is poor, temperatures may rise significantly and like noise, will cause discomfort to workers (www.unionsafe.net.au/hazards/10482038912017.html).

Radiation from the computer is generated when a beam of fast electrons encounters the fluorescent surface of the computer screen thereby producing a luminous image. But, the energy from the electrons is not only used to produce the image, some of the energy is released into the environment in the form of non-ionizing radiations of very low frequency (VLF) and extremely low frequency (ELF) (www.nysut.org/files/hs_070823_computer fact-sheet.pdf). These radiations emanate from the flyback transformer at the rear of the monitor. Radiation is therefore strongest at the back of the machine (www.nysut.org/files/hs_070823_ computer factsheet.pdf; www.emfbioshield.com/).

The electrons which bombard the screen also generate pulse electro-magnetic radiation (PEMR). This effect is known to persist several hours after the computer has been turned off because the computer screen continues to radiate even after the power supply has been cut (www.emfbioshield.com/). At certain distances of separation PEMR has a negative effect on living cells (www.emfbioshield.com/).

Previous studies had focused on the biological and behavioral effects the following parameters associated with computer usage have on humans (Lee, 1994): radioactive emission from monitors (x-rays/gamma rays, ultraviolet); electrical field radiation, E field, from monitors; magnetic field, H field, from monitors; glare and reflection from monitors; static voltage build from monitors; ion depletion in air environment due to monitors; chemical outgases from computer hardware materials and ergonomics (anatomical human engineering).

Chad-Umoren et al. (2006) had assessed the radiation profile of the indoors environment of the physics laboratory of the Rivers State College of Education, Port Harcourt, Nigeria with possible influences from the nearby cement factory, the radiation sources within the laboratory, the materials used in the construction and furnishing of the laboratory and the possible presence of radon gas. Chad-Umoren and Oyekuodi (2007) extended this previous study and evaluated the outdoor radiation profile of the main campus of the college.

In this present study, we examine the impact of radiation emanating from both computers and photocopiers on the overall environmental radiation profile of the campus of the Rivers State University of Science and Technology, Port Harcourt. The University is located between latitudes $4^0\,30'$ and $5^0\,00'$N and between longitudes $7^0\,00'$ and $7^0\,30'$ E of the equator in the heart of the Niger Delta region with its strategic oil and gas operations and multifaceted industrial activities. It has a total area of 32 sq km (Fig. 1). A similar survey had previously been carried out at the Benue State University, Makurdi (Agba and Ayangeaka, 2005). The study at Makurdi considered only the radiation from computer monitor screens. But in this study we examine both the radiation from the entire computer and those from photocopiers. Also, the radiation from this equipment was not studied separately but simultaneously. That is, the computers and photocopiers were both in use as the readings were being taken.

We chose this approach because computer and photocopier operators on the campuses of Nigerian universities store both types of equipment in the same room and use them simultaneously. Consequently, computer and photocopier operations on Nigerian university campuses will contribute simultaneously to the overall environmental radiation profile of these campuses.

This study is important because computers and photocopiers emit radiation into the human environment with three major effects (Gandhi and Hunt, 1977):

1. Heating effect from middle energy or mid-frequency radiation such as infra-red, visible light and microwave radiations.
2. Photochemical and photobiological interactions leading to harmful alterations of the molecular bonds of the body.
3. Ionization and DNA damage resulting from interaction with high energy radiation.

2. EXPERIMENTAL PROCEDURE

Five locations where chosen for this survey, namely the University Main Gate Environs (including the church and roundabout); the Convocation Arena and its environs; the General library and its environs; the Business Centre and Living Quarters (mainly the environment surrounding the houses, Fig. 1).

The Radalert 50 was used for the survey. This instrument detects the radiation passing through it by generating a pulse of electrical current and displaying the count in either count per minutes, milliroentgens per hour (mR/hr) or total count using the liquid crystal display (LCD). It has a mica window of surface density 1.6 – 2.0 mg/cm^2 and takes up to 50,000 cpm/mR/hr reference to ^{137}Cs. It has an accuracy of 15%. Once the detector is turned on for use it does a 3s system check, displaying all the indicators and numbers with the hour glass disappearing after one minute. The disappearance of the hour glass means that the instrument is ready for use.

A preliminary visit was made to the sites selected for the study. The nature, duration and objectives of the study were explained to the operators of the Business Centre so as to secure their cooperation which they gave once their fears were allayed.

At each location, counts were taken at one hour intervals for seven hours for seven days. All counts were taken outdoors except at the Business Centre where indoor counts were also taken since the computers and photocopiers are normally placed indoors. Also, the actual sites used for the survey within a given study location were varied so as to enable the values obtained be as representative as possible for that particular study location.

3.RESULTS AND DISCUSSION

The results of the survey are presented in Tables 1 and 2 and graphically in Fig. 2. Around the Main Gate Area we have an average dose equivalent, D of 0.015±0.004mSv/wk with the lowest value of 0.012mS/wk measured on the first day while the maximum value of 0.017mSv/wk for this area was recorded on three alternate days. The mean dose equivalent for the Convocation Arena and its neighborhood is 0.013±0.003mSv/wk. The dose equivalent for this area varies between the minimum value of 0.011mSv/wk and the maximum value of 0.015mSv/wk.

For the University Library Area, the average dose equivalent is 0.017±0.004mSv/wk. The minimum dose equivalent for the area is 0.014mSv/wk while the maximum value is 0.020mSv/wk recorded on two separate days. At the Business Centre a minimum dose equivalent of 0.015mSv/wk was recorded. This was obtained on two different days. The maximum dose equivalent is 0.017mSv/wk for the area, obtained for three consecutive days of monitoring. The mean dose equivalent for the seven days for this area is 0.016±0.004mSv/wk. For the Living Quarters the minimum radiation dose equivalent is

0.010mSv/wk, while the maximum is 0.012mSv/wk which was obtained on four of the seven days of the survey. The mean dose equivalent for this area is 0.011±0.003mSv/wk.

Table 1. Count rate (Ri), dose equivalent (Di), deviations from mean count rate (ΔRi) and dose equivalent (ΔDi) and percentage deviations from mean (%Δ) for different locations.

s/no	Sampling Area	Count Rate, R_i (cpm)		ΔR_i (cpm)	Dose equivalent, D_i (mSv/wk)		ΔD_i (mSv/wk)	%Δ
		Mean for each day	Sampling Area Mean		Mean for each day	Sampling Area Mean		
1.	University Main Gate Area	14.44	18.17±4.26	-3.73	0.012	0.015±0.004	-0.003	20
		17.87		-0.30	0.015		-0.000	0
		19.54		1.37	0.017		0.002	13
		16.69		-1.48	0.014		-0.001	7
		19.62		1.45	0.017		0.002	13
		18.76		0.59	0.016		0.001	7
		20.24		2.07	0.017		0.002	13
2.	Convocation Arena and Environs	14.17	15.08±3.88	-0.91	0.012	0.013±0.003	-0.001	8
		13.62		-1.46	0.012		-0.001	8
		14.34		-0.74	0.012		-0.001	8
		16.67		1.59	0.014		0.001	8
		17.15		2.07	0.015		0.002	15
		16.24		1.16	0.014		0.001	8
		13.39		-1.69	0.011		-0.002	15
3.	University Library Area	16.70	20.20±4.50	-3.50	0.014	0.017±0.004	-0.003	18
		17.17		-3.03	0.015		-0.002	12
		19.17		-1.03	0.016		-0.001	6
		21.94		1.74	0.019		0.002	12
		23.39		3.19	0.020		0.003	18
		23.86		3.66	0.020		0.003	18
		19.20		-1.00	0.016		-0.001	6
4.	Business Centre	17.98	18.86±4.34	-0.88	0.015	0.016±0.004	-0.001	6
		17.17		-1.69	0.015		-0.001	6
		18.79		-0.07	0.016		0.000	0
		19.55		0.69	0.017		0.001	6
		20.05		1.19	0.017		0.001	6
		19.58		0.72	0.017		0.001	6
		18.87		0.01	0.016		0.000	0
5.	Living Quarters	12.32	13.51±3.68	-1.19	0.010	0.011±0.003	-0.001	9
		14.11		0.60	0.012		0.001	9
		12.43		-1.08	0.011		0.000	0
		13.24		-0.27	0.011		0.000	0
		13.62		0.11	0.012		0.001	9
		14.29		0.78	0.012		0.001	9
		14.53		1.02	0.012		0.001	9

Table 2. Minimum dose equivalent, maximum dose equivalent and mean dose equivalent for the sampling areas.

s/no	Sampling area	Minimum dose equivalent, D_{min} (mSv/wk)	Maximum dose equivalent, D_{max} (mSv/wk)	Mean dose equivalent, <D> (mSv/wk)
1	University Main Gate	0.012	0.017	0.015±0.004
2	Convocation Arena and Environs	0.011	0.015	0.013±0.003
3.	University Library Area	0.014	0.020	0.017±0.004
4.	Business Centre	0.015	0.017	0.016±0.004
5.	Living Quarters	0.010	0.012	0.011±0.003

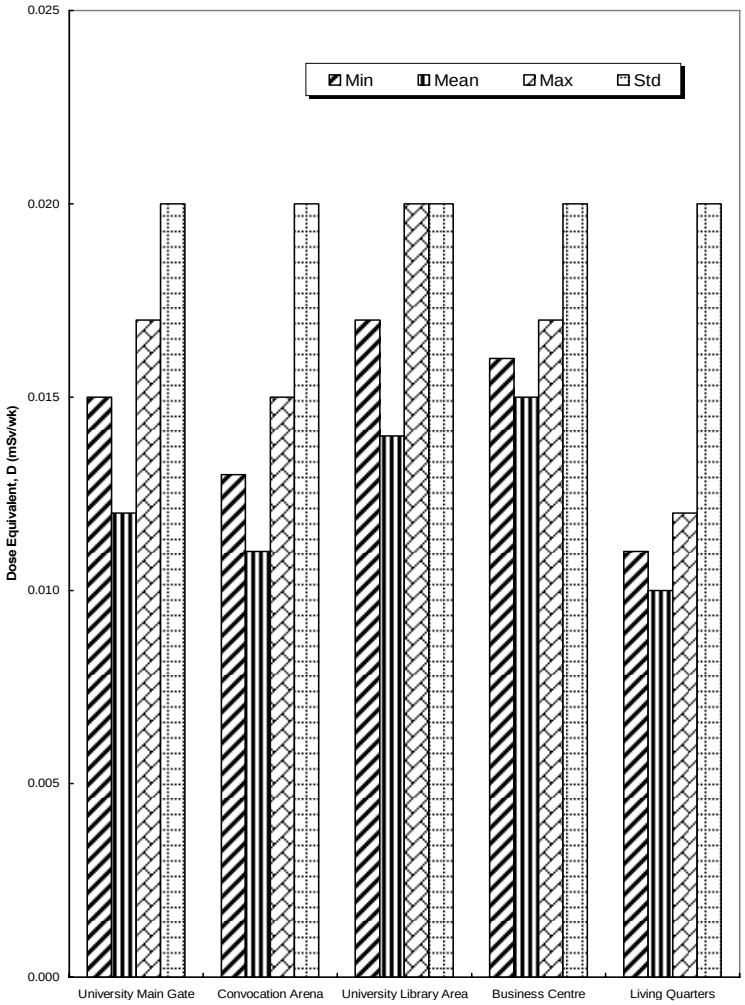

Fig. 2. Minimum, Maximum, Mean and ICRP Standard dose Equivalent

Table 2 gives a comparative analysis of the minimum, maximum and mean dose equivalents respectively for the five areas of the campus that were chosen for this survey. We find that the least of the minimum dose equivalent was obtained at the Living Quarters (0.010mSv/wk) while the largest of the minimum dose equivalent was recorded at the Business Centre (0.015mSv/wk). Considering the maximum dose equivalent, the least value is 0.012mSv/wk and was measured at the Living Quarters while the largest value is 0.020mSv/wk, measured in the area surrounding the University Library. The least value of the mean dose equivalent is 0.011±0.003mSv/wk obtained at the Living Quarters while the largest of the mean values is 0.017±0.004mSv/wk obtained at the University Library and its environs.

We find therefore that the Living Quarters has the least values for the minimum, maximum and mean dose equivalents.

The results from the present study does not differ from the radiation survey of the physics laboratory of the College of Education, Port Harcourt where a dose equivalent of 0.014±0.0004mSv/wk was obtained for the outdoor environment, the area immediately surrounding the laboratory and 0.017±0.0006mSv/wk for the indoor environment [Chad-Umoren et al., 2006). Also, there are similar findings in this study and the survey done for the main campus of the College of Education where a campus average of 0.0143±0.00016mSv/wk was recorded [Chad-Umoren and Oyekuodi, 2007]. Furthermore, in a similar investigation with video computer terminals it was reported that the values obtained were in general not different from those in the environment although significant variations were found in a few cases [Cassano et al., 1985]. This observation is applicable to our present study.

4. CONCLUSION

1. Comparing all five survey areas of this study, the Living Quarters consistently has the least values for each of the three quantities of minimum dose equivalent, maximum dose equivalent and mean dose equivalent. The values of these quantities measured for the Convocation Arena are next in ascending order while the largest value for these quantities alternate between the Business Centre and the University Library. In other words we have:

Minimum dose equivalent:

Living Quarters → Convocation Arena → Main Gate → University Library → Business Centre.

Maximum dose equivalent

Living Quarters → Convocation Arena → Main Gate/Business Centre → University Library.

Mean dose equivalent

Living Quarters → Convocation Arena → Main Gate → Business Centre → University Library

2. The values of the radiation monitoring for the Business Centre are generally higher than those for the other areas of this study, except the University Library area. Considering that of all these areas, only the Business Centre has computers and photocopiers, we conclude that the elevated radiation profile of the Business Centre is evidence that radiation of computer and photocopier origin contributes to the environmental radiation levels of an area.
3. The mean dose equivalent of 0.016±0.004mSv/wk for the Business Centre is less than the value of 0.020mSv/wk recommended by the International Commission on Radiological Protection, ICRP. Consequently, though the radiation from computers and photocopiers contributes to the radiation profile of the environment, the health risk seems to be slight.
4. The radiation profile of the University Library Area (0.017±0.004mSv/wk) is higher than that of the Business Centre (0.016±0.004mSv/wk). This may be due to peculiarities in the environment of the library.
5. In general, the radiation profile of the University indicates insignificant overall health hazards; however, there is still need for proactive preventive measures for the following reasons:
   i. Some segments of the survey area of this study show dose equivalents of 0.02mSv/wk (Table 1). And it has been reported that low frequency radiation from computers and photocopiers above 0.02mSv/week results in subtle neurological and psychological effects called the neurasthenic syndrome. Its symptoms include severe headache, insomnia, lethargy, hyper-irritability, loss of libido and impotence (www.unionsafe.net.au/hazards/10482038912017.html).
   ii. Also, studies show that even low dose radiations can have a hazardous cumulative effect with time [Chang et al., 1997; Shieh et al., 1999].
6. We therefore recommend as follows:
   i. Proper ventilation for computer and photocopier work-environments. The incidence of the toxic gas, Ozone, O_3 associated with the photocopying process can reach levels above the occupational exposure limit (OEL) when the copying room is small, the ventilation is poor, and/or the photocopier is used often (www.lhc.org.uk).
   ii. Periodic monitoring of the radiation levels of these areas
   iii. Regular health evaluation for those on the campus working with or in close proximity to computers and photocopiers.

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RADIJACIONI PROFIL ZEMLJE NA KAMPUSU JEDNOG NIGERIJSKOG UNIVERZITETA: UTICAJ KOMPJUTERSKIH I FOTOKOPIR MAŠINA

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Većina univerziteta u Nigeriji imaju visoke koncentracije fotokopir i kompjuterskih mašina koje su raspoređene po čitavim kampusima, često bez obraćanja pažnje na potencijalne posledice na očuvanje životne sredine koje potiču od radijacije koju ove mašine emituju. U ovom radu istražujemo uticaj prisustva ovakvih mašina na radijacioni profil zemlje jednog univerziteta u Nigeriji, Rivers State University of Science and Technology, Port Harcourt. Kampus je za potrebe istraživanja podeljen u pet oblasti koje su izučavane. Koristeći Radalert 50 specijalizovanu G-M cev i model sedmočasovnog radnog dana u toku sedam radnih dana na svakoj lokaciji, najmanja doza, čija je vrednost 0.011 ± 0.003mSv/po nedelji pronađena je za stambeni deo kampusa dok je doza čija je vrednost 0.016 ± 0.004mSv/po nedelji pronađena u poslovnom centru kampusa gde je koncentracija fotokopir i kompjuterskih mašina bila najveća. Iako su sve dobijene vrednosti u okvirima onih koje preporučuje ICRP, u vrednosti od 0.02mSv/po nedelji, postoji dokaz da radijacija koju emituju fotokopir mašine i kompjuteri kao ishod ima uvećanje radijacionog profila životne sredine.

Ključne reči: *zemljana radijacija, fotokopir mašine, kompjuteri, doze u vrednosti od, apsorbovana doza, opasnost po zdravlje, ozon*