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## Assessment of Occupational Health Hazards from Photocopying Machines

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### **Abstract:**

*An external background radiation study was carried out in Niger Delta University. The study was carried out on 20 different brand of photocopiers in 4 different locations, using a Digilert nuclear Radiation meter to capture the radiation level of these machines and a Geographical Positioning System (G.P.S) to capture Geographical coordinates of the machines' locations. The analysis of the study reveals that 60% of the sampled photocopying machines' external background radiation levels are above the standard radiation level of 0.013mR/hr. Indicating a high measure of radiation health hazard in the study location.*

**Keywords:** Assessment, occupational health, health hazards, health, hazards, photocopiers, machines, environment

### **1. Introduction**

Radiation can be defined as an energy which comes from unstable atoms or are produced by machines. Radiation also refers to an emitted energy that travels as electromagnetic waves, Radiation has different forms and sources, visible light and sound are the most familiar forms of radiation. Others are ultraviolet light, microwaves, gas flaring, television signals, infrared (a form of heat energy) and photocopiers. Technology, no doubt, has made life much easier. The photocopier is an indispensable tool in offices, businesses, schools and even homes. But concomitantly, technology has also spawned many challenges including health hazards, environmental pollution and degradation. The negative impact is enhanced by the increasing demand for such technological innovations for photocopiers. Normally radiation is divided into two types namely IONIZATION and NON-IONIZATION.

Photocopying is one very core activity that takes place on daily basis around the study area being a university community. From the study, it is observed that these photocopier operators have over time complained about some health effects they are faced with as a result of the constant exposure to the radiation emanating from the photocopiers. This study is hence carried out to ascertain the radiation level at the study area with respect to the health and environmental hazards associated with these photocopying machines, such that photocopier operators and individuals living around such environment can have a better understanding of the level of radiation they are being exposed to. This research work was carried out in Niger Delta University, Wilberforce Island Amassoma Bayelsa State Nigeria. Which is located on coordinates N: 04<sup>o</sup> 58' 38.0" E: 006<sup>o</sup> 08.9". The research is aimed at assessing the occupational health hazards to which photocopy machine operators are exposed to with objectives such as determining the different sources of radiation from the photocopying machine, determining the effects of radiation on the machine operator and the environment, determining the brand of photocopying machine that is environmentally friendly, significantly, to determine the radiation level for different brands of photocopying machine, to enlighten operators on the health hazards from photocopying machines, to educate the operators of the machine on safety measures to be taken during photocopying.

The study identifies the following constituents of the photocopying machine as the sources of radiation, they are: toner, carbon black, polymer resin, noise and heat, photoconductive surface, light and ultraviolet light and ozone.

Figure shows the structure or constituents of a typical photocopying machine.

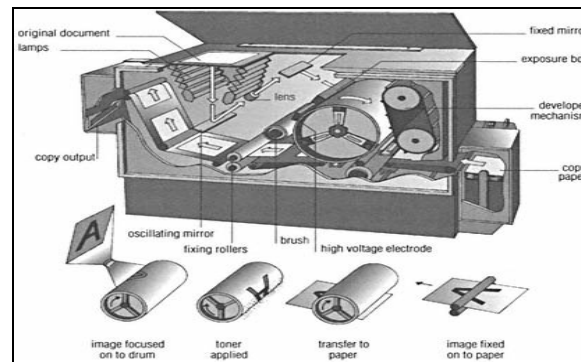


Figure 1. (a) a labelled photocopying machine

## 2. Related Work

[1] carried out research basically on Xerox photocopier machine in order to know if the machine emits radiation, if it's harmful and to what extent. But he got to find out that Xerox photocopier does not emit very harmful radiation as earlier thought by individuals. Barrett now said irrespective of the fact that the Xerox photocopier doesn't emit very harmful radiation it can cause long term harm if basic precautions are not being followed.

[2] carried out a research on how photocopier works using static electricity, he talked about static electricity as one of the major things that make a photocopier work. The static electricity has an intermediate photoconductive surface which is made up of selenium drum or a photoconductive belt. A charged photoconductive surface receives the light reflected off the original and loses charge when struck by the light, creating a charged image that can attract toner particles, the resulting toner image is transferred onto paper fused with heat and pressure, the document or image is being produced. Static electricity copies should be stored at moderate temperature and relative humidity.

[3] gave a conservation case study about the hazards of photocopier machine. It was discovered that the acrylic and styrene components extracted from the toner are vulnerable to ultraviolet radiation, acidity and has oxidizing fumes. Kitty Nicholson also talked about other sources of photocopier hazards like ozone, polymer resin, carbon black, noise and heat, how hazards caused by toner can be cleaned up using solvents, effects of those hazards on the operator's health and the environment and proffered preventive measures.

[4] they all wrote a journal on the study of the physical, chemical and ergonomic occupational hazards faced by photocopier operators. They talked about the permissible exposure limit for an eight (8) hour working job, the illiteracy rate of the operators, independent sample test of the photocopier emissions for various seasons was carried out. This study tends to give operators awareness of the dangers on the health and environmental hazards associated with photocopier practice.

[5] carried out a research about the effect of ozone emission by commercial photocopier machines in Rivers State University of Science and Technology (RUST). They talked about the effects of ozone emission on the operator at different proximity to the photocopier machine, the environment and the brand of photocopier machine suitable for use both for commercial and office use.

[6] carried out a terrestrial radiation profile of photocopier machine at five different locations within University of Port Harcourt. The research basically to ascertain the health and environmental hazards at the different locations sampled, the location and photocopier with the highest radiation level. It was discovered that the developed photocopier has the highest far above the international radiation standard (0.13mR/h-1).

Recent studies of the radionuclide contents and background ionizing radiation of some selected dumped sites in Port Harcourt showed some reasonably high values of the radionuclide levels due to the various types of non-segregated waste ranging from medical, domestic and industrial [7].

The presence of an industry or factory can contribute to the elevation of the background ionizing radiation of the immediate environment. The effect/impact of industrial production on its host environment essentially depends on the nature of the input raw materials, effluents from the production process and the output products. [8] studied the background radiation pattern of pre- and post-industrial activities of a fertilizer plant and reported an increase in the level of background radiation in the post-industrial activities. A thorough assessment was carried out in order to ascertain the natural radionuclide in borehole water in some selected wells in Port Harcourt revealed that the mean specific activity and the resulting annual effective doses for  $^{226}\text{Ra}$ ,  $^{228}\text{Ra}$  and  $^{40}\text{K}$  were  $3.51 \pm 2.22$ ,  $2.04 \pm 0.24 \pm 0.29$  at  $23.03 \pm 4.37$  and  $0.36 \pm 0.12$ ,  $0.51 \pm 0.02$  and  $0.05 \pm 0.01\text{mSv/y}$  respectively [9]. The results of this survey are within the range obtained elsewhere. Generally, public places showed the highest activity concentration due partially to poor sanitation.

Great scientists have carried out research on various activities by man that has led to the increase in radiation on our environment and are highlighted below:

[10] worked on terrestrial sources of radiation and came up with the result that, an average person in the United States of America receives a dose of about 360mrem/year, eight percent of which comes from natural resources (mainly from NORM in the Earth's crust). Also, an average radiation dose of 41mrem/year is released into the environment from terrestrial sources. Certain specific areas in China, India and Brazil have reported levels in the range of 10.20mrem/year from terrestrial source (compared with the legal limit of 5mrem/year for radiation workers).

[11] carried out a study on environmental impact of the offshore oil and gas facilities that produced water from oil and gas production contain naturally occurring radioactive elements (Uranium and Thorium) and their daughter product ( $^{226}\text{Ra}$  and  $^{228}\text{Ra}$ ).

[12] studied the external environmental radiation in the Trans-Amadi industrial area and other sub-industrial area of Port Harcourt and reported an average value of  $0.014\text{mR}\cdot\text{h}^{-1}$ . The result indicated some level of impact of the environment and a significant elevation from the standard background radiation level for similar environment. Also, a determination of radionuclide levels in soil and water around cement companies in Port Harcourt revealed mean dose rate equivalent of  $0.18\text{mSv}/\text{y}$  and  $0.39\text{mSv}/\text{y}$  for water and soil samples respectively. These results were lower than the international communication on Radiological Protection (ICRP) maximum permissible levels but were higher than other non-impacted environments [13].

[14] Gamma radiation is electromagnetic radiation of high frequency (very short wavelength), denoted as  $\gamma$  and is produced by decay of high energy state in atomic nuclei and also energy sub-atomic particle interactions in natural processes and man-made mechanisms.

[15] reported that the background radiation of any environment is a combination of natural and man-made source and the average exposure rate lies between the range of  $8\text{-}15\mu\text{R}/\text{hour}$ .

### 3. Control of Exposure to Radiation

Sources of radiation external to the body account for the radiation dose that can affect the individual due to exposure. Four basic principles and procedures are adopted as control and ways to limit radiation exposure. They are as follows:

#### 3.1. Shielding

Shielding on source of radiation generally reduces the radiation levels around the radioactive source. In particular, shielding should be utilized for stored source. Barriers of lead, concrete or water are used as shields from gamma ray, and neutrons. Some radioactive materials are stored or handled underwater or by remote control in rooms constructed of thick concrete or lined with lead. Shielding can also be designed using halving thickness, the thickness of material that reduces to radiation by half.

#### 3.2. Distance

To reduce the effects of radiation, closeness to a source should be minimized. Radiation intensity (R) decreases sharply with distances (r) according to an inverse square law i.e.  $R \propto 1/r^2$ . Therefore, the nearer a source of radiation the more effective of its action.

#### 3.3. Time

The amount of time spent near a source of ionization radiation is a major factor in the ionization process. Therefore, limiting or minimizing the exposure time will reduce the dose from the radiation source.

#### 3.4. Containment

Radioactive material is confined in the smallest possible space and kept out of the environment from the public reach. Usually, nuclear reactors operate within closed systems with multiple layers which keep the radioactive materials contained. Rooms are designed to have reduced air pressure thus any leaks occur into the room and not out of it.

### 4. Experimental Results

The various radiation data gathered at different locations in the course of this work is presented and efforts will be made to analyze them.

To estimate the whole body equivalent dose rate, we use the National Council on Radiation Protection and Measurement (NCRP, 1993) recommendation.

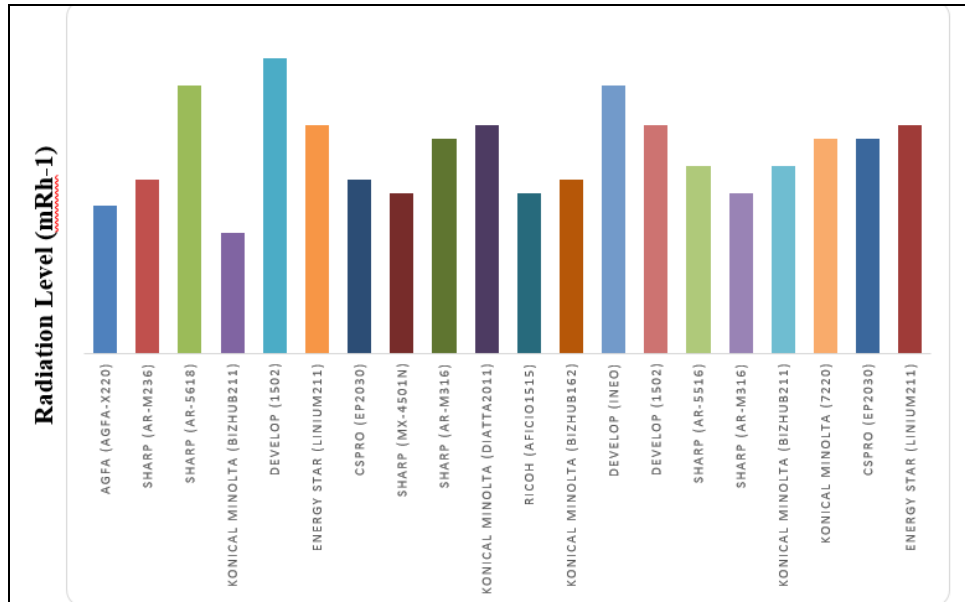
$$1\text{mR}\cdot\text{h}^{-1} = 0.96 \times 24 \times 365 / 100 \text{ mSv}\cdot\text{h}^{-1}$$

SAMPLE AREA	BRAND OF PHOTOCOPIER	MODEL	GPS LOCATION	AVERAGE RADIATION DOSE( $\text{mR}\cdot\text{h}^{-1}$ )	EQUIVALENT DOSE RATE( $\text{mSv}/\text{YR}$ )
UNIVERSITY SHOPPING COMPLEX	AGFA	AGFA-X220	N: $04^{\circ} 58' 38.0''$ E: $006^{\circ} 06' 08.9''$	$0.011 \pm 0.001$	0.929
	SHARP	AR-M236		$0.013 \pm 0.002$	1.093
	SHARP	AR-5618		$0.016 \pm 0.005$	1.345
	KONICA	BIZHUB 211		$0.009 \pm 0.007$	0.756
	MINOLTA DEVELOP	1502		$0.022 \pm 0.007$	1.850
DIAMOND BANK AREA	CSPRO	EP 2030	N: $04^{\circ} 58' 48.1''$ E: $006^{\circ} 06' 10.9''$	$0.013 \pm 0.002$	1.093
	ENERGY STAR	LINIUM 211		$0.017 \pm 0.002$	1.429
	SHARP	MX-450IN		$0.012 \pm 0.005$	1.009
	SHARP	AR-M316		$0.016 \pm 0.006$	1.345
	KONICA	DIALTA 2011		$0.017 \pm 0.001$	1.429
MINOLTA					

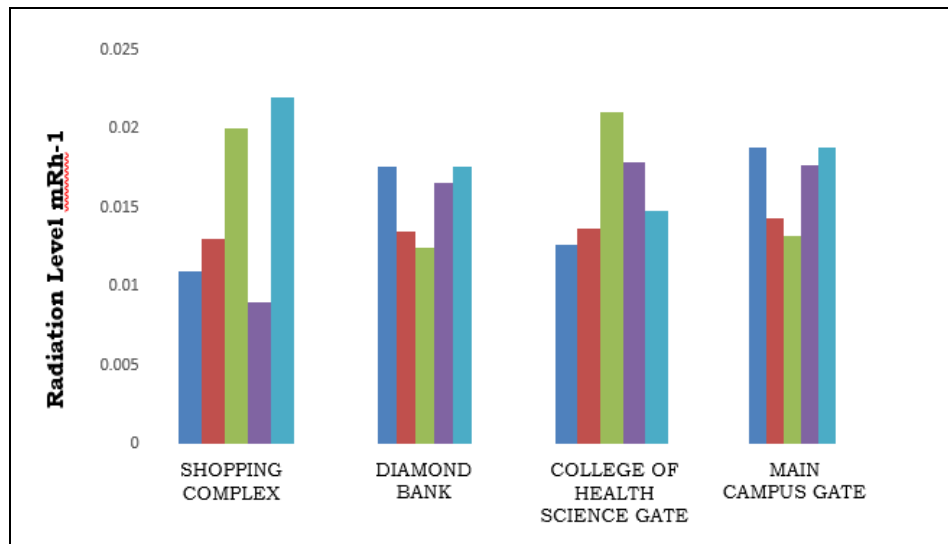
MAIN CAMPUS GATE	SHARP	AR-M316	N: 04 <sup>0</sup> 58' 26.0" E: 006 <sup>0</sup> 06' 10.9"	0.012±0.003	1.009
	KONICAL	BIZHUB 211		0.014±0.003	1.177
	MINOLTA	EP 2030		0.016±0.002	1.345
	CSPRO	LINIUM 211		0.017±0.002	1.429
	ENERGY STAR	7220		0.016±0.004	1.345
COLLEGE OF HEALTH SCIENCE GATE	RICOH	AFRICIO 1515	N: 04 <sup>0</sup> 58' 05.8" E: 006 <sup>0</sup> 05' 51.3"	0.012±0.003	1.009
	KONICAL	BIZHUB 211		0.013±0.004	1.093
	MINOLTA	AR-5516		0.014±0.002	1.177
	SHARP	INEO 213		0.020±0.006	1.681
	DEVELOP	1502		0.017±0.005	1.429

Table 1: Radiation Level of different Brand of Photocopying Machine at Various Locations

Figures below shows the radiation level of different photocopying machines as they are grouped in the sample area. Figs 2. (a) histogram showing the radiation level of different photocopying brands and models. (b) radiation level of 20 samples of photocopying machines grouped in the study area.



a



b

Figure 2

SAMPLE AREA	ES	VS	S	NS	LE
SHOPPING COMPLEX	40%	25%	20%	10%	5%
DIAMOND BANK	30%	25%	25%	15%	5%
MAIN CAMPUS GATE	35%	30%	20%	15%	5%
COLLEGE OF HEALTH SCIENCE	30%	30%	20%	9%	6%

Table 2: Showing the percentage of responses on the effect of radiation from photocopier

Where ES, VS, S, NS and LE are Extremely Severe, Very Severe, Severe, Not Severe, and Less Effects respectively.

Fig.3.Social survey analysis. (a) pie chart showing the percentage of response of the severity of radiation at the Shopping Complex area (b) pie chart showing the percentage of response of the severity of radiation at Diamond Bank area (c) pie chart showing the percentage of response of the severity of radiation at main campus gate area (d) pie chart showing the percentage of response of the severity of radiation at college of health science first gate area

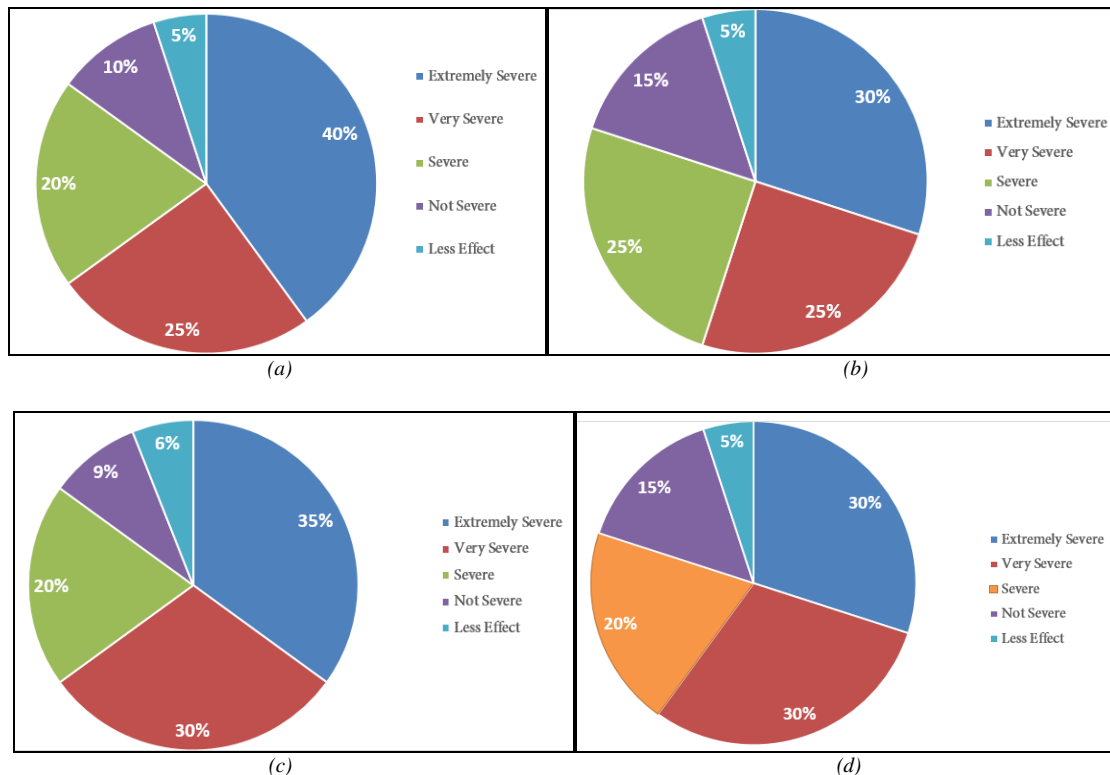


Figure 3

## 5. Discussion

Excessive exposure to radiation courses severe damage to the human skin and consequently poses health problems on individual. The negative effect radiation has on people's health are considered. The study comprises the use of radiation detectors in the likes of radiation meter, and the application of questionnaires for social survey work.

Table 1 shows the data obtained for radiation levels at the various locations and the longitude and latitude of these various locations within Niger Delta University, Amassoma, Bayelsa.

Table 2 shows the percentage of response to radiation dose at the various locations in the study area.

Figure 2 (a). Shows the radiation level for the different brands of photocopier and their models, it shows that the develop (1502) has the highest radiation level of  $0.022\text{mRh}^{-1}$  which is higher than the recommended radiation level of  $0.013\text{mRh}^{-1}$ , the radiation level for Develop (1502) is very high due to the fact that the Develop (1502) is an old brand of photocopier. While the Konica Minolta (bizhub 211) has the least radiation level of  $0.009\text{mRh}^{-1}$  which is below the recommended radiation level this is so because the Konica Minolta (bizhub 211) is a new brand of photocopier and most of the photocopying shops visited had this particular brand and model of photocopier, with this fact and figures its more advisable for photocopying machine operators to use the Konica Minolta (bizhub 211) for their photocopying business. Figure 2 (b) Shows the radiation level of the 20 sampled photocopiers grouped in their different sample areas, it shows that the College of Health Science Gate has the highest radiation level because in that area there is a telecommunication mast and wireless network dish (Wifi) which are also sources of radiation so combined with the radiation from photocopiers it's not safe to site a photocopying shop or live around such environment. While the Shopping Complex is safer to site a photocopying shop because the radiation emitted from most of the photocopiers in that particular environment is lower than the recommended level. Figures 2 (a) –(d) shows the pie chart of the percentage of response to the questionnaires distributed at Shopping

Complex Area, Diamond Bank Area, Main Campus Gate and College of Health Science First Gate Area. The chart indicates that 40%, 30%, 30%, 35% of the respondents agree respectively that the radiation experienced is Extremely Severe, 25%, 25%, 30%, 30% the respondents respectively says that the radiation is Very Severe, 20%, 25%, 20%, 20% respectively Severe, 10%, 15%, 15%, 9% says it's Not Severe and 5%, 5%, 5%, 6% says it has Less Effect.

## 6. Conclusion

This research work was carried out on radiation. The research deals with the factors that cause radiation emission from photocopiers and their effects on human health and the environment.

Radiation from photocopying machines are not very harmful to the body but can be harmful when in high concentration because the radiation from photocopier is falls under Non-Ionizing radiation.

Photocopying machines that emits radiation higher than the standard radiation level are the old model photocopiers while the ones with radiation level lower than the standard radiation level are the modern photocopiers mostly used by operators today.

## 7. Recommendations

1. Proper ventilation of photocopying environment. The incidence of the toxic gas, Ozone and O<sub>3</sub> associated with the photocopying process can reach the occupational exposure limit (OEL) when the photocopying shop or room is small, ventilation poor and the photocopier is usually used often.
2. Periodic monitoring of the radiation levels of the different areas worked on.
3. Regular health evaluation and checkup for those working and living in close proximity to a photocopying environment.
4. Operators carrying out bulk photocopying should set the machine and stay 600mm away from the exhaust.
5. Photocopiers should be sited such that the exhaust emission does not travel over workstations or personnel.
6. Ensure regular servicing of the machine.
7. Refilling techniques for toner in photocopiers should be given special attention in order to avoid spillage.
8. Toner spillage should be cleaned up properly, ideally if persons are known to have problem with their respiratory system they should not be asked to carry out this task.
9. Used toners from the photocopiers should be placed in sealed bags for proper disposal.
10. Installers and operators should make sure that the charcoal filter in Photocopiers are working properly.

## 8. References

- i. Xerox Corporation (2005) Facts about Ozone: "Its effects on people and environment". [www.xerox.com/environment](http://www.xerox.com/environment)
- ii. Chris Woodford (2007) How a photocopier works using electrostatic electricity. <http://www.explainthatstuff.com/photocopier.html>.
- iii. Kitty Nicholson (1989) Photocopier Hazards and a Conservative Case Study. America Institute for Conservation.
- iv. Abira Ismat Butt, Saleema Bashir Sheams, Moinuddin Ghauri, Khurram Shahzad, Mujtaba Hussain Jaffery. (2014) Study of physical, chemical and ergonomics in occupational hazards faced by photocopy machine operator. *Life Science Journal* (2014). <http://www.lifesciencesite.com>
- v. Ayotamuno M.J., Okoroji J., Akor A.J. (2013) Ozone emission by commercial photocopy machine in Rivers State University of Science and Technology, Nigeria. *International Journal of scientific and Engineering Research*, volume 4, Issue 6.
- vi. Margaret A., Briggs-Kamara, Friday B Sigalo, Yehuwda E, Chad- Umoren, Ferdinand A. Kamgba (2009). Terrestrial radiation profile of a Nigerian University campus: impact of photocopier operation. Working and Living environmental protection.
- vii. Avwiri, G.O., Nte, F.U. and Olanrewaju, A.I. (2011): Determination of radionuclide concentration of landfills at Eliozu, Port Harcourt, and Rivers State. *Scientia Africana*, Vol. 10 (In press).
- viii. Ebong, I.D.U. and Alagoa, K.D. (1992): Fertilizer impact on ionizing radiation background in a production plant. *Nig. Journal of Physics*, Vol. 4, p. 143 – 149.
- ix. Avwiri, G.O. and Ebeniro, J.O. (1998): External Environmental Radiation in an industrial area of Rivers State, Nigeria. *Nig. Journal of Physics*, Vol. 10, 103 – 107.
- x. Ebeniro J.O. and Avwiri G.O. (1998) 'External Environmental Radiation in an Industrial Area of Rivers State' *Nig. Jour. Of Phy*, Vol.10, 1998, 105-107.
- xi. Avwiri, G. O., Owate, I. O. and Enyinna (2005): Radionuclide concentrations survey of soil, sediments and water in Aba River, Abia State, Nigeria. *Scientia Africana*, Vol. 4, No. 1&2, p.67-72.
- xii. Inyang S.O. Inyang I.S. and Egbe N.O. (2009) Radiation exposure level within timber industries in Calabar. *Journal of Medical Physics* (2009).
- xiii. Cassano F. Elia, Salamananna G., Santostasi S., Stefanelli V., Carioggia R., Fedeli C. (1985) Ionization Radiation and video computer terminals. *G. Ital Med Lav*. 7:141-144.
- xiv. Chad-Umoren Y.E. and Oyekuodi O. (2007) Determination of Ionizing Radiation level of the main campus of the Rivers State College of Education, Rumuolumeni, Nigeria. *International Journal of Environmental Issues*, 5.1-6.
- xv. Chad-Umoren Y.E., Adekanmbi. M. and Harry S.O. (2006) Evaluation of Indoor Background Ionizing Radiation Profile of a Physics Laboratory. *Facta Universitatis series Working and Living Environmental Protection* Vol.3.
- xvi. Halton. D. (1983) Photocopiers- Do they pose a health hazards? Canadian Centre for Occupational Health and Safety, Hamilton, Ontario.
- xvii. Selway M.D., Allen R.J. and Wadden R.A (1980): Ozone Production from Photocopying Machines. *American Industrial Hygiene Association Journal* 41:455-9.