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ASSESSMENT OF INDOOR NON-IONISING RADIATION OF SELECTED RESIDENTIAL APARTMENTS IN GOMBE METROPOLIS, GOMBE STATE, NIGERIA

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ABSTRACT

A cross sectional design approach was employed to assess the indoor radiation exposure of population in selected residential apartments in Gombe Metropolis, Gombe State Nigeria. Primary data was obtained aided by a hand-held radiation meter and a well-structured questionnaire. With the aim of ascertaining the radiation distribution pattern and occurrence rate of Electro Hypersensitivity Syndrome' (EHS) in the study area. The analysis of variance test 'ANOVA', an inferential statistics was used to ascertain the radiation distribution pattern, while the descriptive statistics was used in determining the occurrence rate of (EHS) in populations of the study area. A convenience sampling technique was adopted, and 30 sampling unit of residential apartment were chosen for the study, relying on homogeneity, inclusion and exclusion criteria. The pre-tested questionnaire scored 74% Cronbach's Alfa reliability. Findings from the study revealed that total indoor radiation varied significantly across the study area, with $F_{(2,27)} = 38.599$, $P < 0.00$, at ($\alpha = 0.05$). The occurrence rate of the understudied EHS illnesses were determined to be in the following order: sleep disorder, fatigues, headaches, dizziness, loss of appetite and memory loss, with mean averages of 3.53, 3.26, 2.97, 2.70, 2.17, and 2.03 respectively. Hence a recommendation for public sensitization on the occurrence, effect and necessary policy control measures, towards minimising public exposure to indoor non-ionising radiation, by relevant stakeholders such as: the Standards Organisation of Nigeria, Federal and States Ministries of Environment and the Nigerian Customs was necessitated.

Keywords: EHS, Homeostasis, Nonionizing Radiation, ROS, Chronic and Acute Toxicities

INTRODUCTION

Radiation is stream of energies emanating from a source with wave like properties and potential to cause harm (Felix., Gabriel., & Emmanuel. 2014). But until very recently, much of what is known about the harmful effect of radiation was limited to the ionising spectrum, majorly from radioactive sources. Neglecting the non-ionising spectrum usually from anthropogenic sources, such as electronic gadgets, equipment and technologies, which includes: mobile phones, televisions, computers, printers, wireless routers, air conditioners, refrigerators, electric heaters and cookers, micro wave cookers, washing machines etc. (Habib, *et al.* 2021; Batool., Bibi., Frezza., & Mangini. 2019).

Ironically, majority of studies on the effects of radiation is focused on occupational exposures, neglecting the vast indoor residential apartments housing this radiation generating gadgets (Abubakar., Sadiq., Musa., Hassan & Malgwi. 2017; Jwanbot., Izam., & Gambo. 2012). Therefore negating the popular recommendation of limiting work hours and adopting work shifts towards reducing exposures, to been applicable only to occupational exposure (Baraya., Sani., & Alhassan. 2019).

More worrisome is the assertion in (Klepeis & Ott. 2014) that the time spent

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by individuals in the indoor environment is on the rise. Although ionising radiations exerts acute toxicities, whose effect is almost immediate or rather requiring shorter time periods, the nonionizing radiation takes a longer time to manifest its effect, thus described as chronic toxicity.

More so, while the ionising radiation exacts its effect via a heating mechanism, the nonionizing radiation exerts its affects via tissue excitation, leading to production of excess Reactive Oxygen Species (ROS), beyond what the endogenous antioxidant could synthesise via homeostasis, leading to oxidative stresses, and consequent illnesses, such as Electro Hypersensitivity Syndrome (EHS) (Pall. 2018; Gallastegi *et al.* 2016).

According to (Frah & Belyaev., 2019) there are growing reports of (EHS) illnesses occurring in the wake of increasing growth in electronic devices and technologies. Furthermore, in (Felix., Adigwe., & Agbaraji. 2014) illnesses such as: headaches, sleep disorder, fatigues, visual disruptions, depressions, memory losses, hearing problem, loss of appetite, dizziness and skin problems, were listed among the symptoms of (EHS). Prompting Panagopoulos and Chrousos (2019) to term (EHS) as a disease nonspecific illness, partly because these symptoms are common in other diseases, also because exposure to this type of radiation in a population doesn't necessarily manifest similar symptoms all across.

A new paradigm in exposure assessment promotes the inclusion of human consumption behaviour, due to huge variations in lifestyle and socio-economic status (Pourhoseingholi., Ahmed., & Mohsen. 2012). Hence it is acknowledged in Hoek *et al* (2018) that the traditional reliance on distance from source to define exposures is insufficient.

Similarly, Njinga and Mamman (2015) concludes that radiation from electronics is a function of model, age, and condition of the gadget. While in Ubani., Alaci., and Udoo (2017) it is reported that the choice of settlement by humans is a function of their economic strength, which also applies to the type of electronic gadgets they are able to afford and consequently the radiation exposures. Yet no single study on indoor radiation exposures has factored this parameter in their methodology.

Another paradigm in exposure assessment involves the use of personal gadgets worn by study subjects, e.g. radiation badges. Though concerns about the inconvenience in wearing and the risk of manipulations of result is still a major limitation. (Wang, *et al.* 2021) affirms the acceptance of the indirect method of radiation assessment, not necessarily requiring personal gadgets or the use of bio markers, but could be successfully archived using a questionnaire or diaries.

MATERIALS AND METHODS

Study Area

The study area, Gombe Metropolis is the capital of Gombe State Nigeria, located on latitude 10º13′N to 10º20′N and longitude 11º02′E to 11º16′E, at an altitude of 460(m) above sea level, with a land area of about 45km^2, and a projected population of 438,164 as at 2021 (Jauro, 2018). With an annual rainfall of approximately (850mm), and temperature range of 35ºC-40ºC characterised by a Sudan/Guinea Savannah and a tropical continental climate, the topography of Gombe State is made up of mainly mountainous, undulating and hilly to the southeast and flat opens plains in the central, north and north-east, west and north-west (NiMet 2017; Mayomi & Mbaya 2016).

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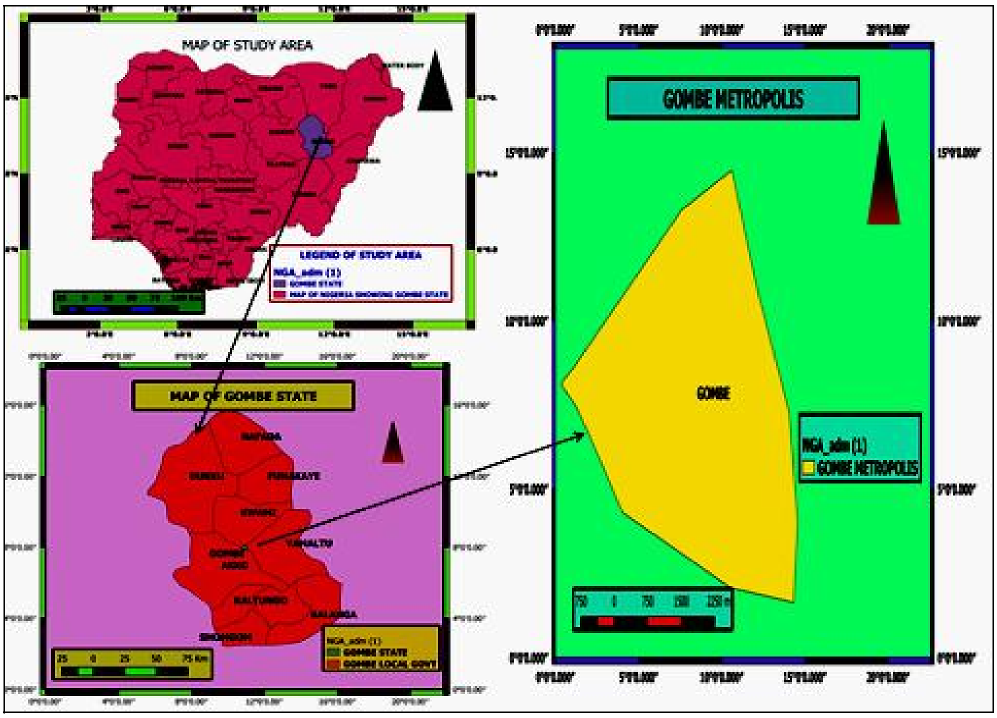

Figure 1: Map of the study area

Source: Digitised by Author Using Qgis 3.2

Equipment and Materials

The materials used for this study includes, a radiation inventory form, a structured questionnaire, a WINTACT (WT3121) hand held radiation meter, Statistical Package for Social Science version 23 (SPSS 23) for data analysis and Qgis software for map digitization.

Radiation Meter Description (WT3121) Suitable for measuring dual fields i.e., electric and magnetic fields, in units of (V/M & µT) respectively, with a precision of 1V/M & 0.01µT & a range of 1-1999V/M & 0.01-19.99 µT, a safety alarm threshold of 40V/M & 0.4 µT, test bandwidth 5Hz-3500Mhz with a sampling time of 0.4sec, operating temperature ranging from 0º-50ºC/30-ºF-122ºF and an operating relative humidity of <80%. With a good precision level ideal for measuring low field range, similar to those emitted by electronic devices popular in our residential apartments, the operating temperature and humidity is compactable to the climate of the study area, and a safety alarm threshold for the user notification is embedded.

Figure 2: Wintact WT3121 Hand Held Radiation Meter

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Sampling and Sampling Technique

Firstly, the stratified sampling was adapted, based on the methodology of Idris & Dharmasiri (2016). ‘Chechnya’, ‘Herwagana’ and ‘Investment Quarters’ were then chosen to represent high, medium and low-density settlements respectively. Each settlement been homogeneous in socio economic status allows for the adoption of the convenience sampling technique (Etikan, Musa & Alkassim 2016).

Consequently, a sample size of 30No housing units was chosen for the study, 10 each for the high, medium, and low-density settlements, based on a convenient sampling technique, guided by an inclusion criterion, that ensured that selected houses are not in proximity to interference from external radiation sources, such as, communication mast, electricity transmission or distribution networks, railways and highways.

RESULTS

Total average radiation frequencies were retrieved and labelled as table 1; for the purpose of comparison. Hence with 3 each for the high, medium, and low-density settlements, based on a convenient sampling technique, guided by an inclusion groups for comparison, the Analysis of Variance (ANOVA) test becomes adequate. Analysed at a confidence level of $\alpha = 0.05$, an $F_{(2,27)} = 38.599$, $P < 0.001$ was returned, summarised in table 2. Indicating that there is a significant different in the average radiation exposures, between the high, medium and low-density settlements respectively, hence the p-value of 0.001 is significantly lower than the test value of $\alpha = 0.05$. Justifying the findings in Ubani., Alaci., and Udoo (2017), Njinga and Mamman (2015) that radiation is a function of model, age and condition of electronic gadgets, while economic strength determine the choice of settlement class, and socio-economic status.

Table 1: Summary of Total Radiation Inventory for Various Settlement Classifications

S/no.	High Density (μT)	low Density (μT)	Medium Density (μT)
1.	5.54	0.38	0.16
2.	8.58	0.14	0.15
3.	3.56	0.12	0.20
4.	6.51	0.21	0.15
5.	3.58	0.96	0.24
6	8.00	0.66	0.19
7	14.77	0.17	0.19
8	3.56	0.21	0.20
9	10.17	0.18	0.22
10	8.01	0.48	0.24

Source: ‘Chechnya’, ‘Investment Quarters’ and ‘Herwagana’

Table 2: ANOVA output for Radiation distribution Pattern

	Sum of Squares	**df**	**Mean Square**	**F**	**P-value**	**Decision**
Between Groups	322.560	2	161.325	38.599	0.000	Significant different
Within Groups	112.847	27	4.180			
Total	**435.497**	**29**				

Source: Author’s analysis (2022)

Occurrence Rate of (EHS) in the Study Area

Result of the occurrence rate of understudied EHS symptoms was analysed for descriptive statistics using SPSS 23, from retrieved responses in the questionnaire and labelled as table 3. The occurrence rate in comparison to the findings in Felix *et al*. (2014) labelled as figure 2. is not similar, while findings from this study shows that sleep disorder with a mean of 3.533 has the highest rate of occurrence, with memory loss at a mean of 2.033 having the lowest rate of occurrence, in Felix *et al* (2014) headaches has the highest rate of occurrence and fatigue is with the lowest occurrence rate.

Surprisingly, fatigues have the 2nd highest rate of occurrence in this study, with a mean occurrence rate of 3.266. This inconsistency between both studies is likely due to the difference in study area, or difference in the methodology employed in each individual study. While this study ensured that the three major settlement classifications were adequately captured, same cannot be inferred for the methodology employed in Felix *et al* (2014).

Table 3: Result of occurrence rate of (EHS) in the Study Area

Occurrence	N	Mean	Std Deviation	Variance	Max	Min
Headache	30	2.9667	.61495	.378	4.00	2.00
Sleep Disorder	30	3.5333	.81931	.671	5.00	2.00
Loss of Appetite	30	2.1667	1.01992	1.040	5.00	1.00
Dizziness	30	2.7000	.95231	.907	5.00	1.00
Memory Loss	30	2.0333	.99943	.999	4.00	1.00
Fatigues	30	3.2667	.73968	.547	5.00	2.00

Source: Author’s Analysis (2022)

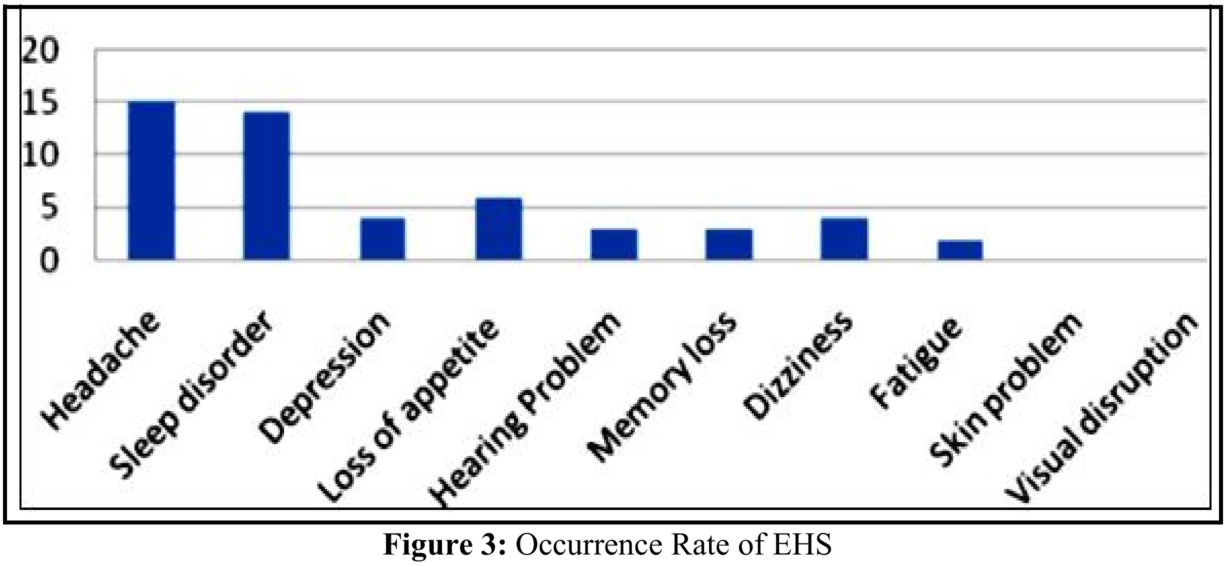

Figure 3: Occurrence Rate of EHS

Source: Felix *et al*. (2014)

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CONCLUSION

From the results obtained in this study, it was concluded that:

1. Radiation distribution pattern varies with settlement type, and is a function of socio-economic status.
2. The occurrence rate of symptoms of EHS in the study area is sleep disorder, fatigues, headaches, dizziness, loss of appetite and then memory loss, in descending order.

This study revealed that human consumption behaviour is an important factor that determines human exposure to various stressors in the environment, in this case radiation from electronic gadgets, as there is a positive correlation between consumption pattern and economic capacity and radiation exposure. The following recommendations were deemed adequate based on findings from the study, thus:

i The need for sensitization of the general public, by relevant stakeholders, e.g. The consumer protection agencies, states ministry and federal ministries of environment, that exposure to radiation from electronic gadgets, is a function of model, age and general state of the gadgets, towards discouraging people on the effect of old modelled and second hand or out-dated electronic gadgets.

ii The need for proper control and certification of second hand imports of electronic gadgets to the markets by relevant agencies such as: the Nigeria Customs, and Standards Organisation of Nigeria SON, towards protecting people from the effects of radiation exposures from this sources.

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