International Journal of Engineering Innovation & Research
Volume 13, Issue 3, ISSN: 2277 – 5668

Assessment of Health Risk Associated with Base Station Mast in Karu, Nasarawa State in Nigeria

K.A. Sauri[1*], W.E. Mangset[2], O.S. Ifeoma[3] and O.J. Matthew[4]
[1,2,3,4]Department of Physics, University of Jos, Jos, Nigeria.
*Corresponding author email id: abednegosauri@gmail.com

Date of publication (dd/mm/yyyy): 15/05/2024

Abstract **– With the growing need for communication and internet technological development of wireless communication and development of networks which allow mobile phone users access to internet and communication, this is accompanied by a rise in mobile base station mast which expands coverage area of network connectivity and signal quality. These masts facilities are most times erected very close to residential area which exposes humans and animals to Radiofrequency (RF) radiation which could cause different health issues like carcinogen (group 2B), memory loss, thermal and non-thermal effect. In this research work, the assessment and evaluation of health risk associated with base station mast in Karu, Nasarawa state as case study was investigated using an electrosmog electromagnetic tester to measure the electric field, magnetic field, power density within the range from 10-100m away from the masts facilities of different network providers (MTN, Airtel, 9mobile, Globacom). The Specific Absorption Rate was evaluated and the results from this study showed that the average SAR for the selected base mast station facilities were within the range of 0.012mW/Kg – 0.16mW/Kg and a power density range between 1..083W/m2-4.855 W/m2 which are lower than the recommended limit by the International Commission for Non-Ionizing Radiation Protection (ICNIRP) (0.08W/Kg) for the SAR and 10 W/m2 for the power density respectively and can be concluded that the results from the study showed that RF radiation from this source poise no significant radiological risk to the general public but can cause thermal and non-thermal effect if exposure is consistent.**

Keywords **– Base Mobile Station Mmast, Electromagnetic Radiation, Specific Absorption Rate, Health Risk, Non-Ionizing Radiation.**

I. INTRODUCTION

With exponential rate of expansion of wireless communication in the world today and mobile networking technology, it is alarming that many studies conducted in more benign environments shows harmful effect from this radiation [1] [2], sees communication as critical in managing the health of any society as it plays an important role in increasing awareness of people on health conditions around. Base stations and cellular phone must forms part of the infrastructure required for an efficient and effective communication system. The general role is that communication tower above 25meters in height should not be permitted within residential areas and according to NESREA, 2011 (National Environmental Standards and Regulation Agency) regulations documents, the distance of foot of mast to a building should be 100m, the fence should be 120m and a generating set should be 80m away from building [3].

The telecommunication market is huge and major economic driver in some countries around the world including Nigeria. In the UK alone, over 22 billion was realized on the sale of licenses to mobile phone industry [4]. Today the advance technological development of wireless communication and the development of 5G network which allows mobile phone users to access internet and communication in Internet of Things (IoT) has advanced the growth of global network for mobile communication applications in GSM and as a result increase in the number of base stations masts since it is technologically impossible to have mobile phones without base stations masts. This wireless communication technology has continue to increase annually with increase in background radiation from it source as a result of emission of EM RF radiation from masts The radiation emitted by the antenna of masts is not ionizing and do not have enough energy to ionize and break chemical

bonds in biological system but, long term exposure to this radiation can be harmful. Some of the biological effects are non-thermal exposure and can affect the cell membrane and people who live or reside in places where telecommunication base station masts are built can experience sleep disorder, cancer and disorder [5]. At the present time, the greatest polluting element in the earth's environment is the proliferation of electromagnetic radiation [6]. It is considered to be greater on global scale, than warming and chemical element in the environment [7]. If radiation dose is low or delivered over a long period of time, there is a great chance of damage cells to successfully repair each other. However, long term effect may still occur if the cell damage is repaired and also transform an irradiated cell that still retains its capacity for cell division. This transformation may result to cancer after some years or even decades. Effects of this type may not also happen but the chance of it occurring is proportional to the radiation dose for which the risk is higher for children and teenager as they are more sensitive to radiation exposure than adults [8] [9]. With erection of cellular telecommunication mast antenna close to residential areas, schools, offices and market affect well being and health of people living close to it which may be thermal or non-thermal effect. The concern to investigate the effect of radiation from telecommunication mast has necessitated the researcher to carry out a comparative research to assess the health risk associated with base station masts in Karu, Nasarawa states of Nigeria.

Considering that more and more mast towers are being approved by government even with the facts that several reports that electromagnetic radiation released by mobile telecommunications, has now become the main man made source of environmental radiation [10] [11]. In Nigeria, the use of mobile phones started in 2001 and this has also prompted the erection of mast to meet the communication demand. These base station masts are mostly located around schools, residential areas, churches, markets, mosques and offices which expose the populace living around such environment to variable levels of electromagnetic fields of RF with respect to distance from the telecommunication base station [12]. The health risk of the RF from GSM base stations use electromagnetic radiation in the microwave range, According to [13], long term exposure or use of cellular phone for greater or equal to 10 years gives a consistent pattern of increased risk is highest for lateral exposure. [14], exposure to RF have effect on two areas of the body like eyes and testes are particularly vulnerable to RF heating because of the relative lack of available blood flow to dissipate the excessive heat load. Although some groups like Mobile Manufacturer Forum (MMF) and (ICNIRP) insist that radiation from base station has no discernible effects on human health.

Since it is nearly impossible to separate mobile phones form human daily routine, the installation of base stations masts by service providers will continue to increase in addition to the presently available ones to meet the demand for high quality services and accessibility needs of the growing number of phone users which results in addition of EM radiation in the human environment and exposure to the general public to the health implication of EM radiation has necessitated this research work despite the fact that the scientific community contentious debate on the effects. The World Health Organization (WHO), International Agency for Research on Cancer (IARC) has classified RF EMFs as possibly carcinogenic to humans, based on an increased risk for glioma, a malignant type of brain cancer [2].

The intensity of electromagnetic field radiation with biological systems is characterized by electromagnetic properties of tissue media, more specifically, the permittivity and permeability and the assessment of EM RF radiation from base stations and mobile phones is based on basic quantities for characterizing RF radiation

energy in power density, electric field E (v/m), magnetic field H (A/M) and Specific Absorption Rate SAR (w/kg) which is an indication of the amount of electromagnetic energy absorbed by the biological tissues [15].

II. Materials and Methods

Materials used for this study include an electrosmog electromagnetic radiation tester, and measuring tape. The electromagnetic radiation meter was used to measure the electric field, magnetic field and power density for the four major GSM providers (MTN, GLOBACOM, 9MOBILE, and AIRTEL) in the study area: Karu, Nasarawa state, Nigeria. Electric field intensity E (V/m), magnetic field intensity H (mA/m) and power density P_d (mW/m^2) measurements were taken first at a distance of 10 m from the base stations by holding the electrosmog radiation tester away from the body and at about 1.5 m above the ground level while pointing the meter towards any of the antenna sectors. Following the same pattern, measurements were taken at distances of 20, 40, 60, 80 and100 m from the base stations.

Study Area

Nasarawa State is located in the North Central region of Nigeria with 13 Local Government Areas and a population of about 2.8 million people. Nasarawa is known to support economic and social development. The geographic coordinates of the state are8º31'N and 7º 43'E. A total of 7 base stations were selected randomly in some populated areas in Karu, Nasarawa such as Ado and New Nyanya located in an environment with high population density within a residential area. These base stations belong to MTN, GLOBACOM, 9MOBILE and AIRTEL network providers.

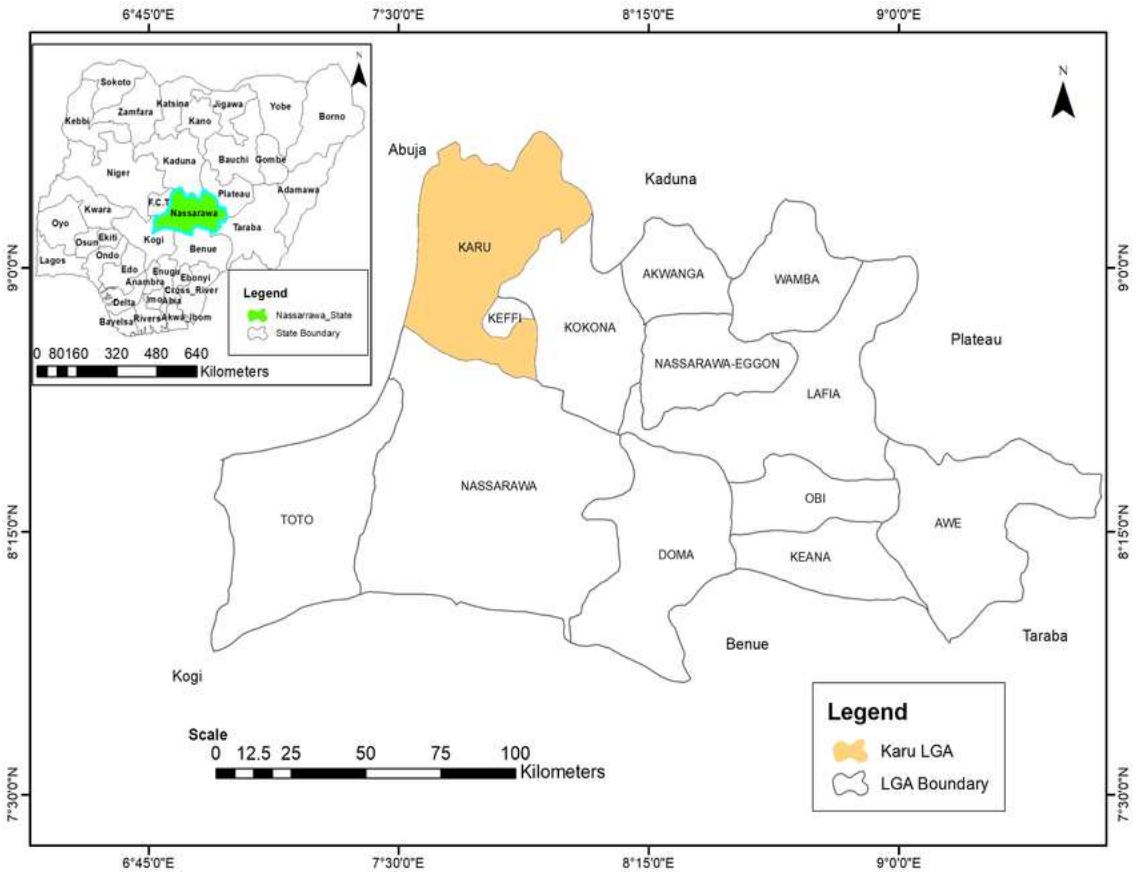

Fig. 1. Showing the map of the study location [16].

Specific Absorption Rate (SAR))

To obtain the relative amount of radio frequency energy absorbed by a body, the Specific Absorption Rate (SAR) is further computed using the formula below [17];

$$SAR = \frac{Pd \times Hsa}{WA} \quad (1)$$

Where:

Pd = power density ($W.cm^{-2}$),

H_{sa} = human surface area (20,128.99 cm^2),

W_A = Weight of Average human (60 kg).

III. RESULTS

Table 1. The Electric field strength E (V/m) associated with the MBS for the major network providers.

Network Provider	Location	Statistical Parameter	10m	20m	40m	60m	80m	100m
MTN	Ado	Min	1.279	1.025	1.113	1.016	1.122	1.022
		Max	1.531	1.437	1.209	1.198	1.153	1.072
		Average	1.405	1.231	1.161	1.107	1.1375	1.047
AIRTEL	New	Min	1.24	1.217	1.168	1.133	1.094	1.012
	Nyanya	Max	1.451	1.319	1.276	1.152	1.136	1.125
		Average	1.3455	1.268	1.222	1.1425	1.115	1.0685
GLOBACOM	Ado	Min	1.475	1.119	1.276	1.034	1.019	1.012
		Max	1.976	1.621	1.441	1.226	1.346	1.373
		Average	1.7275	1.37	1.3585	1.13	1.1825	1.1925
9MOBILE	New		1.478	1.321	1.145	1.126	1.046	1.073
	Nyanya							

Table 2. The Magnetic field strength H (mA/m) associated with the MBS for the major network providers.

Network Provider	Location	Statistical Parameter	10m	20m	40m	60m	80m	100m
MTN	Ado	Min	1.797	2.489	1.653	1.143	1.215	1.125
		Max	2.719	2.719	1.653	1.43	1.346	1.425
		Average	2.258	2.604	1.653	1.2865	1.2805	1.275
AIRTEL	New	Min	1.635	1.459	1.431	1.348	1.215	1.209
	Nyanya	Max	3.307	2.841	2.349	2.425	1.898	1.286
		Average	2.471	2.15	1.89	1.8865	1.5565	1.2475

Network Provider	Location	Statistical Parameter	10m	20m	40m	60m	80m	100m
GLOBACOM	Ado	Min	3.366	2.743	3.386	2.725	1.198	1.78
		Max	3.738	3.375	3.436	3.11	2.78	3.03
	New	Average	3.552	3.059	3.411	2.9175	1.989	2.405
9MOBILE	Nyanya		3.038	2.775	2.436	2.11	1.78	1.43

Table 3. The Power density P_d(mW/m²) values associated with the MBS for the major network providers.

Network Provider	Location	Statistical Parameter	10m	20m	40m	60m	80m	100m
MTN	Ado	Min	2.488	2.17	1.115	1.008	1.033	1.007
		Max	2.788	2.27	1.165	1.108	1.133	1.051
		Average	2.638	2.22	1.14	1.508	1.083	1.029
AIRTEL	New	Min	2.305	1.348	1.304	1.3	1.292	1.059
	Nyanya	Max	4.67	3.316	3.122	2.376	1.734	1.248
		Average	3.875	2.332	2.213	1.838	1.513	1.1535
GLOBACOM	Ado	Min	4.281	2.366	3.803	2.963	1.031	1.742
		Max	5.43	3.679	4.322	3.076	2.534	2.643
	New	Average	4.8555	3.0225	4.0625	3.0195	1.7825	2.195
9MOBILE	Nyanya		3.481	1.679	2.903	1.368	2.238	1.243

Table 4. Showing the Average power density P_d(mW/m²) values and SAR(mWkg^{-1}) for the MBS of the major network providers.

Network Provider	Location	Av. Pd (W/m²) vs. SAR Values (mWKg-1)	10m	20m	40m	60m	80m	100m
MTN	Ado	Av. P_d	2.638	2.22	1.14	1.508	1.083	1.029
		SAR	0.0885	0.07381	0.03824	0.05059	0.03633	0.03452
AIRTEL	New	Av. P_d	3.875	2.332	2.213	1.838	1.513	1.1535
	Nyanya	SAR	0.01299	0.07823	0.07424	0.06166	0.05076	0.0387
GLOBACOM	Ado	Av. P_d	4.8555	3.0225	4.0625	3.0195	1.7825	2.195
		SAR	0.1629	0.1014	0.1363	0.1013	0.05979	0.07363
9MOBILE	New	Av. P_d	3.481	1.679	2.903	1.368	2.238	1.243
	Nyanya	SAR	0.11678	0.05633	0.09739	0.04589	0.07508	0.0417

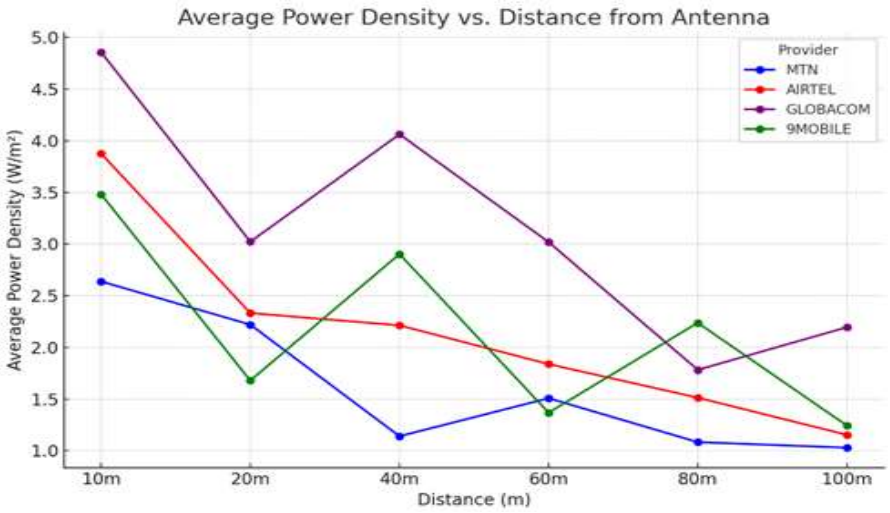

Fig. 2. Showing aplot of the average power density values (mW/m^2) for the different mobile networks at Karu in Nasarawa State.

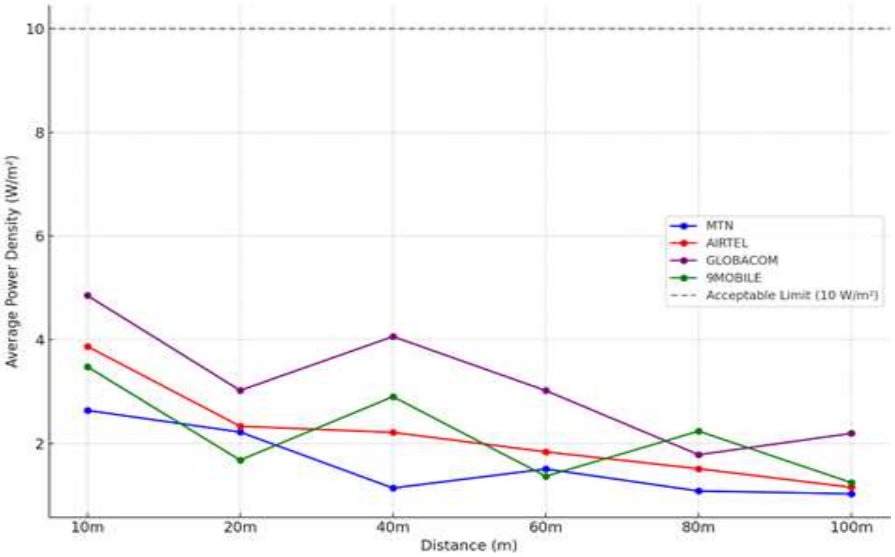

Fig. 3. Showing the power density and the recommended acceptable limit.

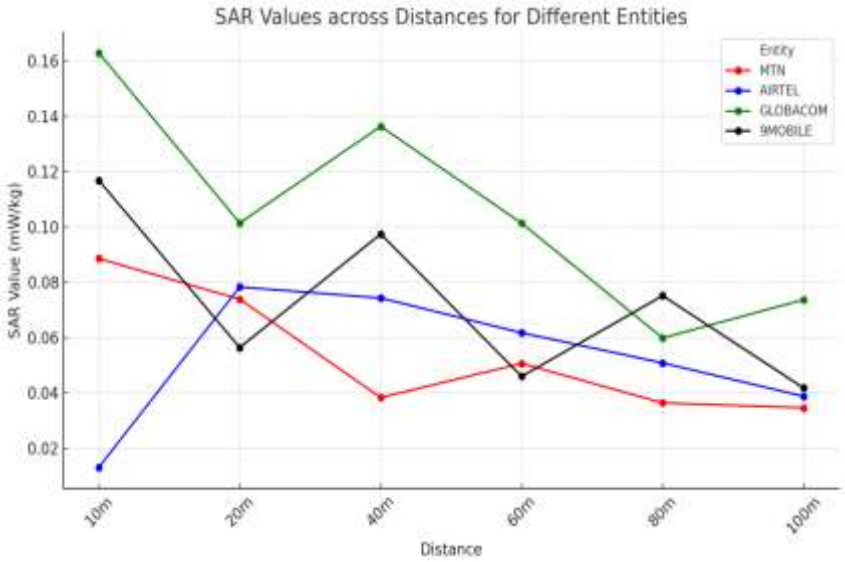

Fig. 4. Showing the SAR values for the different mobile networks to the distance of measurement.

IV. DISCUSSION

The relatively high values of power density and SAR were obtained from the GLOBACOM masts in Ado road while the least was observed in MTN as shown in figure 2, 3 and 4 above which may be as a result of radiation from other electronic sources as the masts is very much situated very close to clustered residential area and an active place of Christian worship named Mountain of Fire. Members of the public who visit this institution. The average SAR from the selected base mast station facilities were within the range of 0.012mW/ Kg–0.16mW/Kg and a power density range between 1.083W/m^2–4.855 W/m^2 which are lower than the recommended limit by the ICNIRP (0.08W/Kg) for the SAR and 10W/m^2 for the power density respectively and can be concluded that results from the study showed that RF radiation from this source poise no risk but can cause thermal and non-thermal effect if exposure is consistent.

According to [18], the acceptable threshold for radiofrequency electromagnetic radiation is 61 V/m for Electric field intensity and 0.16A/m for Magnetic field intensity. The general public exposure from all the considered mobile base stations fall very well within this threshold and so there is no cause for alarm. This means that the power density released by the MBS under review are below the limit as illustrated in figure 2. It is however important to note that some epidemiological studies reported that exposure to RF EMF below ICNIRP exposure limits are statistically linked with more frequently diagnosed cancer diseases. Comparing the electromagnetic field exposure from the masts under review in this study with the restrictions by the International Commission on Non-ionizing Radiation Protection [19] for both occupational and general public, ranging between 0.08 to 0.4Wkg^{-1} for the whole body SAR. The decreasing power density with distance agrees with the report by [20] on a similar research work done in Kaduna State situated exactly north of Nasarawa State. It is however recommended that this low level is maintained to avoid health problems in the future.

V. CONCLUSION AND RECOMMENDATION

In conclusion, the research shows that the electromagnetic field exposure from the mobile base stations of the network providers under review can be termed as ‘safe’ as the radiation emitted are relatively low with respect to the generally accepted limits according to International Commission on Non-ionizing Radiation Protection (ICNIRP). In addition, the SAR values obtained is below the restriction level for both occupational and general public consumption, ranging between 0.08 to 10 Wkg^{-1}. Hence, the residents of the area where the MBS are situated are not at risk of health hazard.

Further research should be carried out using small animal model (wistar rats) which has almost similar biological tolerance to study the direct effect of exposure of this radiation under controlled condition in order to investigate the health risk associated.

REFERENCES

[1] Melnick, R. “Regarding ICNIRP’S evaluation of the national toxicology program’s carcinogenicity studies on radiofrequency electro--magnetic fields”. *Health Physics*, *118*(6), 2020, 678-682.
[2] WHO. Health literacy. The solid facts kickbunch, pelican J.M., Apfel F, and tsouors A.D, (EDS). Denmark. WHO regional office of Europe. Retrieved from http;//www.euro.who.int/pubrequest, 2013.
[3] Akin A.O. and Ademiji, location adequacy of telecommunication mats and residents liability in Osogbo, Nigeria. Information Journal of Research Applied Sciences [RCU], 2014, 7-16.
[4] Eileen O.C. Cancerative: Trustee for EM-Radiation Research Trust: 2005. http://www.radiationresearch.org
[5] Ijabor, B.O., Nwabuoku, A.O., Izediunor, V.C., Odene, C.C., Agbonaye, I., Ebite, E.C., & Elumeshike, C.S. Assessment of Radiation Risk from Selected Telecommunication Base Station in Ogwashi-Uku, Delta State, Nigeria. *Open Access Library Journal*, *10*(3), 2013, 1-12.

[6] Singh, S., & Kapoor, N. Health implications of electromagnetic fields, mechanisms of action, and research needs. *Advances in biology, 2014*.
[7] Singh, S., & Kapoor, N. (2014). Health implications of electromagnetic fields, mechanisms of action, and research needs. *Advances in biology*, *2014*.
[8] ICRU (International Commission on Radiation Units and Measurements). Conversion coefficients for use in radiological protection against external radiation. Report 57, 1998.
[9] NCRP (National Council on Radiation Protection and Measurement). Risk estimates for radiation protection. NCRP Report No. 115. Bethesda (MD), USA, 1993.
[10] Andrew, G. (2008). The Cell Phone and the Cell. Proceedings of the 1st Hellenic Congress on the effects of Electromagnetic Radiation with International Participation, Thessalonica, pp 30.
[11] IEEE. Standard for safety levels with Respect to Human Exposure to RF Electromagnetic Fields 3 kHz to 300 GHz. IEEE Std. C95.1-1999.
[12] Felix, U., Gregory, O., Oghenevovwero, E., & Chinelo, A. Risks associated with radio-frequency radiation exposure at close proximities to mobile phone base stations in Port Harcourt, Rivers State, Nigeria. *Current Journal of Applied Science and Technology*, 2017, *24*(3), 1-8.
[13] Lennart, H., Michael, C., Fredrick, S., Kjell, HM. and Morgan, L. Long-term use of cellular mobile phone and brain tumor; increased risk associated with use greater or equal to 10 years. *Journal of Occupational Environmental Med*, 2007.
[14] Hyland, GJ. How exposure to GSM base Station can advertly affects Human, Department of Physics International Institute Biophysics University of Warwick Neuss-Helzhein Coventry, 2000.
[15] Akpolile, A.F., & Ugbede, F.O. Assessment of radiofrequency radiation levels of mobile phones and evaluation of specific absorption rate to tissues of human head layers. *Federal University Wukari Trends in Science and Technology Journal*, *4*(3), 2019, 643-650.
[16] Ezeamaka K., & Bala D. Profiling the characteristics of Karu slum, Nasarawa state, Nigeria. *Journal of Service science and management (12), 2019, 605-619*
[17] Briggs-Kamara, M.A., Funsho, B.I., & Tamunobereton-Ari, I. Assessment of Radiofrequency Exposure from Base Stations in Some Tertiary Institutions in Rivers State, Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS), 4*, 2018, 188-200.
[18] Abdulsalam, M., Bello, S., Sumaila, S., A., Abubakar, H., Muhammad, I., B., Muhammad, B.G. & Sabiru, A.Y. Health hazards associated with electric and magnetic field intensities around mobile base stations in Katsina State, *Nigeria. Journal of Applied Sciences and Environmental Management, 24 (2), 2021, 253-256. doi:10.4314/jasem.v24i2.10*
[19] International Commission on Non-ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300GHz). *Health Phys. 74(4), 1998, 494-522, www.icn.rp.de*
[20] Garba, N.N., Umar, S & Zakari, Y.I. Assessment of radio-frequency radiation exposure from selected mobile base stations in Kaduna state, Nigeria. *Nigerian Journal of Scientific Research 16 (2) 2015, 184-186.*

AUTHOR'S PROFILE

First Author
Kargwak Abednego Sauri, is a graduate of physics from the University of Jos, Nigeria, where he obtained his Bachelor degree in 2019 and Masters degree (2024) in General and applied physics. He is an aspiring radiation and biophotonics physicist interested in the study of the effect of radiation and light on biological tissues. His research interest spans from radiation physics, biophotonics, and biophysics**.** He is passionate abour research in his field of interest and acquiring new computational skills for analysis in this field.

Second Author
Williams Emmanuel Mangset, is a Professor of Physics at the prestigious, University of Jos, Jos Nigeria where he obtained his Bachelors, Masters and PhD degree in Radiation Biophysics. His research interest is specialized in areas of Radiation biophysics and medical physics and posses numerous research publication in this fields in his Attempt to understand radiation effect on biological tissues and humans in his name. He has supervised numerous masters and PhD research within his field of interest within and outside the University in Nigeria and has also collaborator with numerous local and international research in different project and research. email id: Edaci2001@gmail.com

Third Author
Okoyeibe Ifeoma, is a dedicated researcher and academic professional with a fervent interest in advancing knowledge and contributing to meaningful discoveries in the field of Physics. She graduated with a Bachelor in Physics in July, 2023 and has since volunteered in practical and theoretical works in fields ranging from radiation dosimetry, Geophysics to Astrophysics. She possesses diverse skill set, including data analysis, and scientific writing, as well as strong written and verbal communication skills and is adept at presenting complex scientific concepts to diverse audiences. She has research interests in a wide range of topics within the aforementioned fields. email id: okoyeibeifeoma@gmail.com

Fourth Author
Ogye Matthew John, is a graduate of Physic from the University of Jos, Nigeria. He hails from Nasarawa state, Nigeria. He intern at the Radiology Department of Jos University Teaching Hospital, Nigeria in 2018, cause of his strong passion for medical and health physics: the had had experience in many aspects of Medical and Radiation Physic, after which I decided to make it my area of research interest. He is currently a teaching assistant with College of Agriculture, Science and Technology, Lafia, Nasarawa state, Nigeria. He is passionate about advancing knowledge in this field and I am dedicated to teaching the next generation of scientists. email id: Johnmatthewogye@gmail.com