



Health Implications Emanating From Electromagnetic Radiation Through The Use of Cell Phones: A Case Study of Aba-South LGA of Abia State, Nigeria

G.U. CHUKWU*¹, N.N. ELUWA² and G.I. KANU¹

¹Department of Physics,
Michael Okpara University of Agriculture, Umudike-Umuahia, Nigeria

²Dept. of Physics/Geology/Geophysics,
Federal University, Ndufu Alike Ikwo, Abakaliki, Nigeria

*Corresponding Author's E-mail & Phone Number: chukwug@yahoo.com, +2348025691478

ABSTRACT

The effect of cell phone radiation on human health is the subject of recent interest and study as a result of the enormous increase in cell phone usage throughout the world today. Cell phone uses electromagnetic radiation in the microwave range. The aim of the work is to determine the health implications emanating from electromagnetic radiation on the human body through the use of cell phones. The work was carried out within Aba-South Local Government Area of Abia State, Nigeria. Questionnaire was used to carry out the research which was designed in line with the Likert rating scale and analyzed using statistical methods, Chi-square and Anova tests to test for independence. Bar chart was also used to show comparative figures. The test showed that cell phone device has some effects on human body such as headache, fatigue, burning sensation on the facial skin, low sperm count and Alzheimer's disease. The effect of these problems can be long term or short term. At present the mobile phone technology is being increasingly used with almost no effective precautionary measure or advice to the public and urgent guidance is needed in order to alert the public about the inherent dangers of exposure to electromagnetic radiation.

Keywords: Electromagnetic radiation, cell phone, Likert rating scale, health hazards, biological systems.

1. INTRODUCTION

Electromagnetic Field (EMF) and waves are important and main media to carry signals from a certain source to the desired destination; this signal can be voice, data or image (Mousa, 2011). The EMF is propagating at the speed of light in free space (300,000 km/s) so it can be modulated, transmitted and received while conveying the necessary information (Mohana et al., 2002). Electromagnetic Radiation (EMR) is a form of energy emitted and absorbed by charged particles, which exhibit wave-like behavior as they travel through space (Wikipedia, 2012). The effects of EMR (Wiki, 2014) upon biological systems depend upon the radiation's power and frequency. For lower frequencies of EMR up to those of visible light (i.e., radio, microwave, infrared), the damage done to cells and also many ordinary materials under such conditions is determined mainly by heating effects, and thus by the radiation power. By contrast, for higher frequency radiations at ultraviolet frequencies and above (i.e., X-rays and gamma rays) the damage to chemical materials and living cells by EMR is far larger than that done by simple heating, due to the ability of single photons in such high frequency EMR to damage individual molecules chemically (Wikipedia, 2012).

Cell phone technology has revolutionized the telecommunication scenario in the world and more especially in the developing nations. Due to its several advantages especially in the increasing number of

application benefits, cell phone technology has grown exponentially in the last decade. One could chat with relatives, school mates, colleagues etc. from home or any place, watch real-time events, listen to radio and music, pay for goods and services, read books and online news, monitor and control processes and many more using the cell phone. In 2010, some estimates stated that there were more than fifty (50) million cell phone users and nearly 4.4 thousand cell phone towers to meet the communication demand (Girish, 2010).

Currently the number has increased tremendously due to the reduced price of the cell phones and its portability. Every home is recording at least one cell phone per person; kids in primary and secondary schools are allowed to have their phones with them especially in some developing countries such as Nigeria because of security reasons. Every cell phone has a SAR (Specific Absorption Rate) rating which has a limit of 1.6 W/kg and it is calculated to be 6 minutes (360 seconds) per day usage for a person. Considering the SAR limit, a person should not make use of cell phone for more than 24 minutes (1440) seconds for each call, following the safety standards. Unfortunately, majority of the cell phone users do not have this information, as a result many people make cell phone calls for more than an hour in each call without knowing the health implications related with this issue. The aim of this study is to determine the inherent dangers of cell phone usage and therefore warn the general public to avoid rapid and constant exposure to cell phone use.

This work is carried out within Aba-South Local Government Area of Abia State, Nigeria; the problem experienced by people living in Aba can equally be experienced by people living in any other place within the globe because the mode and mechanism of operation of the gadget is the same everywhere.

2. MATERIALS AND METHODS

Primary sources were used for the study. The survey was carried out in Aba-South LGA of Abia State with the help of questionnaires. The questionnaires were designed to elicit information from respondents. In this study, the population was made up of 200 individuals basically cell phone users like students, businessmen, service holders (customer care representatives) and the general public. The instrument was designed in line with the likert type of rating scale namely, strongly agreed (SA), agreed (A), undecided (UD), disagreed (D) and strongly disagreed (SD) with 5 rating scale. The instrument for data collection underwent face-to-face validation.

The methods of analysis used in this study are Test for independence (chi-square test). The chi-square tests were used to determine whether or not two criteria of classification are independent of each other or not. The contingency tests were used for the classification as shown in Table 1. Contingency classification of attributes or events on cell phone to that of effect on human being like headache, loss of memory, etc.

The general model is given as

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^c \frac{(o_{ij} - e_{ij})^2}{e_{ij}} \quad \dots 1$$

Where o_{ij} is the number of observation in the row and column as shown in Table 1.

e_{ij} is the expected frequency

$$\text{where } e_{ij} = \frac{R * C}{N}$$

Where R = is the row total

C = is the column total

N = is the total number of observations

Secondly, the mean, standard derivation and the standard Error of mean between groups like (SA, A, UD, SD and D) were also computed as shown in Table 7. However, chart of component and compound bar chart were also used to determine the magnitude of the item statement who Strongly Agreed, Agreed, Undecided, Disagreed and Strongly Disagreed and equal compare the proportion of people who SA, A, UD, SD, D and so on, that cell phone has effect on human being.

The formula for mean is $\bar{X} = \sum_{i=1}^n \frac{x}{N}$

Furthermore ANOVA Single factor (one – way Analysis of Variance) were used to determine the effect of cell phone radiation emission on human being, and equate their known change effect variation on the population.

Finally a post-test was computed since the ANOVA test was significant. This post-test was used to determine the group of people who strongly agreed (SA), agreed (A) or undecided (UD), which is different from the groups as shown in Table 13.

3. RESULT AND DISCUSSION

The presentation and analysis of the data collected were analyzed in order to determine the effect of cell phone on human being and also to know whether the cell phone has a dependent or an independent effect on those item statement such as burning sensation on the facial skin, headache, etc.

MINITAB Version 11.21 was used to run the analysis and plot the graph of the original data.

Table 1: Shows the Number of People Who Strongly Agreed (SA), Agreed (A), Undecided (UD), Disagreed (D), and Strongly Disagreed (SD) (i.e. the Response Statement)

ITEM STATEMENT	SA	A	UD	D	SD	Total Row
Burning sensation on the facial skin	40	20	70	30	40	200
Headache	70	30	55	35	10	200
Fatigue	60	20	70	30	20	200
Warming of ear	51	70	49	15	15	200
Blurry vision	49	51	60	33	7	200
Memory loss	30	40	80	30	20	200
Ear aches	59	61	40	30	10	200
Sleep disturbances	60	40	62	30	8	200
Neck pain	31	69	70	20	10	200
No effect	10	20	40	70	60	200
Total	460	421	596	323	200	2000

It was also used to estimate the parameters like chi-square, analysis of variance, and post-test.

Table 2: Observed Number of Expected Count of Response Statement and Chi-Square

O _{ij}	E _{ij}	(O _{ij} -E _{ij}) ² /E _{ij}
40	46.000	0.783
20	42.100	11.601
70	59.600	1.815
30	32.300	0.164
40	20.000	20.000
70	46.000	12.522
30	42.100	3.478
55	59.600	0.355
35	32.300	0.226
10	20.000	5.000
60	46.000	4.261
20	42.100	11.601
70	59.600	1.815
30	32.300	0.164
20	20.000	0.000

51	46.000	0.543
70	42.100	18.49
49	59.600	1.885
15	32.300	9.266
15	20.000	1.250
49	46.000	0.196
51	42.100	1.881
60	59.600	0.003
33	32.300	0.015
7	20.000	8.450
30	46.000	5.565
40	42.100	0.105
80	59.600	6.983
30	32.300	0.164
20	20.000	0.000
59	46.000	3.674
61	42.100	8.485
40	59.600	6.446
30	32.300	0.164
10	20.000	5.000
60	46.000	4.261
40	42.100	0.105
62	59.600	0.097
30	32.300	0.164
8	20.000	7.200
31	46.000	4.891
69	42.100	17.188
70	59.600	1.815
20	32.300	4.684
10	20.000	5.000
10	46.000	28.174
20	42.100	11.601
40	59.600	6.446
70	32.300	44.003
60	20.000	80.000
2000	2000	367.979

Statement Hypotheses.

Ho: The effect of cell phone is independent.

H₁: The effect of cell phone is not independent.

Test statistics is

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^c \frac{(o_{ij} - e_{ij})^2}{e_{ij}} = 367.979$$

Where $e_{ij} = \frac{R_i \times C_j}{N}$

Where R_i= row total of the ith row

C_j= column total of the jth column

N= grand total.

Where O_{ij} is the observed frequency of the individual

And e_{ij} is the expected frequency of the e_{ij}^{th} cell with the formula:

$$E_{11} = \frac{R_1 * C_1}{N} = \frac{200 * 460}{2000} = 46.00$$

$$E_{13} = \frac{R_1 * C_3}{N} = \frac{200 * 596}{2000} = 59.60$$

$$E_{14} = \frac{R_1 * C_4}{N} = \frac{200 * 323}{2000} = 32.3$$

And so on.

Decision Rule:

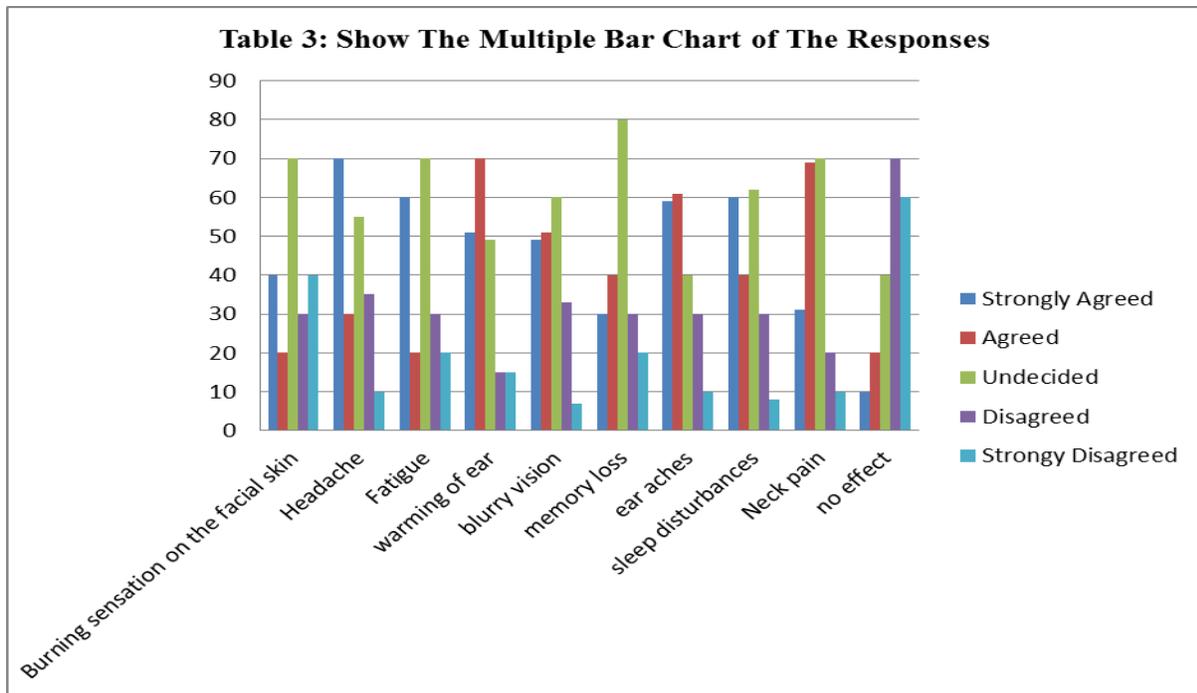
Reject H_0 if $p < 0.05$ otherwise accept at $\alpha = 0.05$ with degree of freedom $v = (r-1)(i-1)$.

Conclusion:

Since p -value is $0.000 < 0.05$ we reject the H_0 and conclusion that effect of cell phone are not independent of the responses.

In order words the cell phone device has some effect on human beings such as causing Head ache, warming of the ears, fatigue and so on. Note that the χ^2 that were used in this study following the assumption below

- 1 That the individual observation must be independent of each other, row and column are also independent.



Here, it is observed that the population of people who were affected by warming of ear, head-ache, ear-ache are of a greater number than others.

Table 4: Shows the Mean, Standard Deviation, The Standard Error Of Mean And Total Number Of Observation Of Each Column

Item Statement	Strongly agreed	Agreed	Undecided	disagreed	Strongly disagreed
Burning sensation on the facial skin	40	20	70	30	40
Headache	70	30	55	35	10
Fatigue	60	20	70	30	20
warming of ear	51	70	49	15	15
blurry vision	49	51	60	33	7
memory loss	30	40	80	30	20
ear aches	59	61	40	30	10
sleep disturbances	60	40	62	30	8
Neck pain	31	69	70	20	10
no effect	10	20	40	70	60
Mean	46	42.1	59.6	32.3	20
Standard deviation	18.20866704	19.886	13.5334975	14.552968	17.12048805
SEM(standard Error of mean)	5.758086102	6.2883	4.27966769	4.6020527	5.41397369
total number of observation N	10	10	10	10	10

Table 5: Summary

Groups	Count	Sum	Average	Variance
Strongly agreed	10	460	46	331.5556
Agreed	10	421	42.1	395.4333
Undecided	10	596	59.6	183.1556
Disagreed	10	323	32.3	211.7889
Strongly disagreed	10	200	20	293.1111

Table 6: Shows the ANOVAs Table
ANOVA

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	8838.6	4	2209.65	7.807705	0.000072	2.578739
Within Groups	12735.4	45	283.0089			
Total	21574	49				

Test of hypothesis:

$$H_0 = \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$$

H_1 = not all mean are equal.

$$\text{Test statistic } E_{\text{cal}} = \frac{\text{MSS}}{\text{MSE}} = \frac{2209.65}{283.0089} = 7.807705$$

When MSS is mean sum of square between groups at α 0.05 i.e. 95% is mean sum of square error with the group.

If $E_{\text{cal}} > F_{\text{tab}}$ we reject H_0 otherwise accept

$$\text{Correction} = C = \frac{(2000)^2}{80} = 5000$$

$$\text{Where Total SS} = 40^2 + 20^2 + 70^2 + \dots + 60^2 - C$$

$$= 21574$$

$$\text{Total SS between group} = \frac{421^2 + 596^2 + 328^2 + 200^2 - C}{10} = 888.6$$

Table 7: Shows the Comparison Test Between SA vs A

t-Test: Two-Sample Assuming Equal Variances

	<i>Strongly agreed</i>	<i>Agreed</i>
Mean	46	42.1
Variance	331.5555556	395.4333333
Observations	10	10
Pooled Variance	363.4944444	
Hypothesized Mean Difference	0	
Df	18	
t Stat	0.457404803	
P(T<=t) one-tail	0.326426379	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.652852758	FALSE
t Critical two-tail	2.100922037	

Table 8: T-test of Two-sample assuming equal variances

	Strongly agreed	Undecided
Mean	46	59.6
Variance	331.5555556	183.1555556
Observations	10	10
Pooled Variance	257.3555556	
Hypothesized Mean Difference	0	
Df	18	
t Stat	-1.895645554	
P(T<=t) one-tail	0.037090069	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.074180139	FALSE
t Critical two-tail	2.100922037	

Table 9. t-test of two sample assuming equal variances

	<i>Strongly agreed</i>	<i>disagreed</i>
Mean	46	32.3
Variance	331.5555556	211.7888889
Observations	10	10
Pooled Variance	271.6722222	
Hypothesized Mean Difference	0	
Df	18	
t Stat	1.858587242	
P(T<=t) one-tail	0.039758304	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.079516607	FALSE
t Critical two-tail	2.100922037	

Table 10. t-test of two sample assuming equal variances

	<i>Strongly agreed</i>	<i>Strongly disagreed</i>
Mean	46	20
Variance	331.5555556	293.1111111
Observations	10	10
Pooled Variance	312.3333333	
Hypothesized Mean Difference	0	
Df	18	
t Stat	3.289646123	
P(T<=t) one-tail	0.002036664	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.004073328	TRUE
t Critical two-tail	2.100922037	

Decision if $p < 0.01$ is true showing that is significant. Therefore, here the data is significant.

Table 11. t-test of two sample assuming equal variances

	<i>Agreed</i>	<i>Undecided</i>
Mean	42.1	59.6
Variance	395.4333333	183.1555556
Observations	10	10
Pooled Variance	289.2944444	
Hypothesized Mean Difference	0	
Df	18	
t Stat	-2.300662979	
P(T<=t) one-tail	0.016791525	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.033583051	FALSE
t Critical two-tail	2.100922037	

Table 12. t-test of two sample assuming equal variances

	<i>Agreed</i>	<i>disagreed</i>
Mean	42.1	32.3
Variance	395.4333333	211.7888889
Observations	10	10
Pooled Variance	303.6111111	
Hypothesized Mean Difference	0	
Df	18	
t Stat	1.257628143	
P(T<=t) one-tail	0.112299157	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.224598314	FALSE
t Critical two-tail	2.100922037	

Table 13 t-test of two sample assuming equal variances

	<i>Agreed</i>	<i>Strongly disagreed</i>
Mean	42.1	20
Variance	395.4333333	293.1111111
Observations	10	10
Pooled Variance	344.2722222	
Hypothesized Mean Difference	0	
Df	18	
t Stat	2.663337993	
P(T<=t) one-tail	0.007917924	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.015835849	FALSE
t Critical two-tail	2.100922037	

4. CONCLUSION

The use of cell phone is increasing tremendously day-by-day but most people (who use cellular phone) have no knowledge how the cell phones impact on human health. It is almost clear from the research that the radiation from cell phone is responsible for many diseases like brain tumor, headaches, short-term memory loss, different types of heart diseases etc.

In the presence of various RF sources, including cell phone handsets and broadcast antennas which contribute the overall environmental exposure has become a great concern about safety of this new technology and as well as human health. However we should contribute more efforts to transform mobile radio communication to an efficient, secure and convenient system useful for the welfare and positive advancement for the global society. And for this the Government and should take necessary steps for the mobile industry with proper regulations. There should be a new focus for Government to address EMF issues: Currently the Government has divided responsibility for EMF among a number of agencies.

5. RECOMMENDATIONS

The following recommendations are directed at the government:

The government, its policy makers and regulators, should take a more proactive role in providing health advice in relation to EMF and managing this issue through a single agency. This agency should be established and properly resourced with a mandate to cover the electromagnetic radiations from cell phones.

Ideally this agency should:

- Have a mandate to cover all radiations and fields in the electromagnetic spectrum.
- Provide advice to local and central government, and other public bodies, on all appropriate radiation issues. This includes advice on regulations and standards for the safe use of cell phones.
- Provide information to the general public and the media on health and safety aspects of radiation the electromagnetic radiations from cell phones.
- Monitor radiation exposures to the public.
- Conduct or manage research on radiation health and safety issues
- Make more research to better communications;
- Greater availability of data on phone emission levels by providing information materials on exposures to dangerous radiation produces materials especially cell phones substandard batteries.
- Encouragement of continued reduction of RF transmission levels used by phones; by improving design of hands-free kits, making greater provision of hands-free kits, and a greater encouragement to use hands-free kits.

- The government should provide an outright ban of fairly used equipment being imported because this might be an avenue for manufacturers to dispose-off gadgets that failed standard test abroad.

Role of Individuals

- Habitual users of cell phones must learn to use their gadgets safely.
- Needless calls can be reduced to limit the call hours per day considerably and also to discourage unhealthy sedentary habits.
- Avoid using phones in areas where the signal is poor because a weak signal from the base station causes modern handsets to increase their broadcast power.
- Children should be protected from increased RF exposure.
- Individuals should never use cell phones while driving.
- Consumers are advised to use hands-free materials and gadgets to limit exposures from direct contact to the head and body.

Role of Manufacturers/Service Providers

- The cell phone manufacturers should provide information services on this issues. I.e. possible health hazards of RF energies.
- Cell phone manufacturers should provide Sponsorship programs in universities for research on RF fields as being done in sports and social activities.
- Meet safety standards for the public.
- Manufacturers should improve network services because irregular services increase the amount of RF emission of handsets.

It is shown, in this research that electromagnetic waves as well as the electromagnetic radiation that is given out by some of the equipment we use, create negative effects on biological systems of humans. Moreover; it had concluded that there are roles of molecular pathways such as oxidative stress on electromagnetic field induced diseases. These effects are the short term effects and long term effects. Decreasing of the area of vision, heavy stress and feeling of tiredness, loosing of concentration and attention, voices in the ears and warming of ears, reversible hearing problems, headache, burning sensation on the facial skin and such can be seen as the short term effects. The long term effects that are commonly encountered are; irreversible hearing problems, damaging of the embryonic development, increasing risk of miscarriage, decrease in the number of sperms, damaging of the brain tissue leading to brain tumors, heart and kidney related problems, cancer, weakening of the memory, lymphoma, and damaging of the genetic structure.

Besides; some antioxidants exhibits a protective effect on EMF induced impairment. From a public health perspective, manufacturers who sell these products have a lot of responsibilities. As expectedly, each device comes with a manual. While manuals provide instructions on how to operate the product, they also provide preventive information on side effects. Especially kids have to be informed and educated about these kinds of products. We have to be smart buyers when we purchase phones. Especially we should pay attention to cell phone's radiation levels. Hence, public sensitivity to these issues is a necessity and preventative measures should be high priority and risks should be minimized.

REFERENCES

- Bakshi, U,A, Godse A,P (2009); Basic Electronic Engineering Technical. Publication.vol1 (2) pp:8-10
- Cardis, (2007); The Interphone Study: Design, Epidemiological Methods, and Description of the Study Population. *European Journal of Epidemiology*.
- Cellular Base Stations in Nablus. *Journal of Engineering Science and Technology Review*, 4(1) 35-42. Communication. pp: 1 -14.
- Condon, J.J. (2008); *Essential Radio Astronomy*. A Journal of national radio astronomy observatory.
- Cox, D.R. (2003); Communication of Risk: Health Hazards From Mobile Phones. *Journal of Royal Statistical Society: Series A (Statistics in Society)* 166: 241-245.

- Feynman, R., Leighton, R. and Sands, M. (1963); *The Feynman Lectures on Physics, Vol.1.* Australian Journal of Basic and Applied Science.
- German, K. (2011); *Report on Cities and States Consider Cell Phone Radiation Laws.*
- Girish K., (2010); *Radiation Hazards from Cell Phones/ Cell Towers.*
- Gonzalez, M. M., Goodman, J. A., Hays, E. and Hoffman, C. M. (2007); "Discovery of TeV Gamma-Ray Emission from the Cygnus Region of the Galaxy". *The Astrophysical Journal* p 658
- Grupen, C., Cowan, G., Eidelman, S. D. and Stroh, T. (2005); *Astroparticle Physics.* p109.
- Hsermann, D.M. and Hossmann, K.A. (1997); *Neurological Effects of Microwave Exposure Related to Mobile Phones.*
- Herschell, (2012); *Herschell Discovers Infrared Light. A journal of physical sciences* pp: 2-25
- Hyland, G.J. (2000); *Physics and Biology of Mobile Telephone.* Vol 356(9244): 1833-1836.
- ICNIRP (1998); *International Commission on Non-Ionizing Radiation Protection - Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz).* 74, 494-522 November 22, 2013)
- Jensh, R.P. (1997); *Behavioral Teratology Studies Using Microwave Radiation: Is There an Increased Risk from Exposure to Cellular Phones and Microwave Ovens?* 11: 601-611.
- Koprivica, M. (2013); *Statistical Analysis of Electromagnetic Radiation Measurements in the Vicinity*
- Kovach, S. (2007); *The Hidden Dangers of Cell Phone Radiation, Life Extension Magazine.*
Limits.
- Mann, K. and Roschke, J. (1996); *Effects of Pulsed High-Frequency Electromagnetic Fields on Human Sleep.* *Medicine;* Vol 48:357-360.
- Misran, R. I. and Islam, M. T. (2011); *Analysis of SAR Levels in Human Head Tissues for Four Types of Antennas*
- Mohana, P. S. (2002); *Introduction to Wireless Systems. Journal of Environment and Ecology* ISSN 2157-6092 2014, Vol. 5, No. 1(46).
- Mohr, P.J., Taylor, B.N. and Newell, D. B. (2008). "Recommended Values of the Fundamental Physical Constants: 2006". *Rev. Mod. Phys.* 80 (2): 633–730.
- National Cancer Institute. (2013); *Cell Phones and Cancer Risk.* *Nero-psychobiology;* 33 pp 41-47.
- Nigerian Communications Commission (2011) *Wireless Devices and Health Concerns. Current Exposure Occupational Management Review,* 51(1) pp: 25-35.of GSM/UMTS Base Station Antenna Masts.
- Oftedal, G., Wilen, J., Sandstrom, M. and Mild, K.H. (2000); *Symptoms Experienced in Connection With Mobile Phone Use. A journal of Occupational Management;* 50:237-245. Schilling, C.J. (2011); *Effects of Acute Exposure to Ultrahigh Radio Frequency Radiation on Three AntennEngineers.* *ASciences,* Vol 5(3)pp:96107. *OccupationalEnvironmentalManagement* 199 :54:281-284.
- World Health Organization (2011); *Electromagnetic Fields and Public Health: Mobile phones.* USA: Addison-Wesley. pp. 2–5users.9: pp 20-24.
- Wiki, (2014); *Mobile Phone Radiation and Health. Vol1 (2) pp: 21-22.*
- Wikipedia (2012). *Electromagnetic Radiation. A journal environmental science technology.* Vol 2(1).pp: 17-20.
- Wilhelm R, Davidson, M. and Johann, W. (2013); *Wilhelm Ritter Discovers Ultraviolet Rays With Portable Telephones. Australian Journal of Basic and Applied Sciences,* 5, 3, 96-107.