IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 11, Issue 6, Ver. IV (Nov.-Dec .2016), PP 83-88
www.iosrjournals.org

Study on Electromagnetic Field Emission from GSM Base Stations in Nigeria

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Abstract: *In Nigeria, there has been a substantial growth in the use of mobile communication services over the last few years and this growth is expected to continue for the foreseeable future with the introduction of the 3G and 4G mobile technologies. With this growth comes the inevitable, increase in the number of base station sites, accompanied by public concern and fears of adverse health effects for these communication systems despite reassurances from the service providers that international exposure standards will be followed. The globally recognized, independent International Commission on Non-Ionizing Radiation Protection (ICNIRP) has released guidelines that provide levels of radio frequency (RF) exposure that are regarded as safe for all members of the community. Therefore, this paper seeks to address such concerns by assessing the radio frequency radiation from mobile base stations in some selected towns of Jigawa State. The methodology employed for the study is measurement and instrumentation method. Handheld spectrum analyzer (Aaronia HF 4040V3) and a wheel meter were used for the measurement of electromagnetic emissions from Airtel, Glo, MTN and Etisalat base stations at Kazaure, Hadejia, Gumel, Ringim and Dutse towns respectively. It was found from the study that 17 to 70mW/m^2 is the average electromagnetic radiation emitted in the study area, which showed total compliance of exposure limit by the GSM service providers in the state. The result confirmed that environmental levels of RF energy encountered by the general public are typically far below levels necessary to produce significant health effect to human.*

Keywords: *GSM Base Stations, Electromagnetic Radiation, Field measurements, and Compliance Assessment.*

I. Introduction

Base stations are required to enable mobile phone communication, including calls and data transfer. They consist of different electronic components and antennas located on masts, rooftops, or on the outside or inside of buildings. Base stations emit high frequency (HF) fields in the range from several hundred MHz to several GHz in which mobile telephony utilizes only small part of the frequency range between 935 to 960MHz and 18005 to 1880MHz [12]. The exact frequency bands used differ between technologies (GSM, UMTS, CDMA2000, 4G) and between countries [12]. Nigeria is experiencing rapid growth in telecommunication industry with about 21 mobile wireless communication service providers and 20,000 base transceiver stations (BTS) spreads across the country, which Jigawa state is included [3]. In response to the increased deployment of mobile telephony transceiver base stations in Jigawa state, concern about the resultant exposure to electromagnetic fields and possibility of adverse health consequences have arisen. Moreover, a large number of different application services have been given license to use the radio frequency in the state which is part of the electromagnetic spectrum [ref]. According to Mobile Manufactures Forum 2013, assessment of exposure levels are most accurately achieved through onsite field measurements [12]. However, theoretical calculations are also common but are complicated by the many factors that influence the actual exposure such as the height, tilt and direction of antenna, absorption from trees and plants or reflections from buildings, as well as distance [12]. Therefore, this paper employed field measurement of electromagnetic radiation emission from selected BTS in Jigawa state. The paper compiled the exposure data in the state and investigated the levels of compliance with health based exposure recommendations by ICNIRP international standard.

II. Safety And Standard Of Radio Frequency Radiation

There are two main exposure guidelines for RF radiation in Europe [6]. The National Radiological Protection Board (NRPB) published in 1993 and the International Commission on Non-Ionization Radiation Protection (ICNIRP) published in 1998. The guidelines established by the (NRPB) were based on the potential of RF radiation to cause illness or injury through heating of the body tissues, while the ICNIRP guidelines give general recommendations regarding HF exposure [6]. ICNIRP provide limitations, expressed in terms of the Specific Absorption Rate (SAR), for the absorption of energy from HF fields [10]. Distinct SAR values apply to whole-body exposure, which is typical from base stations, and for the head, which is relevant for exposures from mobile phones. Since publication of the ICNIRP guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields many scientific studies of the effects of such fields have been published

[1]. In the frequency range of about 100 kHz, health hazard assessments have been undertaken by organizations such as the World Health Organization 2006, 2007 [13] [14], national radiation protection institutions HPA 2006, 2008 [16], [17] and by ICNIRP 2003 [18]. For static and extremely low frequency (ELF) fields, ICNIRP's process of reviewing its guidelines is, respectively, finalized (ICNIRP 2009) or in progress. For frequencies above 100 kHz, including frequencies used for modern wireless communications, several major national and international research programs have been completed recently [15] and others are ongoing. The new data need to be reviewed and assessed with respect to possible health hazards prior to a revision of ICNIRP's recommendations in this frequency band.

III. Hf Effects On The Body And Health Implication

High frequency fields have the ability to penetrate the human body, though the depth of penetration is dependent on the frequency used [10]. The higher the frequency, the lower the depth of penetration, with the main effect of this being a rise in temperature in the exposed tissue. The human body can adjust to small temperature increases in the same way as it does when undertaking exercise and performing sporting activities. This is because the body can regulate its internal temperature. However, above a certain level referred to as the threshold depending on the duration, HF exposure and the accompanying temperature rise, can provoke serious health effects, such as heatstroke and tissue damage or burns [10]. A large number of studies have been undertaken on both acute and long-term effects from HF exposure typical of base stations[11]. However, research at these levels of exposure has provided no conclusive evidence of any related adverse health effects [11].

IV. Materials And Method

The materials used are handheld spectrum analyzer (Aaronia HF 4040V3), the wheel meter and a digital computer. The study was carried out at Jigawa State, North Western region of Nigeria. The state lies between latitudes 11^{o}N and 13^{o}N and longitudes 8^{o}E and 10^{o}35 'E with average rainfall of between 600mm to 1000mm, while ambient temperature fluctuates between 15^{o}C and 35^{o}C [19]. Assessments of exposure levels was achieved through onsite field measurements. Data on electromagnetic emissions from Airtel, Glo, MTN and Etisalat base stations at Kazaure, Hadejia, Gumel, Ringim and Dutse were measured and analyzed using Microsoft Excel. The received power (dBm) and exposure limits (mW/m^2) measured at distances from 20 to 460 meters away from the selected Base Stations with frequency range of 100MHz to 4GHz. The net effect of RF emissions were evaluated and compared with ICNIRP standard.

V. Result And Discussion

Results for the field measurement were presented in tabular and graphical forms. Table 1.1 to 1.5 below presents the measured radiation levels, while figure 1.1 to 1.5 presents the graphs of distance against the exposure limit radiated from base transceiver stations (BTS) for Ringim, Gumel, Dutse, Kazaure and Hadejia respectively.

Table1.1: Ringim Radiation Levels

Distance (Meter)	**MTN 950-955MHz Power (mW/m^2)**	**Glo 945-950MHz Power (mW/m^2)**	**Etisalat 890-895MHz Power (mW/m^2)**	**Airtel 955-960 MHz Power (mW/m^2)**
20	1.24	1.06	2.47	2.06
40	1.45	1.18	4.83	2.25
60	2.37	5.11	5.15	2.35
80	4.14	6.32	6.00	2.38
100	6.26	11.67	6.75	7.16
120	6.34	13.68	7.16	16.34
140	16.86	16.47	7.60	35.30
160	20.51	21.65	7.88	35.45
180	20.23	21.88	8.99	46.44
200	43.13	29.54	13.35	80.40
220	55.63	32.23	16.39	89.61
240	41.14	39.17	18.26	95.85
260	17.11	49.85	18.38	89.75
280	22.69	78.15	20.96	115.90
300	25.54	95.61	24.95	214.64
320	80.97	98.62	25.59	275.08
340	77.47	104.33	30.80	245.80
360	90.17	145.60	36.93	342.08
380	71.20	159.48	57.15	355.18
400	74.21	161.30	60.20	300.40
420	50.11	164.37	75.45	450.30
440	70.18	173.50	80.35	403.45
460	53.16	134.45	95.55	415.56

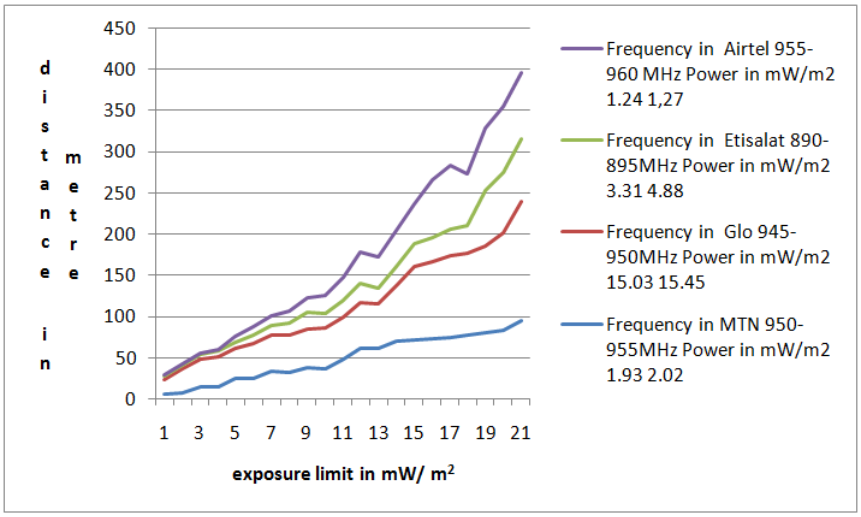

Figure 1.1: Graph for Ringim Exposure Limits

Table 1.2: Gumel Radiation Levels

Distance (Meters)	MTN 950-955MHz Power (mW/m^2)	Glo 945-950MHz Power (mW/m^2)	Etisalat 890-895MHz Power (mW/m^2)	Airtel 955-960 MHz Power (mW/m^2)
20	1.16	1.17	11.31	1.43
40	1.53	1.28	12.78	1.52
60	1.62	1.71	15.51	7.94
80	2.05	2.89	16.66	11.05
100	2.30	7.42	16.51	11.36
120	3.06	15.91	26.78	11.48
140	6.51	16.92	23.94	12.26
160	6.72	18.53	28.58	15.47
180	11.46	43.53	34.83	16.97
200	12.06	46.23	39.84	18.59
220	12.62	46.65	32.78	19.39
240	13,.36	58.23	43.93	22.95
260	14.12	59.31	47.98	23.31
280	17.60	62.50	49.80	25.18
300	20.32	63.49	60.53	30.16
320	21.38	74.93	62.30	31.13
340	22.27	90.35	64.84	31.29
360	24.41	92.08	65.03	38.59
380	26.50	108.89	68,78	39.67
400	30.33	120.96	67.55	56.47
420	31.16	135.45	70.62	71.03
440	48.11	150.34	75.66	76.43
460	50.56	162.85	78.56	84.27

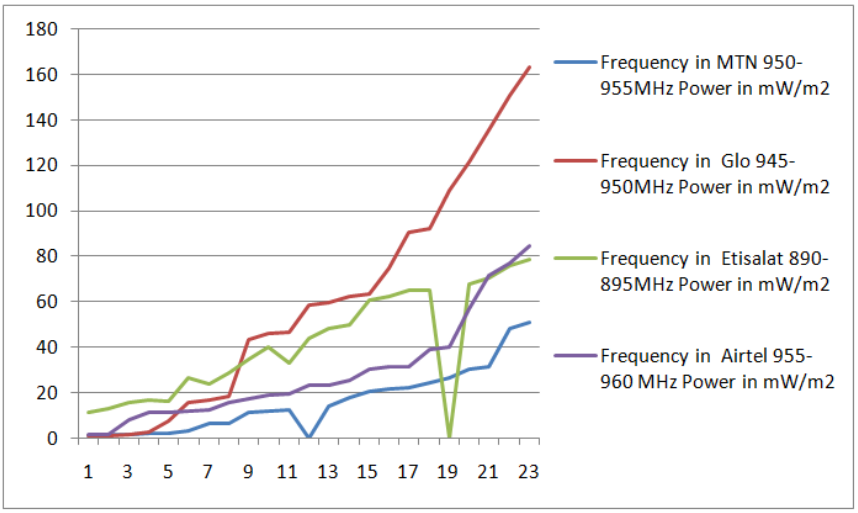

Figure 1.2: Graph for Gumel Exposure Limits

Table 1.3: Dutse Radiation Levels

Distance (Meters)	MTN 950-955MHz Power (mW/m^2)	Glo 945-950MHz Power (mW/m^2)	Etisalat 890-895MHz Power (mW/m^2)	Airtel 955-960 MHz Power (mW/m^2)
20	1.93	15.03	3.31	1.24
40	2.02	15.45	4.88	1,27
60	6.00	16.65	5.35	1.67
80	7.25	28.44	6.02	1.70
100	15.09	32.40	6.17	1.96
120	15.30	34.77	8.72	2.25
140	24.79	35.68	8.90	7.04
160	25.23	41.02	11.45	10.48
180	33.64	43.82	12.27	11.69
200	31.76	44.50	15.90	15.33
220	37.89	45.53	22.05	17.70
240	36.34	48.47	19.63	21.64
260	48.59	50.67	21.41	27.89
280	61.11	54.53	25.10	37.28
300	61.22	53.41	20.26	38.10
320	70.41	65.71	24.49	44.46
340	71.86	88.87	28.15	47.78
360	72.78	92.48	30.35	70.30
380	75.08	97.49	32.96	77.75
400	77.78	98.61	34.24	62.80
420	79.89	104.39	68.61	75.89
440	84.05	116.62	74.92	79.42
460	95.25	143.80	76.72	80.45

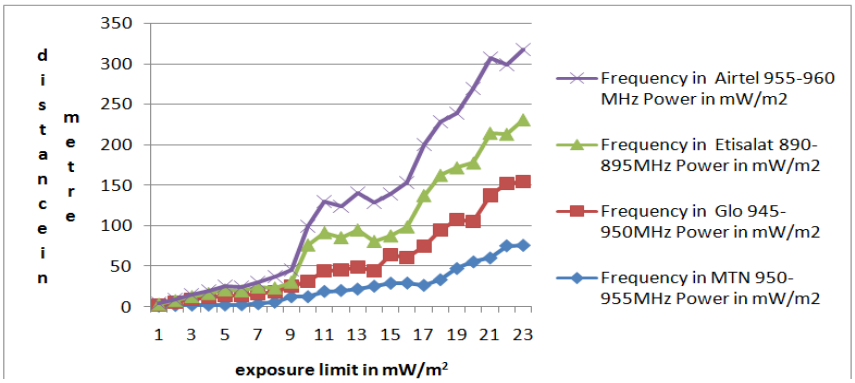

Figure 1.3: Graph for Dutse Exposure Limits

Table 1.4: Kazaure Radiation Levels

Distance (Meters)	MTN 950-955MHz Power (mW/m^2)	Glo 945-950MHz Power (mW/m^2)	Etisalat 890-895MHz Power (mW/m^2)	Airtel 955-960 MHz Power (mW/m^2)
20	1.21	1.56	1.04	2.79
40	1.94	1.63	1.28	2.68
60	2.20	1.67	1.72	2.88
80	5.68	1.68	2.67	3.35
100	8.89	3.68	3.43	3.24
120	8.57	4.64	3.87	3.65
140	9.15	3.78	4.40	4.46
160	9.55	7.93	4.87	5.78
180	10.19	9.28	4.07	5.91
200	10.54	12.61	4.68	5.87
220	10.59	19.60	6.91	5.92
240	11.43	19.82	13.17	6.64
260	12.72	20.80	14.91	14.97
280	13.79	19.23	17.88	13.08
300	13.41	20.11	22.33	22.67
320	14.02	23.68	23.80	23.29
340	14.19	21.73	37.40	34.64
360	15.56	28.47	39.29	45.79
380	18.53	39.78	46.57	36.66
400	43.20	66.13	49.40	51.49
420	48.45	68.45	51.45	54.70
440	53.43	70.85	53.80	57.10
460	56.43	74.05	55.87	61.20

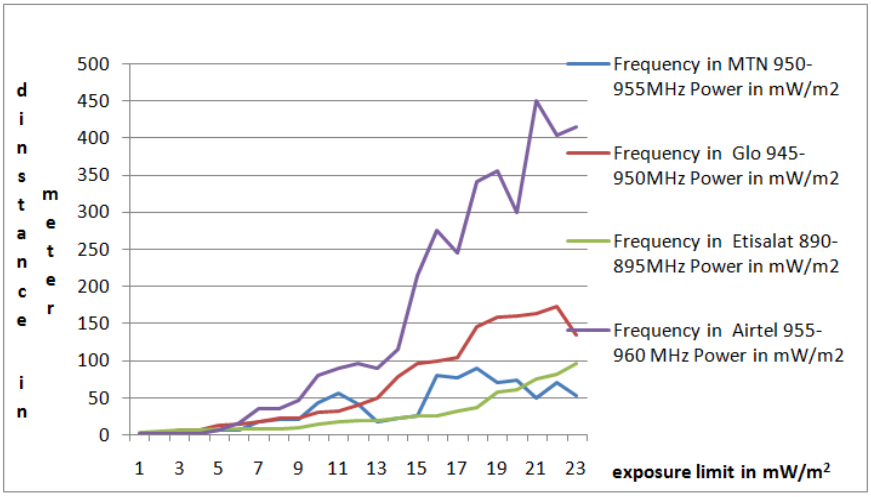

Figure 1.4: Graph for Kazaure Exposure Limits

Table 1.5: Hadejia Radiation Levels

Distance (Meters)	MTN 950-955MHz Power (mW/m^2)	Glo 945-950MHz Power (mW/m^2)	Etisalat 890-895MHz Power (mW/m^2)	Airtel 955-960 MHz Power (mW/m^2)
20	1.04	1.23	1.02	1.31
40	1.92	4.38	1.46	1.71
60	2.30	7.32	3.14	1.89
80	2.33	9.50	4.75	3.68
100	2.49	10.91	7.64	4.66
120	2.71	10.69	6.38	4.50
140	4.03	12.62	7.99	5.62
160	5.90	12.83	4.62	14.55
180	12.55	13.62	4.62	15.42
200	12.62	19.17	44.82	22.68
220	19.15	25.68	46.95	38.82
240	20.31	25.48	39.82	39.13
260	22.02	27.19	46.02	45.59
280	25.65	18.64	36.74	48.06
300	29.27	34.64	23.93	51.49
320	29.48	30.90	38.58	54.76
340	26.67	48.21	62.87	62.51
360	33.63	60.84	68.27	65.82
380	47.38	60.09	64.50	67.34
400	55.58	50.14	72.20	91.36
420	60.45	77.09	77.28	92.73
440	75.43	76.76	61.27	85.55
460	76.09	78.43	76.78	86.56

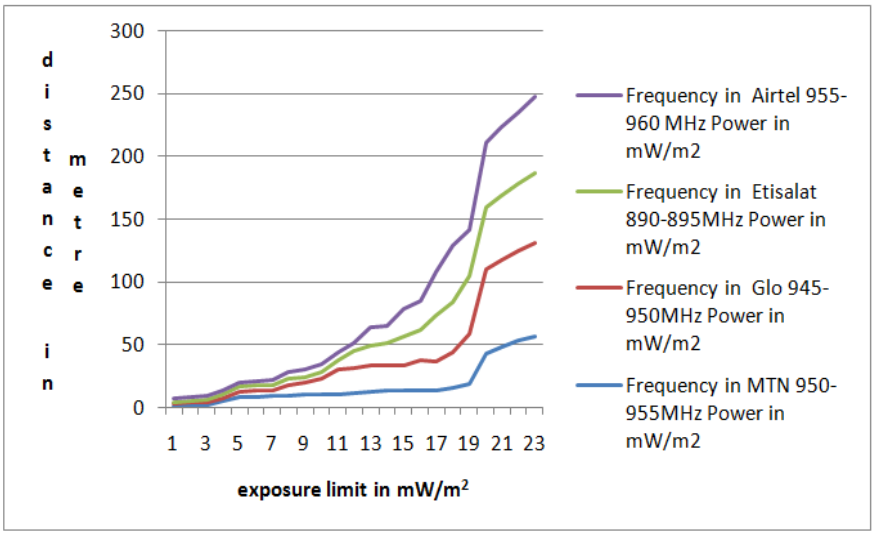

Figure 1.5: Graph for Hadejia Exposure Limits

From the graphs, result clearly shows that exposure limits for the GSM operators considered in this study decreases slightly at different rates over the measured distance. As the distances increases from the BTS there is significant decrease in the exposure limit. The results shows that the exposure limit from the base transceiver stations have an average of 17-70mW/m^2, which is far below the recommendation of International Commission on Non-Ionization Radiation Protection (ICNIRP, 1998) of 4-9W/m^2 as the exposure limit for electromagnetic radiation from base transceiver stations for GSM 900MHz and 1800MHz.

VI. Conclusion And Recommendation

Electromagnetic field emission from GSM base stations in Jigawa state were measured, analyzed and assessed. The assessment results confirmed that the GSM service providers in the state comply with health based exposure recommendations by ICNIRP standard. It can be concluded that, people living in those community are safe and secure to use the services provided by *Airtel, Glo, MTN and Etisalat* telecommunication companies. It is recommended that similar study should be carried out at major cities in Nigeria, where there is complex, sophisticated and highly congested traffic base stations. Similarly, medical survey study should be carried out on the people living within the vicinity of these telecommunication tools in order to ascertain the adverse health effect or otherwise.

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