Journal of Sustainable Development in Africa (Volume 18, No.3, 2016)
ISSN: 1520-5509
Clarion University of Pennsylvania, Clarion, Pennsylvania

SPATIAL DISTRIBUTION OF TELECOMMUNICATION BASE STATIONS AND ITS ENVIRONMENTAL EFFECT ON RESIDENTS OF FEDERAL CAPITAL CITY ABUJA, NIGERIA.

[1]Musa DALIL, [2]YAHAYA Abdullahi Abbas, [3]Umar Faruk Yaya and [4]ABD'RAZACK Nelson Tajudeen Adewale

[1,2,4]Department of Urban and Regional Planning, Federal University of Technology, Minna, Nigeria.
[3]Department of Urban and Regional Planning, Ahmadu Bello University Zaria, Nigeria

ABSTRACT

Global System for Mobile Communications (GSM) started operation in Nigeria in early 2001. This has led to ease in the communication system in the country. Together with its benefits comes the attendant effect. The problems associated with telecommunication mast siting in the Federal Capital City Abuja are numerous and include the following incompatibility of land use, loss of environmental aesthetic and pollution (Air and Noise). This study aimed at evaluating the spatial distribution of telecommunication base stations and their environmental effects on residents of the Federal Capital City, Abuja. The objectives are: identifying and locating the telecommunication base stations; assessing the environmental problems of telecom mast and examining the process of ameliorating the effects. Primary and secondary data were used for the study. Ambient air quality/noise level measurement around some telecommunication base stations was carried out using RASI-700 handheld air quality meter and Gas detector to measure air quality (TESTO 815). The noise level was measured at an intervals of three hours per day within the radius of 10m, 20m and 30m. 193 questionnaires were administered randomly to households of location close to base station. The results revealed that, the use of diesel engine by GSM operators has brought about the emission of gases into the atmosphere; Nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2) which ranged between 0.08ppm and 0.29ppm respectively. These have been found to have exceeded the recommended limit of 0.04ppm set by the Federal Ministry of Environment (FMENV). Noise level in sampled base stations has also been noticed, exceeding the approved limit of 90 dBA. The cumulative effects of the noise level in the long run can lead to temporary deafness. It is, therefore, recommended that telecommunication operators should subscribe to co-location in order to reduce the number of mast siting and adoption of eco-friendly telecommunication infrastructures to minimize gas emission and noise pollution.

Keyword: Base Station, Effect, Environment, GSM, Land use and Space

INTRODUCTION

Global System for Mobile Communications (GSM) dominates the Nigerian telecom industry, accounting for almost 98% share of the market (NCC, 2014). GSM is one of the fastest growing and most demanding telecommunication applications in the world now and Nigeria **(**Shalangwa, Bello 2010**)**. It presents a constantly growing telephone subscription around the globe. Nigeria is one of the major consumers of GSM for communication in Africa, over 60% of the whole populace in Nigeria depend on the GSM as the fastest means of communication (Zain, 2005).
Four GSM operators (Airtel, Etisalat, Globacom, and MTN) control the industry in Nigeria. According to the Nigerian Communications Commission (NCC,2014), the number of structured transceiver base stations (BTSs) or mast sites by the four service operators grew from zero in 2001 to about 44,000 in 2014 (Ekata & Kostanic, 2014). There are four GSM providers in Nigeria with a subscription base of over 143.05 million people (National Bureau of Statistics, 2015). Ever since the launch of mobile phone service in Nigeria in the early 2001, it has played a crucial role in the dissemination of information (communication, SMS and Data for internet usage). The sector had recorded an excessive growth from 2.27 million subscribers in 2002, when the first mobile permit was issued, to 143.05 million at the end of the first quarter of 2015 (NBS, 2015).

The role and distribution of mobile phones and supplementary wireless communication services round the world is portents, it has not merely eased the world into a universal group, but beyond highly into a global home (Olukolajo *et al*, 2013). What was once exclusively a business instrument; remote telephones are presently a mass business sector customer gadget contributing emphatically, to the Gross Residential Items (Gross domestic product) of different nations and giving openings for work to a large number of young people, experts and even insignificant dealers (Otubu, 2012).

Ndukwe (2004) posited that in today's world, modern digital telecommunication network are as necessary for economic growth and to attracting foreign investment. Furthermore, a reliable telecommunication network can improve the productivity and effectiveness of other sectors of the economy and improve the quality of life generally. Thioune (2003) suggest that for the past two decades, most advanced countries have witnessed substantial multifaceted changes that can be traced to telecommunication. These multidimensional changes have been in almost all aspects of life, economic, education, communication and travel. In a technology driven society, communication is vital for both sender and receiver. Thioune (2004) indicates that many initiatives have been at the international level to support Africans effort to develop communication infrastructure, and those efforts are designed to enable African countries including Nigeria, to foster ways of achieving durable and sustainable development.

The mast is a free standing structure which supports antennas at a height where they can transmit and get radio waves, a mast is usually 15m high and plays no part in the transmission of radio waves. The base stations are sites that enable mobile phones to work. They can be big or small and have transmitters and receivers in a cabin or cabinet attached to antennas (MOA, 2015). They can be mounted on a substantial pole or tower, an existing building rooftop or street furniture such as street lamps, so without the base station, mobile phone will not work. GSM base stations and cellular telecommunication masts represent part of the infrastructure required for effective communication system. In order to have effective network coverage, several base stations are located close proximity to the target users; the reason telecom operators also place their masts in residential neighbourhoods. The base stations transfer signals between mobile telephones and a network for mobile or normal telephone service through means of radio frequency electromagnetic fields.

Telecommunication Base trans-receiver stations (BTSs) are designed to enhance communication radio-frequency network signals for the rapidly expanding digital telecommunication users both in urban and rural communities (Turletti, Bentzen & Tennenhouse, 1999). It also facilitates the extension of communication network accessibility to sub-urban and rural communities lacking access to telecommunication services. Typical BTS consists of telecommunication mast on which are installed radio frequency transmitters and receivers, powered by digital electronic boasters which are installed in shelters within the BTS site. A number of environmental issues have attended the introduction of this technology. This includes the indiscriminate siting and erection of base trans-receiver stations all over Nigeria. A conservative estimate of over 20,000 Base trans-receiver stations are scattered around the country. Many of the BTSs are sited within residential, commercial, industrial and transit routes. Aside from the risk of chronic human and environmental exposure to radiations and other environmental and safety matters, air quality damage appears to be of priority (IFC, 2007), since many of the base trans-receiver stations are powered by diesel run power generating sets. Diesel run combustion engines are known to release fugitive emissions and other air pollutants (Dürkop & Englert, 2004). Thus, the atmosphere receives gaseous and particulate pollutants from BTSs operations.

Sustainable development came to prominence in international discourse around the same time as the global satellite for mobile telecommunication became a public resource, thanks to the report of the World Commission on Environment and Development (the Brundtland Commission), published as *Our Common Future* in 1987, and to the first Earth Summit held in Rio de Janeiro in 1992.

The concept of sustainable development that emerged from these sought to establish three interlinked objectives – economic prosperity, inclusive social welfare, and environmental protection or lasting viability. Development which did not integrate these three objectives would not be sustainable. Environmental viability, in this context, was defined largely in terms of two core principles: that development should be based on consumption of resources that lay ‘within the bounds of the ecological possible and to which all can reasonably aspire,’ and, as importantly, that development should ‘meet the needs of the present without compromising the ability of future generations to meet their own needs.’ Together, these can be said to define the meaning of sustainable development.

Pollution, specifically (Noise and Air) is a consequential effect of hazards from mast installations. The noise from generating sets combined with horn vehicles polluting the peaceful, serene that characterize the atmosphere and serenity of the residential area. Also, residents who live close to installed masts experience continuous disturbing sound from generating sets that are used to power base stations which cause noise and environmental pollution (Thisday, 2013). Telecommunication masts are being indiscriminately located within residential areas in Abuja without recourse to the provision of infrastructure in the Abuja master plan. The implication of this trend on human health is obviously significant (Aderoju, Godstime, Olojo, Oyewumi, Eta, Onuoha, Salman, & Nwadike, 2014). The components and constituents solid waste is another major effect of the abandonment of telecommunication masts gadgets which are hazardous and injurious to human health. The hazardous nature of the waste is a serious threat to human health, water, soil and the entire ecosystem. This is because it poses serious health challenges to the human being in addition to creating an eyesore in the environment. Most of the masts are being located without an environmental impact assessment, the resultant effect of this on people's life and the environment of Abuja may be put into question.

This study, therefore, focuses on the spatial distribution of telecommunication base stations and its environmental effect on residents of Federal Capital City Abuja, Nigeria. The specific objective of the study includes: Identification and location of telecommunication base stations within the Federal Capital City; assess the environmental problems of telecommunication mast erection and examining the role of telecommunication operators in ameliorating the effect of telecommunication masts erection in the Federal Capital City.

GSM base stations poses a number of major environmental challenges (UNEP, 2004). It is today the most rapidly growing contributor to waste generation around the world, thanks to the growing range and short lifespan of communication devices such as computers and mobile phones (Mansell,2012). Current arrangements for the disposal of electronic waste, some of which is toxic, are unsatisfactory and insufficient (UNEP, 2004). The GSM operation is also the fastest growing contributor to greenhouse gas emissions, currently contributing around 2.5% of global emissions, with these increasing at a rate of 6% p.a (IISD, 2012). This growth is attributable to the energy used as a result of the spread of ICT networks and devices, the growing number of devices used by individuals, businesses and organisations, and the increasing length of time each day during which devices are in use. These direct impacts on greenhouse gas emissions are, therefore, the result of beneficial use of ICTs to access information, enable social and business interactions and, ultimately, develop knowledge societies.

The use of Information and Communication Technology (ICT) in general and GSM and its facilities (Base Stations) has profound effects on society and its production capacity. In Singapore, the use of ICT is pervasive in all sectors of the economy and the ICT sector alone is worth S$83 billion in 2014. The government proactively promotes the use of ICT to improve efficiency and has invested heavily in building ICT infrastructure that. By 2015, Singapore will have an all-fibre network, the Next Gen Nationwide Broadband Network (NBN) that will deliver ultra-high broadband access speeds of 1 Gbps and more throughout the nation. The infrastructure and other ICT developments will place Singapore in a better position to tackle the challenges of sustainable developments.

Cities globally are fast transforming into artificial ecosystems of interconnected, interdependent and intelligent digital organisms (William, 2012). ICT can provide new functionalities by integrating these independent, heterogeneous and multi-disciplinary systems to provide a "System of Systems" intelligence where the overall properties will be greater than the sum of its parts. The resulting combined system will be able to address problems which the constituent systems alone would not be able to do and can result in the creation of new "emergent" information sources. Consequently, such information and data will help to better configure the various elements of a system so as to optimise its overall energy performance in a cost-effective manner.

The idea of the "System of Systems" intelligence can be illustrated using the climate control system in a building. The cooling, lighting and electrical systems and their sensors, access control and management systems could be combined to control the climate within a building

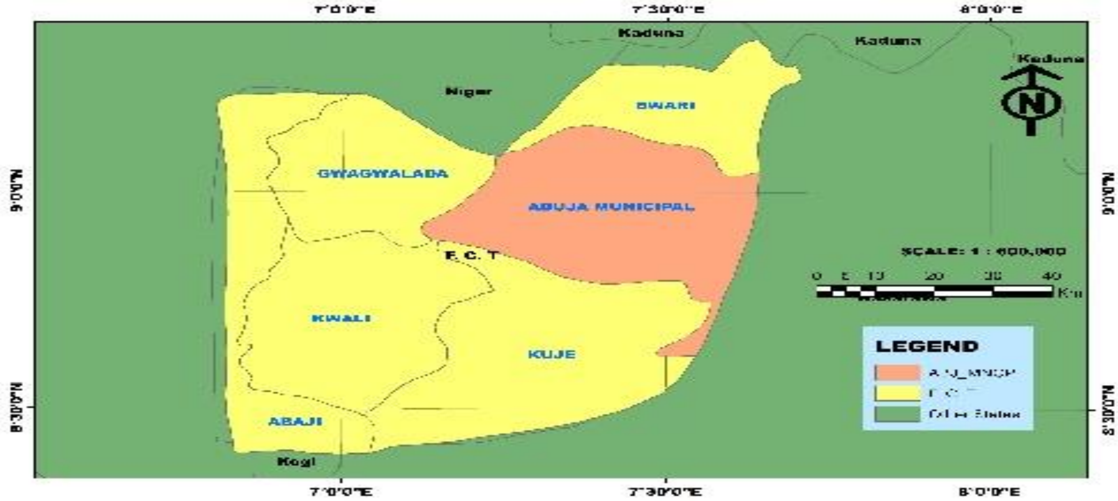
THE STUDY AREA

Abuja which is located in Nigeria and as well its capital city of Nigeria with co-ordinates $9{\cdot}40''$N and $7{\cdot}29^{0}0$''E covering an area of 713 km^2, Abuja's geography is define by Aso Rock, a 400- metre monolith left by water erosion. The Federal Capital City (FCC) is a central point in the Nigerian state. FCC is a major city in FCT, Abuja Nigeria, FCT covers an area of about 8, 000 Km^2. FCC is bounded by Kaduna and Nassarwa State. The FCT which in the national context is placed entirely in the region, which is referred to the middle belt of Nigeria. This belt is the transition between the northern ecological zones dominated by sparse vegetation. The FCT therefore shares some of the attribute of the two zones, thus making it's a fascinating area for urban development. The site for new capital city has been selected from the north-eastern quadrant of FCT and it occupies about 250 Km^2. Figure 1 and Figure 2 shows the FCC in the context of Nigerian nation. The master plan as prepared and approved by the government put the ultimate population of the city at 3 million people, planned to be developed in four phases as shown in Table 1.

Figure 1.1: **Map of Nigeria showing Abuja**

Source: Authors Fieldwork, 2015

MAP OF FCT SHOWING ABUJA MUNICIPAL AREA COUNCIL



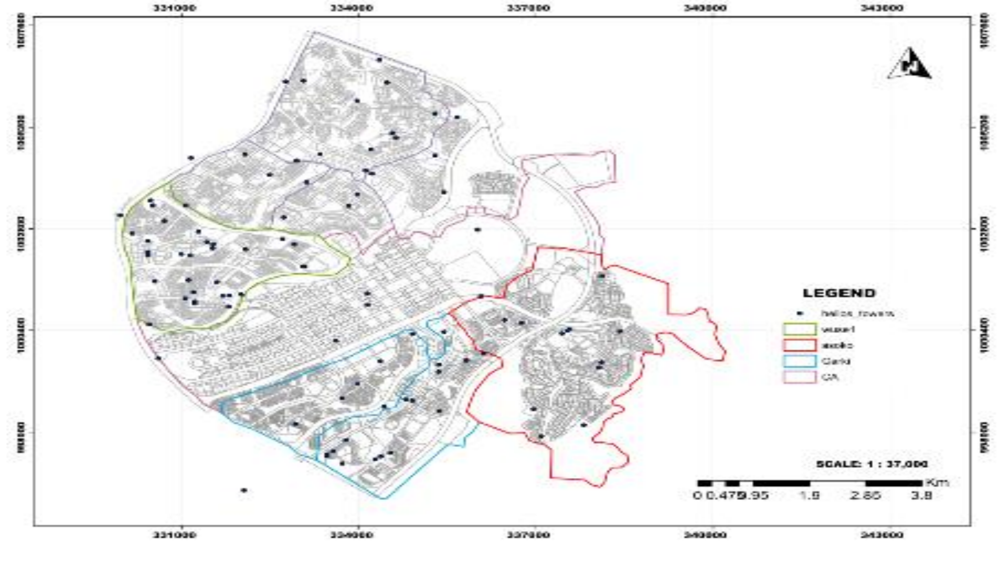


Figure 1.1: **Map of Abuja depicting the Study Area**

Source: Authors Fieldwork, 2015

Table1: Phases of the FCC and the Target Population

Phases	**Projected Target Population**
I	20,000
II	585,000
III	640,000
IV	1,700,000
Total	**3,100,000**

Source: AGIS, 2009

The development of FCC as the Federal Capital of Nigeria was phased into four. The first phase which is the focus of this study has five neighbourhoods of which Central Area is not included in the study; this is because it is not residential area. The detailed land use planning and site development plan of Phase I of the FCC has been completed and is made up of five (5) district with its population projection shown in Table 2:

Table 2: Districts within the FCC and Planned Population in Phase I.

	District	**Land Budget in (Ha)**	**Planned Population**	**2015 Projected Population**
A	The central Area	1,658	30,000	
B	Garki I and II	865	50,000	62,540
C	Wuse I and II	1,530	69,000	86,305
D	Asokoro	897	30,000	37,524
E	Maitama	1,050	35,000	43,778
	Total		**214,000**	**267,671**

Source: AGIS, 2009 and Authors' Computation, 2016

MATERIALS AND METHODS

An opinion survey was conducted to investigate the current perceptions of residents towards living near telecom base stations and how this proximity might affect environmental quality. Residents were asked questions, about: how they rate their neighbourhoods relative to other similar neighbourhoods in the city; the environmental effect of base station sitting in their neighbourhoods and the degree of concern of the effects on environmental quality.

Structured questionnaires were used to collect data from the households and relevant agencies. The questionnaire was aimed at ensuring that, enquiries and questions asked are of relevance to, and addressing specific objectives of the study. Instruments used for data collection include Satellite imageries, Land use map, Data on telecommunication masts location points (NCC, Development Control, Helios Towers Nigeria limited, and other various Telecommunication networks providers), Records from relevant literature, Handheld Global Positioning System (GPS), Camera and instrument such as RASI-700 hand-held air quality meter and Gas detector and TESTO 815 Sound level meter.

A total of 193 questionaire were randomly distributed to the four neighbourhoods in FCC for the study and distribution across the four neighbourhoods as shown in Table 3.

Table 3: Sample Size for the Study

District(s)	Planned population FCDA 2009	2015 projected population	No.of Households	Sample Size
Garki I and II	50000	62540	10423	52
Wuse I and II	69000	86305	14384	72
Asokoro	30000	37524	6254	32
Maitama	35000	43778	7296	37
Total	**214000**	**267671**	**38357**	**193**

Methods of Collection of Air Quality (AQ) and Noise Level Samples

Random selection of base stations across the four neighbourhoods was carried out. Measurements were conducted in twelve telecommunication base stations; three base stations from each of the districts within and around the city and its environs.

Air samples were measured at a height of 2 metres above the ground level at each of the graded distances of 10m, 20m, 30m respectively, this measurement was done at the windward direction. Air sample was taken at 12 noon and 6 pm in the evening. Ambient Air Load (AAL) was measured includes: Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Carbon monoxide (CO), Hydrogen sulphide (H_2S), and Suspended particulate matter(SPM), Total Hydrocarbon (THC) and ambient temperature were equally determined. Also the noise level was measured at 10 m, 20 m and 30 m to determine the level of noise generated by the base stations. Table 4 shows the possible exposure limit approved by Fedral Ministry of Environment on residential area in Nigeria.

Table 4: Noise Exposure Limits in Nigeria

Duration per day	**Possible exposure limits (dB)**
15 Minutes or less	115
30 Minutes	110
1.0 Hour	105
1.5 Hours	102
2.0 Hours	100
3.0 Hours	97
4.0 Hours	95
6.0 Hours	92
8.0 Hours	90

Source: FEPA, 1991.

The ambent air quality allowable to be exposed by residents in Nigeria is also set by the ministry. The approved ambent air quality limit and exposure for good health is shown in Table 5.

Table 5: Nigerian Ambient Air Quality Standards

Pollutants	**Time of Average**	**Limit**
Particulates	Daily average of daily	250 ug/m^3
	values 1 hour.	*600 ug/m^3
Sulphur oxides	Daily average of hourly	0.01 ppm (26 ug/m^3)
(Sulphur dioxide)	values 1 hour	0.1 ppm (26 ug/m^3
Non-methane	Daily average of 3-	160 ug/m^3
Hydrocarbon	hourly values	
Carbon monoxide	Daily average of hourly	10 ppm (11.4 ug/m^3)
	values 8-hourly average	20 ppm (22.8 ug/m^3)
Nitrogen oxides	Daily average of hourly	0.04 ppm-0.06 ppm
(Nitrogen dioxide)	values (range)	(75.0 ug/m^3-113 ug/m^3)
Photochemical oxidant	Hourly values	0.06 ppm

Source: (FEPA, 1988)

Techniques for Air and Noise Pollution Measurement

Measurements of the concentrations of ambient air pollutants such as Nitrous oxide (NO_2), carbon monoxide (CO), Hydrogen sulphide (H_2S) and Sulphur dioxide (SO_2), Suspended particulate matter (SPM) and Total Hydrocarbon (THC) were carried out in the Federal Capital City, Abuja. The procedure involves taking repeated readings at different locations, was adopted. Concentrations of gases were measured in parts per million (ppm) as well as using the RASI-700 handheld air quality meter and Gas detector, during the gas measurements, and TESTO 815 Sound level meter with measuring range of 20.3-120 dBA, accuracy of ±1.5 dBA. The hand held equipment was held at about 2m level and the readings were recorded within 10 seconds. All the results of air quality collected and analysed were compared with FMEVN/WHO standards.

RESULTS AND FINDINGS

Length of Stay of Residents in the City

In view of this research it tends to assess the spatial distribution of telecommunication mast in the Federal Capital City, Abuja over a thirteen year period between 2002 to 2015, it is quite expedient to consider the length of respondents stay in the study area .This is with a view to understanding if the respondents actually have a good knowledge of the events that have occurred in the city within the period under review. In this case, Figure 2 shows that 20.0% said they have only been in the city for a period that ranges between 1-5 years; 44% lived between 6-10 years; 31% have lived in the area for about 11-15 years, while, 5% of the sampled residents have lived between 16-25years. This assessment therefore shows that the majority of the respondents have a good knowledge of the various activities going on in the city over the period under review.

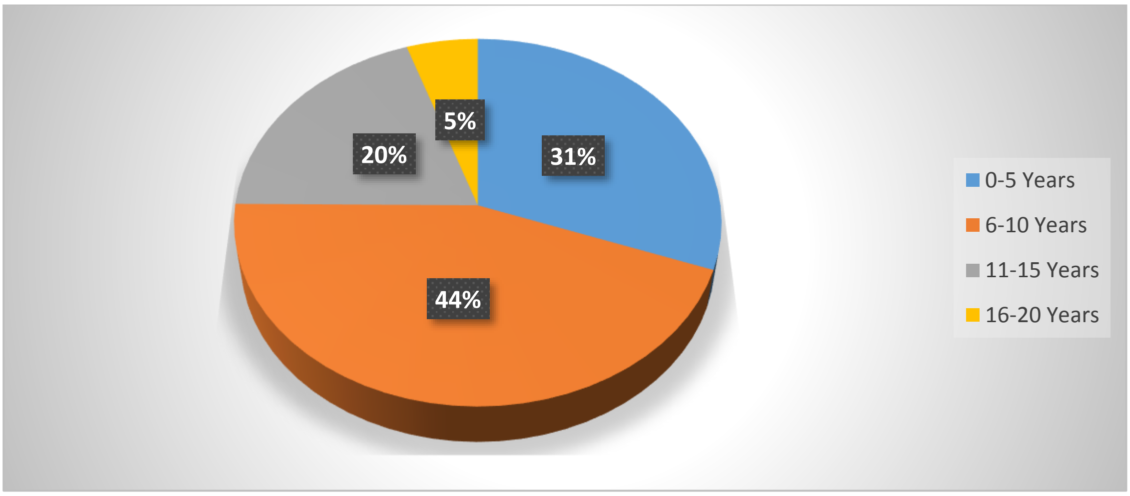


Figure 1: Length of Stay in the City

Source: Authors Fieldwork, 2016

Benefit of Telecommunication Mast to the Residents

Figure 3 revealed all the factors that are considered by the respondents living in the Federal Capital City, Abuja about the economic benefit derived from siting of telecom masts in their area. The mean responses indicated that the least benefit is the proximity to Marketplace with mean response of 2.18. security, affordable rent, good access road, constant electricity and good network coverage with a mean of 3.58, 3.01, 2.58, 2.32 and 2.23 respectively.

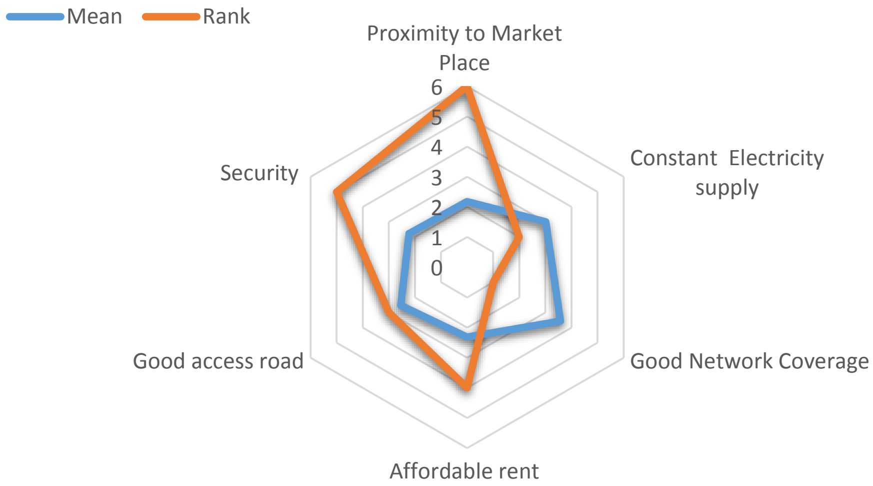


Figure 3: Benefit of Telecom Mast to Residents

Source: Authors Fieldwork, 2016

Types of Telecommunication Masts of each Operators in Federal Capital City, Abuja

There are basically two types of telecommunication masts used by service operators in the study area, these are; Single and multiple telecommunication masts. The single telecom base station users include MTN, Globacom, Airtel and Etisalat, while the multiple service operators are Visafone, Startime and Multilink.

Number of Telecommunication Masts per Operators in the Federal Capital City, Abuja

There are a total of 35 base stations being used by MTN in the FCC; 29 by Glo; Etisalat has 5 base stations; 15 by Airtel, while the multiple operators has 8 base stations. The breakdown of the location of the base stations across the four neighbourhoods shows that Wuse I and II has 41 base stations, 22 base stations are in Garki I and II, Maitama has 15 while Asokoro has 14 base stations as shown in Table 6.

Table 6: Summary of Telecommunication Service Operators

District(s)	Telecom Service Providers				
	Single Base Station Operators				Multiple Base Station Operators
	MTN	Glo	Etisalat	Airtel	
Wuse I and II	14	13	3	7	4
Garki I and II	8	8	1	3	2
Maitama	5	5	1	2	2
Asokoro	8	3	-	3	-
Total	**35**	**29**	**5**	**15**	**8**

Source: Authors Fieldwork, 2016

Telecommunication Masts Location in Federal Capital City, Abuja

As earlier stated, there are four GSM operators within the study area, which is shown in Table 4, the composite map showing the total base station in the study area and spatial distribution of the base stations in the neighbourhoods (district) is shown in Figure 4.

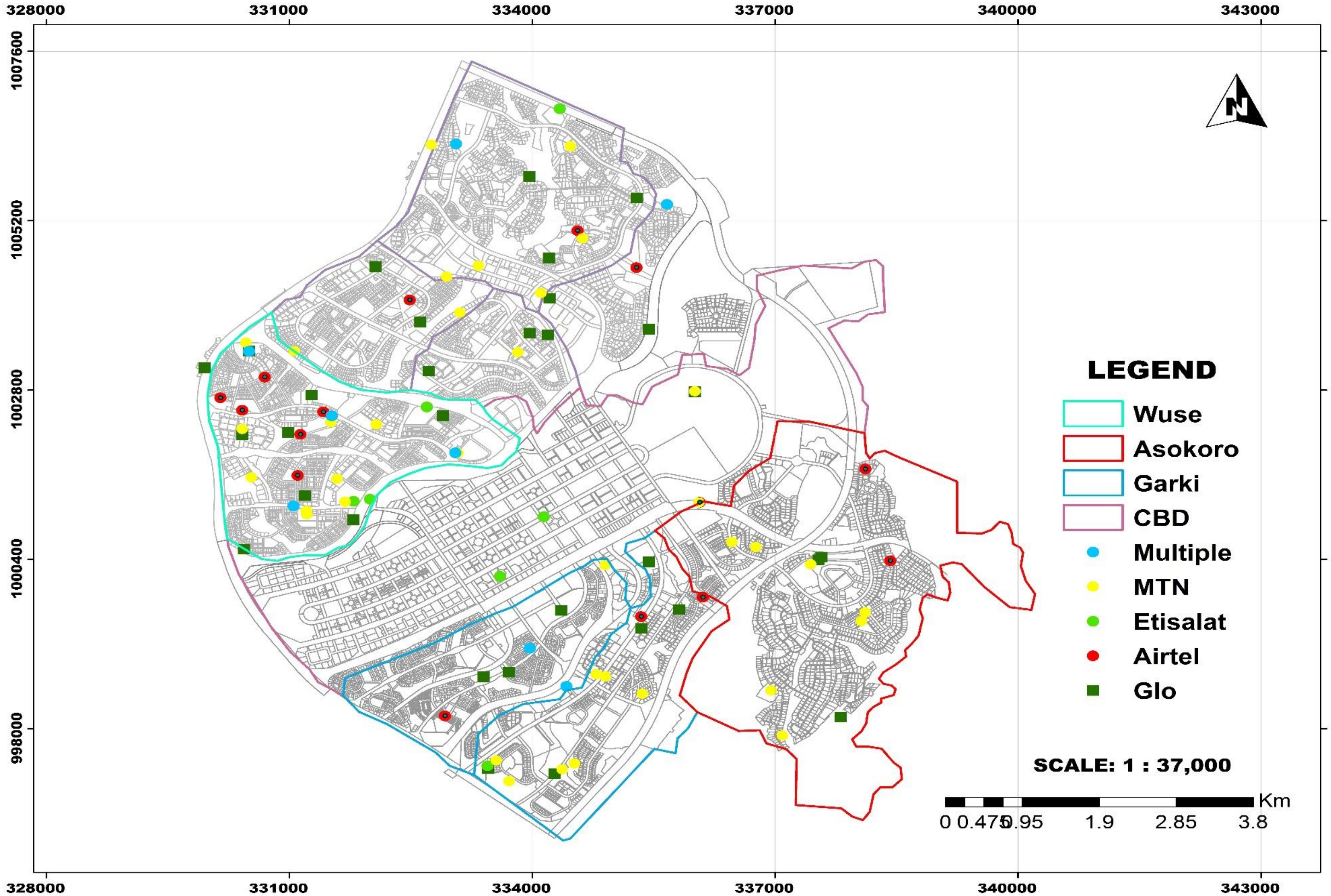


Figure 4: Composite of Spatial Distribution of Base Stations in F.C.C, Abuja

Source: Authors Fieldwork, 2016

Environmental Problems associated with Telecommunication Mast Siting

The environmental problems associated with the siting of base stations on the environment in the study area, ranges from gases and noise emission level on the environment. The ambient air quality and noise level measurements were carried out around the twelve base stations sampled. Comparism of the result was also made with the standards stipulating limit of emission set by the Federal Ministry of Environment in Nigeria (FMENV) as shown in Tables 7, 8, 9 and 10.

Pollution Effect of Telecommunication Mast on the Environment

In Wuse district, Etisalat proves to be the most pollutants in the environment with NO. The closer the residents to the masts, the more pollutant of nitrogen oxide (NO) they inhale at 10m radius which is 500 times the recommended standard. The farther away from the masts the lower the NO pollution. Also the total hydrocarbon (THC) was polluted beyond the recommended standard because of the use of diesel engines. It also shows that the farther away from the mast the lower the THC pollution. It means that Etisalat at Wuse district is a pollutant to the environment which may be injurious to human health with exposure over a long period of time. Also MTN network in Wuse district contributes in polluting the environment with the Nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2) as pollutants.

Study carried out, reveals that there is a high level of pollution on the environment which is above the FMENV recommended standards. In Garki district, all the sampled telecommunication base stations by various network providers use eco-friendly equipment's such as sound proved generating sets and less vibrating electronic materials for their base stations in running their daily activities. The detected concentration level of SO_2 did not exceed the FMENV ambient air limit of 0.1 ppm in the sampled points at the base stations surveyed. After a careful observation on the ambient air quality measurement in Maitama District; MTN network has proved to be the most pollutant in the environment, with nitrogen dioxide (NO_2) of 0.3ppm, 0.25ppm and 0.18ppm at 10m 20m and 30 meters radius respectively.it also includes, Sulphur dioxide (SO_2) of 0.4ppm, 0.31ppm at 10 and 20 meters respectively. In addition, Total Hydrocarbon (THC) emission of 11.3ppm at 10 meter and 10.3ppm at 20 meter radius was measured. Whereas, Airtel network accounts for 0.4ppm, 0.29ppm, 0.12ppm of Nitrogen dioxide at 10m, 20m and 30 meters. Also, total hydrocarbon emission of 16.0ppm at 10 meter; 13.4 ppm at 20 meter respectively, which are all above the set limit of emission set by the Federal Ministry of Environment.

The research has shown that emissions from Airtel network of nitrogen dioxide (NO_2) measured 0.4ppm, 0.29ppm and 0.12ppm at 10m 20m and 30 meters respectively. Total Hydrocarbon emission (THC) of 16.0ppm at 10 meter; 13.4 ppm at 20 meter was recorded. The findings show that the farther away the residents from the base stations the lower the nitrogen dioxide, Sulphur dioxide and total hydrocarbon emission in the environment. In addition to the measurement and monitoring of the ambient air quality assessment in Asokoro district, MTN has Sulphur dioxide emission levels of 0.4ppm at 10 meter ; 0.31ppm at 20 meter radius which are above the instrument detection limit of (0.1 ppm). The concentration of Nitrogen Oxide (NO) measured 2.5ppm at 10 meters and Nitrogen Dioxide (NO_2) of 0.1ppm at 10 meters radius respectively.

Table 7: Ambient Air Quality and Noise Level measured at selected Base Stations in Wuse District, Abuja

s/no	Site id	Coordinates (m)		sampled location	operator	Distance (m)	Noise level (dB)	C0 ppm)	N0 ppm)	$N0_2$ (ppm)	$S0_2$ (ppm)	H_2S (ppm)	SPM (µg/m³)	THC (ppm)
		Eastings	Northings											
1.	BTSs 01	332701.5	1002560.7	Wuse	Etisalat	10 m	**92.3**	0.0	**2.0**	0.03	0.0	0.003	103.6	**11.02**
						20 m	57.9	0.0	**0.09**	0.02	0.0	0.02	97.4	9.6
						30 m	56.6	0.0	**0.06**	0.0	0.0	0.0	71.7	8.2
2.	BTSs 02	332900	1002435	Wuse	Glo	10 m	46.2	2.0	0.01	0.003	0.001	0..1	81.7	3.01
						20 m	51.8	1.07	0.0	0.0	0.0	0.0	77.1	2.06
						30 m	52.3	1.0	0.0	0.0	0.0	0.0	72.03	1.03
3.	BTSs 03	333825.3	1003336.3	Wuse	MTN	10 m	**91.6**	2.01	0.0	**0.08**	**0.3**	0.03	147.3	6.4
						20 m	**90.1**	1.05	0.0	0.03	0.01	0.0	131.8	4.6
						30 m	65.5	0.04	0.0	0.0	0.0	0.0	124	3.04
				FMENV Limits			**90**	**10**	**0.04-0.06**	**0.04-0.06**	**0.1**	**0.02**	**250**	**10**

Source: Authors Field Work, 2016
Key: Red= Above FMENV Limits

Table 8: Ambient Air Quality and Noise Level measured at selected Base Stations in Garki District, Abuja

s/no	Site id	Coordinates (m) Eastings	Northings	sampled location	Operator	Distance (m)	Noise level (dB)	C0 ((ppm)	N0 (ppm)	$N0_2$ (ppm)	$S0_2$ (ppm)	H_2S (ppm)	SPM (µg/m³)	THC (ppm)
4.	BTSs 04	332924.37	998181.91	Garki	Airtel	10 m	47.6	3.0	0.0	0.016	0.0	0.005	82.1	3.02
						20 m	44.2	2.03	0.00	0.009	0.00	0.001	78.4	2.05
						30 m	40.3	1.06	0.00	0.005	0.00	0.00	74.9	1.06
5.	BTSs 05	333402.73	998734.89	Garki	Glo	10 m	42.5	3.0	0.00	0.001	0.00	0.005	46.8	6.12
						20 m	41.0	2.05	0.00	0.00	0.00	0.001	43.9	5.58
						30 m	40.2	1.07	0.00	0.00	0.00	0.00	41.3	3.03
6.	BTSs 06	333450.00	997475.00	Garki	Etisalat	10 m	39.2	4.0	0.0	0.001	0.0	0.005	63.0	9.3
						20 m	37.8	3.02	0.00	0.00	0.00	0.001	58.9	7.1
						30 m	36.1	2.00	0.00	0.00	0.00	0.00	51.7	6.03
				FMENV Limits			**90**	**10**	**0.04-0.06**	**0.04-0.06**	**0.1**	**0.02**	**250**	**10**

Source: Authors Field Work, 2016
Key: Red= Above FMENV Limits

Table 9: Ambient Air Quality and Noise Level measured at selected Base Stations in Maitama District, Abuja

s/no	Site id	Coordinates (m) Eastings	Northings	sampled location	operator	Distance m)	Noise level (dB)	C0 (ppm)	N0 (ppm)	$N0_2$ (ppm)	$S0_2$ (ppm)	H_2S (ppm)	SPM (µg/m³)	THC ppm)
						10 m	**90.1**	4.0	0.0	**0.3**	**0.2**	0.006	151.3	**18.02**
7.	BTSs 07	334109.76	1004176.85	Maitama	MTN	20 m	67.6	3.13	0.00	**0.25**	0.01	0.001	141.8	**15.9**
						30 m	54.8	2.01	0.00	**0.18**	0.00	0.00	137.0	**14.1**
						10 m	**90.1**	3.0	0.0	0.001	0.0	0.006	108.4	7.03
8.	BTSs 08	334217.67	1004102.06	Maitama	Glo	20 m	58.2	2.6	0.00	0.00	0.00	0.002	98.6	6.03
						30 m	54.9	1.07	0.00	0.00	0.00	0.00	92.9	3.98
						10 m	**90.8**	4.0	0.0	**0.4**	0.0	0.006	172.3	**16.0**
9.	BTSs 09	334562.00	1005062.00	Maitama	Airtel	20 m	60.6	3.01	0.00	**0.29**	0.00	0.003	163.8	**13.4**
						30 m	49.4	2.05	0.00	**0.12**	0.00	0.00	143.7	8.8
				FMENV Limits			**90**	**10**	**0.04-0.06**	**0.04-0.06**	**0.1**	**0.02**	**250**	**10**

Source: Authors Field Work, 2016
Key: Red= Above FMENV Limits

Table 10: Ambient Air Quality and Noise Level measured at selected Base Stations in Asokoro District, Abuja

s/no	Site id	Coordinates (m) Eastings	Northings	sampled location	operator	Distance (m)	Noise level (dB)	C0 (ppm)	N0 (ppm)	$N0_2$ (ppm)	$S0_2$ (ppm)	H_2S (ppm)	SPM (µg/m³)	THC (ppm)
10	BTSs 10	336070.17	1001210.08	Asokoro	MTN	10 m	**90.3**	4.0	0.0	0.04	**0.4**	0.001	121.8	**11.3**
						20 m	87.2	3.04	0.00	0.00	**0.31**	0.00	113.4	**10.3**
						30 m	63.0	2.10	0.00	0.00	0.000	0.00	103.6	9.2
11	BTSs 11	336070.17	1001210.08	Asokoro	Airtel	10 m	**90.1**	3.0	0.0	0.001	0.0	0.001	91.6	0.04
						20 m	74.4	2.03	0.00	0.00	0.00	0.00	85.8	0.01
						30 m	51.8	2.00	0.00	0.00	0.00	0.00	78.7	0.00
12	BTSs 12	337810.20	998164.96	Asokoro	Glo	10 m	20.6	9.02	**2.5**	**0.1**	0.0	0.001	95.02	2.5
						20 m	36.4	3.69	0.00	0.08	0.00	0.00	87.9	2.0
						30 m	34.1	2.34	0.00	0.005	0.00	0.00	83.4	1.8
				FMENV Limits			**60**	**10**	**0.04-0.06**	**0.04-0.06**	**0.1**	**0.02**	**250**	**10**

Source: Authors Field Work, 2016
Key: Red= Above FMENV Limits

Perception of Resident on Siting of Telecommunication Masts

Table 11 shows the perception of residents on siting of telecommunication mast erection close to their house; 2.6% of the respondents strongly agreed on the siting close to their house; 15.0% agreed on siting of the masts. However, 3.1% either agreed or disagreed; 54.9% of the resident disagreed on the notion of siting of mast close to their house while 24.4% strongly disagreed. From the result, it can be observed that majority of the residents sampled in city do not like siting of masts close to their houses.

Table 11: Siting of Telecommunication Mast

Response	Frequency	Percentages %
Strongly Agreed	5	2.6
Agreed	29	15.0
Indifferent	6	3.1
Disagreed	106	54.9
Strongly Disagreed	47	24.4
Total	**193**	**100.0**

Source: Authors Fieldwork, 2016

4.7.1 Environmental Impact Generated by Telecommunication Mast

The level of impact generated by telecommunication mast on the environment as shown on Figure 5 reveals that about 57.5% is the level of noise generated, 5.7% of fumes, 29.5% of vibration and 7.3% are for other impact generated by telecommunication mast on the environment within and around the city.

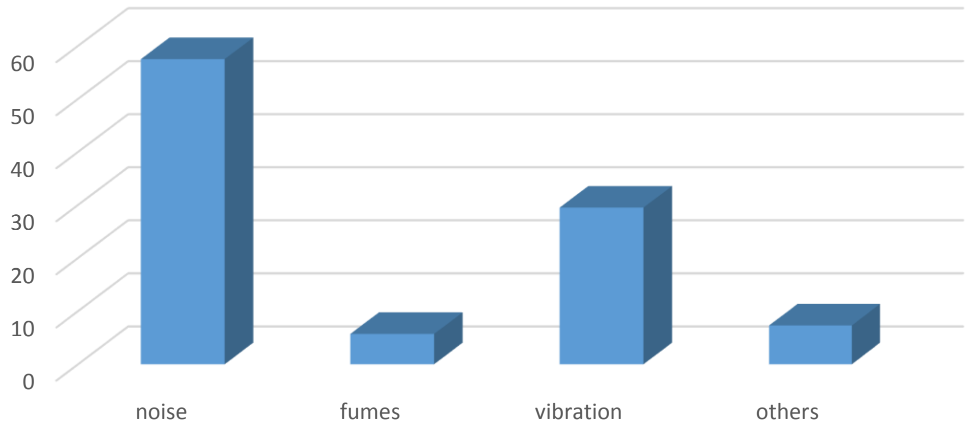


Figure 5: Impact Generated by Telecom Masts

Source: Authors Fieldwork, 2016

According to a report from OECD (Berkhout and Hertin, 2010) there are three main types of environment effects caused by ICT and by extension GSM base stations:

i. First order impact – direct environment effects of the production and use of ICTs, such as resource usage, electricity consumptions and electronic (e-) waste disposal.

ii. Second order impact – the indirect environment impact related to the effects of ICTs on the structure of the economy, production processes, products and distribution systems. Examples are dematerialisation (substitution of tangible goods using digital goods) and 'demobilisation' (substitution of travel with "telecommuting").

iii. Third order impact – indirect effects on the environment through the stimulation of more consumption and higher economic growth by ICTs, and through impacts on life styles and value systems.

Table 12 discusses the effects ICT and base station on environment. With regard to environmental impact, it is estimated that the global ICT sector currently produces around 2% of the world's greenhouse gas emissions (Gartner, 2007), roughly equivalent to that of the aviation sector. According to the World Summit on the Information Society, the energy demand of the GSM base stations sector is between 5 and 10% of the world's total energy demand (UN, 2005). With the proliferation of base station usage, electricity demand is expected to double to between 10 and 20% by 2020(UN, 2005). Such demand comes from the extensive utilisation of ICT end-user devices, telecommunication networks, and the data centre facilities hosting servers and data storage devices.

The frequent replacement of ICT devices, falling prices and rapid obsolescence have resulted in a fast-growing surplus of e-waste around the world. The global e-waste is estimated to be 53 million tonnes in 2012 (Satish, 2012); only 13% of this waste is reported to be recycled with adequate safety procedures (Electronics Takeback Coalition, 2012).

Despite the direct environmental impact from the usage of ICT, there exist larger opportunities for the ICT sector to help other industries to become even more efficient in resource/energy use and thus reduce operating costs. ICT plays three important roles that will contribute to overall sustainability.

Table 12: ICT impacts on the environment

	Positive Impacts	**Negative Impacts**
First order	effects environmental ICT applications e.g. environmental monitoring, smart grid systems	environmental impact on the production and use of ICTs e.g. energy consumption by data centres hosting ICT applications (base stations)
Second order	effects Dematerialization e.g. e-books and digital downloads to replace traditional physical goods (e.g. telephones	Higher environmental burdens from new digital devices e.g. e-book readers, mp3 players and the associated end-of-life cost of the devices (such as battery disposal)
Third order	effects lifestyle changes e.g. green consumerism	"Rebound Effect", i.e. efficiency gained is outweighed by increases in consumption. e.g. using an energy-efficient mobile longer and charging it more frequently

4.8.2 Perception of Residents on Distance from Telecommunication Mast to Residents

On the issue of distance between telecommunication mast and the residence of respondents in the Federal Capital City Abuja. Figure 6 showed the comfortability of residents on the erection of telecommunication mast close to their house, 22.0% strongly agreed that they are comfortable with the distance between their house and the telecommunication mast; 5.0% agreed; 8.0% neither agreed nor disagreed, while 47.0% disagreed on the erection of telecommunication masts close to their homes and 18.0% strongly disagreed.

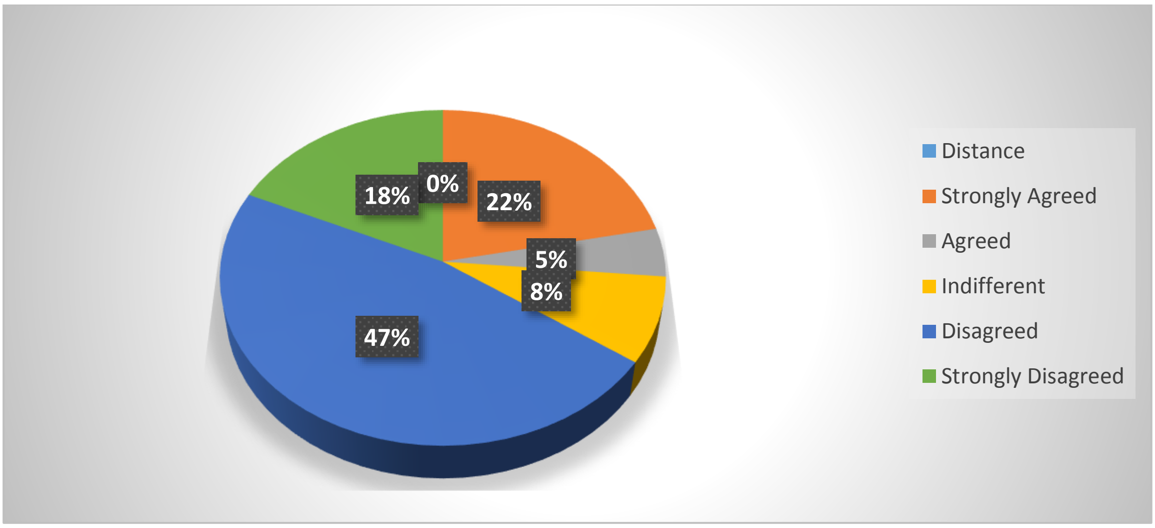


Figure 6: Distance from Telecom Masts to Residents

Source: Authors Fieldwork, 2016

Consultation Made Before Sitting of Telecommunication Mast

The research investigated the development of siting of telecommunication mast in the study area. The field survey as presented in Figure 6 shows that there have been different opinion and perception of residents in the city as it pertains to consultation been made by telecommunication operators when erecting their base stations . The result from the findings reveals that 13.5% of respondents strongly agreed that there was some consultation been made by telecommunications operators before siting their mast; 5.2% agreed; 20.2% neither agreed nor disagreed; 48.7% of the respondents disagreed that there was no consultation been made while 12.4% strongly disagreed to that.

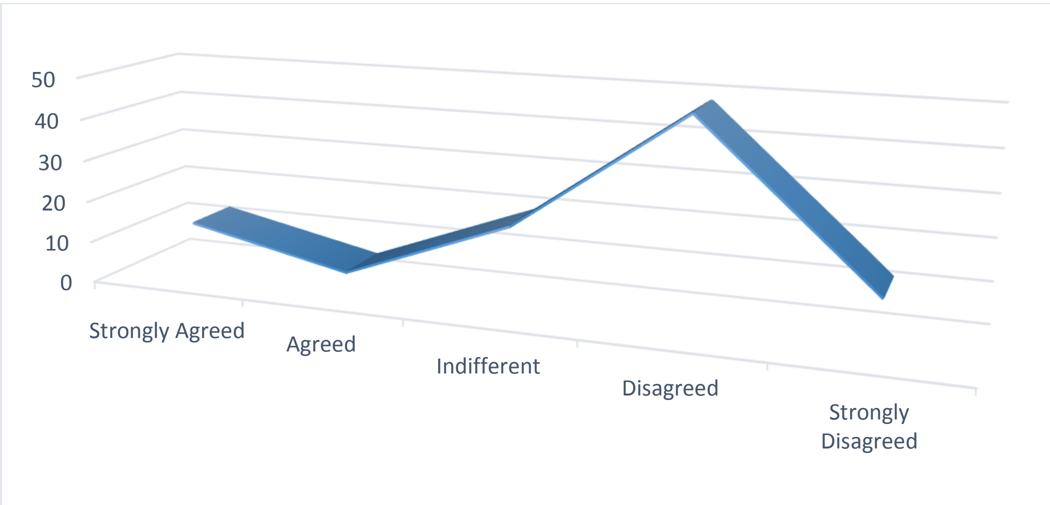


Figure 7: Consultation made before the siting of Telecom Masts

Source: Authors Fieldwork, 2016

CONCLUSION

The study revealed that there is proliferation of base stations in the study area with about 92 base stations. The standard of the siting of base stations indicated that there supposed to be about 80 of such stations. The districts in the study area revealed that different types of pollutants being released by the base stations. The pollutants range from noise, CO_2, NO_2, SO_2 and THC. All these are injurious to human health. Different districts also shows different pollution level, the worst hit is Maitama district and least polluted is Garki district.

The perception of the residents of FCC varies on the benefits and environmental consequences of the proliferations of the base stations. Majority of respondents disagreed with the siting of the base stations and the environmental impact range from pollution, e-waste among others which has both positive and negative impact on the environment. The presence of pollution that is injurious to human health and e-waste is a threat to sustainability of the city and human race.

RECOMMENDATION

The environmental problems associated with siting of base stations lead to contamination of the air quality which may lead to severe environmental pollution and health problems. The study therefore, recommends that the use solar energy should be adopted by telecommunication service operator as an alternative means of power generation. The diesel power generating used by the telecom service operators set should replace by less combusting and less vibrating one. In addition the telecom operators should adopt the latest (modern) technological methods of operating and maintaining the base stations.

REFERENCES

Aderoju Olaide M, Godstime James, Olojo Olabamiji, Oyewumi Ademuyiwa, Eta Joseph, Onuoha Hilda U, Salman Khalid, Nwadike Blessing K. (2014): Space-Based Assessment of the Compliance of Gsm Operators in Establishing Base Transceiver Station (Bts) In Nigeria Using Abuja Municipal Area Council as Case Study. *Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 8, Issue 10 Ver. I (Oct. 2014), PP 46-57*

Bello, M.O. (2010). Effects of the Location of GSM Base Stations on Satisfaction of Occupiers and Rental Value of Proximate Residential Property. *Journal of Computer and Information Science,* 3(4), 159 – 170

Berkhout, F and Hertin, J. (2012). Impacts of Information and Communication Technologies on Environmental Sustainability: Speculations and Evidence: Report of OECD. Available online at http://www.ictliteracy.info/rf.pdf/OECD-ICT-EnvrnmtImpct.pdf [Accessed 9th July 2012].

Dürkop, H. J. and Englert N. (Editors) 2004. Environmental health in Germany Every Day examples: Status as of April 2004. Published by Bundesamt für Strahlenschutz, Federal Office for Radiation Protection, Postfach

Ekata, G., & Kostanic, I. (2014). OPEN ACCESS A Model for Monitoring GSM Base Station Radiation Safety in Nigeria, *4* (10), 97–104.

Electronics Takeback Coalition 92012). Facts and Figures on E-Waste and Recycling. Available online at http://www.electronicstakeback.com/wp-content/uploads/Facts_and_Figures [Accessed 9th July 2012].

Gartner P (200). Gartner Estimates ICT Industry Accounts for 2 Percent of Global CO_2 Emissions. Available online at http://www.gartner.com/it/page.jsp?id=503867 [Accessed 9th July 2012].

IFC, (2007). General EHS guidelines: environmental air emissions and ambient air quality: Environmental, Health, and Safety Guidelines. International Finance Corporation

Infocomm Development Authority of Singapore (2012). Infocomm Statistics. Available online at http://www.ida.gov.sg/Annual%20Report/2010/subpages/infocomm_stats/infocomm_industry.htm l [Accessed 9th July 2012].

Ministry of the Environment and Water Resources, Government of Singapore. About the Sustainable Blueprint. Available online at http://app.mewr.gov.sg/web/Contents/ContentsSSS.aspx?ContId=1034 [Accessed 9th July 2012].

Ndukwe E. (2003): An Overview of the Nigeria Telecommunications Environment, Nigerian Communications Commission.

Ndukwe E. (2004): Use of Wireless Infrastructure for Accelerating Universal Service Provision in Nigeria. PP 1-4.

Nigeria Bureau of Statistics (2015):00 Nigeria Telecommunications Sector: Quarter 1 2015 summary report

Nigeria Communication Commissions (2014): "*Industry information*" Available at http://www.ncc.gov.ng/index.php?option=com_content&view=category&id=65&Itemid=67

Olukolajo, M. A., Ezeokoli, N. B., & Ogungbenro, M. T. (2013). Locational Effect of GSM Mast on Neighbouring Residential Properties ' Rental Values in Akure , Nigeria, *2*(3), 147–156. http://doi.org/10.5901/ajis.2013.v2n3p147

Otubu A. K. (2012) Mass Mast in Planning and Environmental Law Maze: Need to Regulate. Available at SSRN:http://ssm.com

Satish, S. (2012). Sustainable E-Waste Management. Available online at http://www.toxicslink.org/art-view.php?id=134 [Accessed 9th July 2012].

Shalangwa D.A (2010): Measurement of Exposure of Radiofrequency Field (RF) Radiation from Global System for Mobile Communication (GSM) Mast. *Journal of Electrical and Electronics Engineering Vol.2* (3); pp.75-84. Available online at http://www.academicjournals.org/jeeer ISSN-2367

The Mobile Operators Association (2015):"Base Stations and Mast" what is Mast? Available at www.mobilemastinfo.com/base-stations-and-masts retrieved on 12th August 2015.

Thioune R.M.C (2003): Information and Communication Technologies for Development in Africa. Opportunities and Challenges for Community Development. Volume 1. Ottawa.

Thisday (2013): "Nigeria: Menace of Indiscriminately-Mounted Communication Masts retrieved on 21st August 2015 from http://allafrica.com/stories/201305231136.html

Turletti, T., Bentzen, H. J. and Tennenhouse, D. 1999. Toward the Software Realization of a GSM Base Station. IEEE J. on Selected Areas in Communications, 17(4): 603-612

United Nations (2005). The 2005 World Summit. Available online at http://www.un.org/summit2005/ [Accessed 9th July 2012].

ABOUT THE AUTHORS:

Musa DALIL, YAHAYA Abdullahi Abbas, and ABD'RAZACK Nelson Tajudeen Adewale: Department of Urban and Regional Planning, Federal University of Technology, Minna, Nigeria.

Umar Faruk Yaya: Department of Urban and Regional Planning, Ahmadu Bello University Zaria, Nigeria