Sudan University of Science & Technology
College of Graduate Studies

كلية الدراسات العليا

Effect of Radiation Power from Towers and Transmission Lines on Safe Healthy Distance in Khartoum State

تأثير القدرة الاشعاعية الصادرة من الأبراج وخطوط الضغط العالي على المسافة الصحية الامنة في ولاية الخرطوم

A Thesis Submitted for Fulfilment of the Requirement for the Degree of Ph.D. in Physics

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بسم الله الرحمن الرحيم

الآية

قال تعالي:

(اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ * خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ * اقْرَأْ وَرَبُّكَ الْأَكْرَمُ * الَّذِي عَلَّمَ بِالْقَلَمِ * عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ) [العلق: 1 - 5]

(يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ) [المجادلة: 11]

(وَلَقَدْ آتَيْنَا دَاوُودَ وَسُلَيْمَانَ عِلْمًا وَقَالَا الْحَمْدُ لِلَّهِ الَّذِي فَضَّلَنَا عَلَى كَثِيرٍ مِنْ عِبَادِهِ الْمُؤْمِنِينَ) [النمل: 15]

صدق الله العظيم

DEDICATION

First. I dedicate this work
To everyone who loves me and pray for
Me
In this world
To my great
Father & mother
My Beautiful children
My special Dedication to my beloved
Wife
And every Person who helped me to finish this
Research

Mohammed Idriss Ahmed
2022

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Abstract

The aim of this work is to determine the exposure to radiation from communication towers and transmission lines and the safe distance from these sources. It also aimed to determine the relation between radiation power beside safe distance and communication towers density beside high voltage power lines.

Measurements have been taken from 150 towers at distances of up to 100 m from the towers, at Khartoum, Khartoum North, and Omdurman. The measurements have been taken at frequencies of 1800 and 900 M Hz. Using the Active Log Per measurement, Aaronia Hyper LOG 4040 X, device the magnetic field strength was measured. The maximum power density found in Khartoum and the minimum in Omdurman. This could be due to the fact that the population of communication towers is maximum in Khartoum. The radiation power become negligible at 100m. It has been noticed that this distance is much smaller than that in other countries. This could be due to the relatively small density of communication towers in Khartoum compared to other countries. It is observed that the safe distance in this study is 100 m, compared to 120 m in Tanzania, 300 m in France, 400 m in Germany and 500 m in Brazil. This may be attributed to the fact that the intensity of towers is higher in these countries compared to the study area, where the high intensity towers accumulated power and dose at any point, as the comparison between towers density and accumulated power shows in this study. This makes the dose in other countries at 100 m exceeds the permissible safe dose (4.5-5-50w/nm^2). Apart from the maximum power the radiation power in Omdurman was larger in the tower vicinity compared to the ones in Khartoum. This is related to the geometry of the tower's sources. The towers sources in

Omdurman are in the form of complete Circle sources, thus radiates more photons compared to that of Khartoum which subtends 60 degrees only (1/6 circle). However, the situation is different for the maximum power which travels far from the source thus affected by the nearby towers. This means that it is affected by the intensity of the towers, which is observed, where the maximum power in Khartoum where the intensity of the towers is maximum, was higher compared to Omdurman, where the towers intensity was lower. Which are surrounding by a relatively high tower and high lines density where the number of towers in residential areas are at least two times that the Markets (AL- Souq) and school s in all Khartoum state cities as record in and figure s in this work.

The statistical data of **Radiation & Istopes Central-Khartoum (RICK)Hospital demonstrates** that the percentage of cancer disease was higher for women's (56%) compared to men's (44%) This is since women's take a very long time in homes which are surrounded by a relatively high towers and voltage lines density. This make them exposed to high radiation doses due to the increase of exposure time and towers density which increases cancer percentage, for older men (60-90) who take very long time in homes the cancer percentage (57.5%) is relatively high compared to younger ones (30-60) with preparental (42.5%) since they go to schools and markets where doses are relatively low. However, forewomen's the situation is different. The cancer is considerably low (37%) for older women's (60-90) compared to younger ones (30-59) with percentage (63%). This may be attributed to the fact that younger women's who uses cosmetics intensively and take relatively long time in homes compared to older ones who spend long time in social activities taking long time along the roads and rural areas where the doses are low.

Electromagnetic radiation has been measured from 150 high voltage lines sites at Khartoum State. At a distance of 10 m the values have been ranging from 45 to 30 n T. The values have been decreasing fast with distance to become very small at a distance of 70 m. A distance of 100 m from the lines could be considered as a safe distance. It has been noticed that there are many buildings at a distance less than 100 m from the power lines. The occupant of these houses could require regular medical checkup.

The field study made in Khartoum state for the relation of cancer with towers and high-tension voltage electric lines may be conform with that obtained from the data of **Radiation & Istopes Central-Khartoum (RICK)Hospital demonstrate**. Cancer percentage of urban areas, where radiation is intensive, is 65. 9%, about two times of that of rural areas, which is 34.1%. This results from the fact that the number of towers in urban areas are considerably large compared to rural areas. The cancer percentage for women and older men in rural areas is 86.7%, compared to workers and students, which are 13.3 %. This is related to the fact that towers are concentrated near houses rather than farms and schools which are temporarily and less populated, thus only few towers are needed for them. Recently strong evidence indicated that the appearance and wide spread of covid19 beside the increase of mortality rate, is associated with the suppression effect of G5 towers radiation on the immunity system. This suppression effect will of course increase cancer spread rate, which conforms with the results of this study.

المستخلص

الهدف من هذا البحث هو تحديد التعرض للإشعاع الصادرة من أبراج الاتصالات وخطوط النقل وتحديد المسافة الآمنة من هذه المصادر. وتهدف أيضا لمعرفة علاقة كثافة القدرة والمسافة الآمنة مع كثافة أبراج الاتصالات وخطوط الجهد العالي. بالإضافة لمعرفة علاقة كثافة الابراج وزمن التعرض مع السرطان.

وقد تم أخذ القياسات من **150** برج على مسافات مختلفة تصل إلى **100 متر** من الأبراج، في الخرطوم ، الخرطوم شمال(بحري) وأمدرمان. وقد تم أخذ القياسات عند ترددات 1800 و 900 هيرتز للابراج. وقد تم استخدام جهاز **Aaronia Hyper LOG 4040 X** لقياس شدة المجال المغناطيسي المسجلة بالموقع ،. وجد ان كثافة القدرة القصوى في الخرطوم اكبر مقارنة بالقيمة و الدني في امدرمان. قد يرجع ذلك إلى حقيقة أن عدد أبراج الاتصالات هو الحد الأقصى في الخرطوم. في وقد أصبحت قدرة الاشعاع مهملة عند **100 متر**. هذا يجعل المسافة **100 م** لتكون مسافة آمنة من الأبراج. وقد لوحظ أن هذه المسافة أصغر بكثير من تلك الموجودة في البلدان الأخرى. يمكن أن يكون هذا بسبب الكثافة الصغيرة نسبيا لأبراج الاتصالات في الخرطوم مقارنة بالبلدان الأخرى. ومن الملاحظ أن المسافة الآمنة في هذه الدراسة هي **100متر** مقارنة ب **120** متر في تنزانيا و **300** متر في فرنسا و400 متر في ألمانيا و 500متر في البرازيل . ويرجع السبب في ذلك لأن كثافة الابراج في هذه الدول عالية مقارنة بمنطقة الدراسة. حيث أن كثافة الابراج يجعل القدرة و الجرعة عاليتين. كما بينت مقارنة كثافة الابراج مع القدرة في هذه الدراسة .وهذا يجعل مدي الجرعات في مدي **100** متر في الدول الأخري يتخطى الجرعة والقدرة الآمنة المقدرة ب (50-**5**-4.5) **n W/m²**.

وبغض النظر عن القدرة القصوى.،فقد لوحظ أن قدرة مصادر الابراج في امدرمان هي أعلي من قدرتها في الخرطوم في المناطق القريبة من البرج .ويرجع السبب في ذلك الي الشكل الهندسي للمصدر .ففي ام درمان يكون المصدر في شكل دائرتكاملة لذا يصدر إشعاع ذو قدرة أعلي مقارنة بمثيلاتها في الخرطوم حيث يكون المصدر في هيئة سدس دائرة تتمدد في **60** درجة فقط. وهذا يجعل القدرة في الخرطوم أقل. ورغم ذلك فإن الوضع يختلف بالنسبة للقدرة القصوي التي ترحل

لمسافات بعيدة .لذا فهي تتأثر بالقدرة القصوي لأبراج المجاورة مما يجعلها تتأثر بكثافة الابراج .وهذا مالوحظ فعلا، حيث لوحظ ان كثافة القدرة في الخرطوم حيث تكون كثافة الابراج عالية أعلي من مثيلاتها في ام درمان حيث تكون كثافة الابراج أقل .حيث أن اعداد الابراج في المناطق السكينة علي الاقل ضعف مافي الاسواق في كل مدن ولاية الخرطوم كما هو مدون في في الجداول والرسوم في هذا البحث وقد بينت إحصاءات مستشفى الذرة بالخرطوم أن نسبة الإصابة بالسرطان أعلى في النساء **(56%)**مقارنة مع الرجال **(44%)** لأن النشء يقضون وقتا طويلا في المنازل التي بها كثافة أبراج وخطوط جهد عالية نسبيا، مما يعرضهم لجرعات عالية نسبيا فيزيد نسبة السرطان فيهم. وبالنسبة للرجال كبار السن الذين يقضون وقتا طويلا بالمنزل تكون نسبة السرطان **57.5%** ع مقارنة بصغار السن حيث تكون النسبة42.5 **%** . لأنهم يذهبون للمدارس والأسواق حيث تكون الجرعات منخفضة. ولكن الوضع يختلف بالنسبة للنساء حيث تكون نسبة السرطان متدنية بصورة واضحة لكبار السن **37%** مقارنة مع صغار السن حيث تكون النسبة **.63%** وقد يعزي هذا لحقيقة أن النساء صغار السن يستخدمن مساحيق التجميل بصورة مكثفة وياخذن زمن أطول في المنازلمقارنة مع الكبار الذين يقضون وقتا طويلا في المجاملات الاجتماعية وياخذن وقتا طويلا في الطرق والارياف حيث تكون مستويات الإشعاع منخفضة تم قياس الإشعاع الكهرومغناطيسي من **150**موقع خطوط جهد عالي بولاية الخرطوم. وعلى مسافة **10** أمتار ، تتراوح القيم بين **45** و 30 نانومتر، وتتناقص القيم بسرعة مع المسافة لتصبح صغيرة للغاية على مسافة 70 م. يمكن اعتبار مسافة **100** متر من الخطوط مسافة آمنة. وقد لوحظ أن هناك العديد من المباني على مسافة أقل من **100 م** من خطوط الكهرباء. يتطلب ساكنين هذه المنازل إجراء فحص طبي.

نجد ان هنالك علاقة بين الامراض السرطان في حيث تتراوح النسبة في النساء اكبر من الرجال وهذا يعزي الي الزمن التعرض اكبر بالنسبة للنساء. نجد ان عدد الابراج في الاسواق مقارنة بالأماكن السكينة اقل وهذا يعزي ان الزمن الذي يستغرقه الشخص في الاسواق مقارنة مع المناطق السكينة اقل تعرض.

من الملاحظ ان المسافة الامنة في منطقة الدراسة هي الاكبر من **100 م** مقارنة مع المسافة الامنة في تنزانيا اكبر من **120 م** وفرنسا اكبر من **300** متر والمانيا اكبر من **400 م**

ويرجع السبب في ذلك لان كثافة الابراج في هذة الدول عالية مقارنة بمنطقة الدراسة مما يجعل الجرعة عالية بفعل تجمع اشعاعات عدد كبير من الابراج في منطقة وهذا يجعل الجرعات في مدي الدراسة الميدانية التي أجريت في ولاية الخرطوم فيما يختص بعلاقة السرطان مع الابراج وخطوط كهرباء الضغط العالي مع تلك التي تم الحصول عليها من بيانات مستشفى الذرة بالخرطوم . حيث اتضح أن نسبة السرطان في المناطق الحضرية، حيث يكون الإشعاع كثيفا هي وهي ضعف تلك التي في المناطق الريفية والتي تساوي .وهذا ناتج من أن عدد الابراج في المناطق الحضرية أعلى . بصورة معتبرة مقارنة بالمناطق الريفية .اما نسبة السرطان للنساء وكبار السن في المناطق الريفية فتساوي وهي ذات علاقة بحقيقة أن الابراج تتركز قرب المنازل أكثر من الحقول والمدارس والتي تكون مأهولة موقتا وكثافة أقل لذا تحتاج فقط لابراج قليلة وقد ظهرت مؤخرا أدلة قوية توضح أن ظهور وانتشار مرض كوفيد بالإضافة لزياد معدل الوفيات له علاقة وطيدة بكبح اشعةابراج الجيل الخامس لجهاز المناع. هذا التأثير الكابح سيزيد بالتأكيد معدل انتشار السرطان مما يتسق مع نتائج الدراسة.

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Chapter Two: Literature Review

Abbreviations

ABREVATION &KEY WORDS

AC	Alternating current
ACGIH	American Conference of Governmental Industrial Hygienists
AMPS	Advanced Mobile Phone System
ANSI	American National Standards Institute
ARFCN	Absolute Radio Frequency Channel Number
ATMS	Antenna Test & Measurement Society
AuC	Authentication Center
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Transceiver Station
C	Capacitance
CBC	Charge Back Center
CDMA	Code-Division Multiple Access
DAMPS	Digital-Advanced Mobile Phone Service
DC	Direct Current
DCS	Distributed Control System
DER	Distributed Energy Resource
DNA	Deoxyribonucleic Acid
DS-CDMA	Direct-Sequence Code Division Multiple Access
EF	Electric Fields
EDGE	Enhanced Data Rates for GSM Evolution
EIR	Equipment Identity Register
ELF	Extremely Low Frequency
EM	Electromagnetic
EMF	Electromagnetic Fields
ETSI	European Telecommunications Standards Institute
EU	Europe Union
FACTS	Flexible Ac Transmission System
FCC	Federal Communications Commission
FDM	Frequency Division Multiplexing
FDMA	Frequency-Division Multiple Access
FH-CDMA	Frequency Hoping Code Division Multiple Access
FSK	Frequency-Shift Keying
Ft	Feet

G	Conductance
GMS	Global Management System
GMSC	Gateway Mobile Services Switching Center
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GPS	Global Positioning Satellite System
GSM	Global System for Mobile Communications
H	Magnetic Fields
HCMTS	High-Capacity Mobile Telephone System in Japan
HERO	Hazards Of Electromagnetic Radiation Ordnance
HERO	Hazards Of Electromagnetic Radiation to Ordnance
HLR	Home Location Register
HVDC	High Voltage Direct Current
Hz	Hertz
I	Current
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IMT	International Mobile Telecommunications
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
KHz	Kilohertz
L	Inductance
LAN	Wireless Local Area Network
LMR	Land Mobile Radio
LPC	Linear Predictive Coding
MCN	Multi-Channel Network
MG	Milligauss
MHz	Mega-Hertz
MS	Mobile Station
MSC	Mobile Services Switching Center
MSK	Minimum Shift Keying
MW	Microwave
NCRP	National Council of Radiation Protection and Measurements
NMT-900	Nordic Mobile Telephone in Sweden
OSS	Operations and Support Subsystem

P_{av}	Power Average
PBX	Private Branch Exchange
PDAs	Personal Digital Assistants
PLMN	Public Land Mobile Network
PSDN	Public-Switched Telephone Network
PSK	Phase-Shift Keying
PSPDN	Packet-Switched Public Data Network
PSTN	Public Switched Telephone Networks
QPSK	Quadrature Phase-Shift Keying
R	Resistance
RELP	Residually Excited Linear Prediction
RF	Radio Frequency
SAR	Specific Absorption Rate
SDH	Synchronous Digital Hierarchy
SIM	Subscriber Identity Module
SMS SC	SMS Serving Center
SS	Signaling System
SVC	Static Var Compensator
SWR	Standing Wave Ratio
TDMA	Time-Division Multiple Access
TEM	Transverse Electromagnetic
TIA	Telecommunications Industry Association
TRAU	Transcoder And Adaptation Unit
TV	Television
UHF	Ultra-High Frequency
UMTS	Universal Mobile Telecommunications System
V	Voltage
VAC	Volts Ac
VLR	Visitor Location Register
WCDMA	Wideband Cdma System
WHO	World Health Organization
WLAN	A Wireless Local Area Network
Z	Impedance
Z_{in}	Input Impedance
Z_L	Load Impedance

Chapter One

Introduction

1.1 General Background:

Nowadays, the telecommunication technology is very helpful in such a way that we can draw money from ATM centers without limitation of time. This saves time to customers as well as provides quick and easily adapted services. In connection to this, the use of mobile phone also facilitates communication among people. It is obvious that you can talk with someone who is at a far distance within seconds. These modern tools of communication are electronic devices so the user is always exposed to radiation that, to some extent, has a negative impact on the user of the device. Even though the effects are minimum, but the more the exposure to radiation, the frequent use of the electronic devices, the higher the chance to develop negative outcomes.

Researchers are trying to minimize this negative impact and recommend the safe frequency and distance. Then, it is important for researchers to conduct experiments in order that we know how often someone can be exposed to the radiation without causing great side effects.

The exposure to high electromagnetic field from high voltage power lines has an influence on the human health. It necessary to find the safe distance from the source for a person who works or lives in areas with high voltage.

There are several organizations and research bodies specialized in the study of non-ionizing radiation began a long time in conducting some tests and experiments to determine the seriousness of these radiation on human health Do you have any relationship with the health impact of diseases where these results are summarized in the table below

Table (1.1): show the Reports and previous studies of Non-Ionizing Radiation [1, 143, 144]

NO	Reports and Organizations studies of Non –ionizing Radiation (NIR)	Recommendations for studies
1	The International Committee on Non-Ionizing Radiation Protection (ICNIRP 2009) http://www.icnirp.de	• No changes needed compared to previous advises • Recommendations (1998) remain valid
2	Scientific Committee on Emerging and newly Identified Health Risks (SCENIHR), EU, January 2009 SCENIHR (2009) (all topics covered, in vitro, in vivo, epidemiological investigations)	• No cancer risk identified‘ insufficient evidence for electromagnetic hypersensitivity, cognitive effects and reproductive and developmental disorders and Uncertainties remains
3	HEALTH COUNCIL OF THE NETHERLANDS (2008-2009) (Electromagnetic hypersensitivity and effects on brain activity)	• No indications of effects on brain activity • No causal relationship between RF-exposure and complaints(hypersensitivity)
4	Swedish radiation protection agency) SSI (2009) (epidemiological investigations, in vitro, i vivo studies)	• No strong indications of effects on health
5	European Health Risk Assessment Network on Electromagnetic Fields Exposure” EFHRAN (2010) (human, in vitro and in vivo studies)	• No strong indications of effects on health • In vitro studies show at the most some ‘limited evidence’
6	LATIN AMERICAN EXPERT GROUP (2010) (all topics covered, includes exposure standards and risk communication).	• Insufficient evidence for adverse health effects from in vitro and in vivo studies • Epidemiological investigations are reassuring but uncertainty remains regarding long-term effects • Also advantages of mobile phones are highlighted
7	BIOINITIATIVE REPORT (2007-2010) (all topics covered) A Rationale for a Biologically based Exposure Standard for Electromagnetic Radiation www.bioinitiative.org/report/ index.htm	• RF-radiation is hazardous to humans, even at low (daily life) exposure levels (below the current exposure standards). • Hazards were identified for virtually all possible endpoints.

8	BELGIAN SUPERIOR HEALTH COUNCIL (2009-2010) (exposure standards for fixed antennas for mobile communication)	• Previous advises (3V/m at 900 MHz) remain valid
9	French academy of medicine, academy of sciences en academy of technologies AFSSET (2010) (Effects of mobile phones, especially on the blood-brain-barrier and brain cancer)	• So far, no indications of short-term and long-term effects • Long-term effects remain uncertain yet
10	FRENCH ACADEMY OF SCIENCES (2009) (all topics covered)	• No risks identified
11	FRENCH ACADEMY OF SCIENCES AND TECHNOLOGIES (2009) (all topics covered)	• No risks identified
12	FRENCH MINISTRY OF HEALTH (2009) (all topics covered)	• No risks from base station antennas • No indications for risks from mobile phones (but still uncertainty)
13	French Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST; 2009) (France) (all topics covered)	• Adverse effects from mobile phone technology are not proven yet
14	Bundestag (Germany, 2009) BUNDESTAG (D) (all topics covered)	• No risks • Adequacy of current German exposure standards is confirmed
15	Commission on Radiological Protection (SSK, Germany, August 2009) SSK (D) (2009) (Genetic effects)	• No scientific evidence in favor of genotoxicity of RF-radiation
16	German Federal office for radiation protection BfS (D) (2009) (Fertility)	• No significant effects on testes and sperm
17	GERMAN EXPERT GROUP ON CHILDREN (Jülich Research Institute) (2009) (risks for children)	• No indications of adverse health effects in children

18	The German Mobile Telecommunication Research Programmer (DMF, 2009) F (German) (general) http://www.emfforschungsprogramm.de/	• No reasons to lower current exposure limits
19	Radiation and Nuclear Safety Authority (STUK, Finland, 2009) (general)	• No indications of long-term effects
20	RADIATION SAFETY AUTHORITY OF 5 NORDIC COUNTRIES (Scandinavia) (2009) (all topics covered)	• There is no scientific base to conclude that RF radiation at "normal exposure levels" is hazardous to humans • There is no reason to lower existing exposure standards
21	Comité Cientifico Asesor en Radio-frecuencias CCARS (E) (2009) (general)	• No increased incidence of brain cancer • Uncertainties remain with respect to long-term effects • No reasons to lower existing exposure limits
22	COUNCIL OF MINISTERS OF ISLE OF MAN (UK) (2009) (Antennas)	• No health risks for humans • Electromagnetic hypersensitivity related to mobile phones is not proven
23	Institute of Engineering and Technology (IET, 2010) (all topics covered) Position statement on low level electromagnetic fields up to 300GHz.www.theiet.org/factfiles/bioeffects/postat02final.clin?type=pdf	• No indications of health risks
24	Reports from the Health Protection Agency (HPA)) (UK) (2010) (all topics covered) http://www.hpa.org.uk/	• No danger from mobile phones (except traffic accidents)
25	AUSTRIAN MINISTRY OF HEALTH ((2009) (all topics covered) http://www.bmg.gv.at/home	• No danger from mobile phones

26	Australian Radiation Protection and Nuclear Safety Agency (ARPANSA, 2009) (all topics covered) www.arpansa.gov.au/ www.arpansa.gov.au/pubs/eme/fact1.pdfARPANSA (AUS) (2009)	• No evidence for an increased cancer risk from mobile phone radiation
27	Health Canada, July (2009) HEALTH CANADA (All topics covered) http://www.hcsc.gc.ca/ewhsemt/radiation/cons/stations/index-eng.php http://www.hc-sc.gc.ca/ewhsemt/radiation/cons/radiofreq/index-eng.php http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/radio_guide-lignes_direct-eng.	• No risks • Current exposure limits remain valid
28	Food and Drug Administration (FDA, USA, 2009 – 2010) http://www.fda.gov/ EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertain ment/CellPhones/ucm116282.htm http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertain ment/CellPhones/ucm116331.htmFDA (USA) (2010)	• No risks from mobile phones (also in children)
29	National Cancer Institute (NCI, USA, September 2009) http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones	• No adverse effects from a mobile phone • Uncertainty related to long-term effects warrants some care
30	Committee on Man and Radiation COMAR (INT) (2009) (all topics covered) http://ewh.ieee.org/soc/embs/comar/	• Scientific data are not at all in accordance with the conclusions and assertions of the Bio initiative report. • Exposure limits (IEEE and other) are certainly adequate

31	WHO (INT) (2010) (all topics covered) http://www.who.int/en/ http://www.who.int/peh-emf/publications/facts/factsheets/en/	• Adverse effects from mobile phones are not proven
32	Council of Europe's Committee on the Environment, Agriculture and Local and Regional Affairs IARC/WHO (2011) (cancer)	• RF-radiation is possibly carcinogenic in humans (group 2B in IARC classification)
33	The International Committee on Non-Ionizing Radiation Protection ICNIRP 2017 http://www.icnirp.de.	• The Report of the 3rd International UV and Skin Cancer Prevention Conference, 2015, is published (Review of The Global Solar UV Index. Health Phys. 114(1):84–90; 2018).

1.2 Radiation Sources:

We live in a world that is full of radiation. There are numerous normal sources of radiation which have been available since the earth was shaped, like cosmic radiation. In the most recent century, we have added fairly to this regular founded radiation some artificial sources.

A great part of the artificial radiation, which individual's experience, originated from electronic items. It includes diagnostic X-ray machines, television sets, microwave ovens, radar devices, and lasers [1,2,3,5].

1.3 Ionizing Radiations:

The ionizing radiation usually has enough energy so that when hitting an atom, it can expel the firmly bound electrons from the atomic levels, causing the atom to become charged or ionized. Kinds of ionizing radiation are X-rays, used in radiography for medical diagnosis. Gamma radiation, usually emitted by radioactive atoms [4]**.**

The biological impacts of radiation are recognized in terms of their effect on living cells. For low levels of radiation experience, the biological impacts are so little that they may not be recognized in epidemiological examinations. The body repairs many sorts of radiation and chemical damage. Natural impacts of radiation on living cells may cause many different results, such as:

Cells encounter DNA harm and can't repair the damage. These cells may go through the process of programmed cell death, or apoptosis, consequently dispensing with the potential hereditary harm from the bigger tissue.

Cells encounter a nonlethal DNA change that is passed on to consequent cell divisions. This mutation may contribute to the formation of cancer [6]**.**

1.4 Non-ionizing Radiation:

It is any type of electromagnetic radiation that does not carry enough energy per quantum (photon energy) to ionize atoms or molecules [7] **.** Non-ionizing radiation is associated with two major potential hazards: electrical fields (current & voltage) and biological. International Agency for Research on Cancer (IARC) recently stated that there can be some risk from non-ionizing radiation to humans, but a consequent examination revealed that the premise of the IARC assessment was not reliable with watched rate patterns [8]**.**

1.5 Radiation from Transmission Lines

The oscillating electric and magnetic fields in electromagnetic radiation will induce an electric current when they pass in any conductor. Strong radiation can induce a current that can cause an electric shock to persons or animals. It can also overload and destroy electrical equipment [9]**.**

Extremely high-power electromagnetic radiation can cause electric currents, which are strong enough to create sparks. These sparks can then ignite flammable materials or gases, possibly leading to an explosion. This can be a particular hazard in the vicinity of explosives or pyrotechnics, since an electrical overload might ignite them. This risk is commonly referred to as Rad Hazards or HERO (Hazards of Electromagnetic Radiation to Ordnance) [10]**.**

The best way to understand biological effect of electromagnetic fields is to cause dielectric heating. For example, touching an antenna while a transmitter is in operation can cause severe burns. Birds sitting on very high-power antennas when transmission begins can be instantly cooked by the radio frequency (RF) energy. In fact, that is the principle behind the operation of a microwave oven [11]**.**

This heating effect varies with the frequency of the electromagnetic energy. The eyes are mainly exposed to RF energy in the microwave range, and the prolonged exposure to microwaves can lead to cataracts. Each frequency in the electromagnetic spectrum is absorbed by living tissue at an alternate rate, referred to as the specific absorption rate or SAR, which has units of watts per kilogram (W/kg). The IEEE and numerous national governments have set up safety limits for experience to different frequencies of electromagnetic energy in view of SAR [12]**.**

There are also a body of evidence bolsters the presence of complex natural impacts of weaker non-thermal electromagnetic fields, such as weak extremely low frequency (ELF) magnetic fields, adjusted RF and microwave fields. The theoretical mechanism of action of non-thermal electromagnetic fields is not fully understood, but there are some established biological effects for ELF. As the extent of non-thermal effects is not fully established, they may be beneficial or harmful. A common position presented regarding these effects is that, since they are not well understood, a precautionary principle approach would suggest minimizing exposure whenever possible. However, it should be recognized that the claims of biological hazards from low-energy electromagnetic radios (e.g., from mobile phones) are considered controversial [13].

1.6 Radiation from Communication Towers

Base stations transmit control levels from a few of watts to 100 watts or more, contingent upon the measure of the locale or "cell" that they are intended to benefit. Base station antennae are normally around 20-30 cm in width and a meter long, mounted on structures or towers at a stature of from 15 to 50 meters over the ground [14,15,16]. These receiving wires produce RF waves that are regularly extremely limit in the vertical heading however very wide in the flat bearing. On account of the tight vertical spread of the pillar, the RF field power at the ground specifically beneath the receiving wire is low. The RF field power increments is noted as one moves far from the base station and after that it declines at more prominent separations from the antenna [17,18,19].

Typically, inside 2-5 meters of a few antennae mounted on housetops, walls keep individuals far from places where the RF fields surpass introduction limits. Since reception apparatuses coordinate their energy outward, and don't transmit noteworthy measures of energy from their back surfaces or towards the top or the bottom of the antenna. Also, the levels of RF energy inside or to the sides of the building are normally very low [20].

Global System for Mobile Communications (GSM) and the Universal Mobile Telecommunications System (UMTSS) were issued by the phones highway in the main stations power frequencies, to allow linking handsets highway and transmitters. In the GSM the power of the transmitter in the phone highway relies on the distance between the phone and the station key. If the distance is long, the phone uses maximum power, but if the station is close, the power of the transmitter is low, and the overall goal is to run the handset and less energy is sent in order to maintain the vitality of the battery.

The human exposure to radiation is represented by the UMTSS and the Global Management System (GMS) systems. Table (2.1) shows the extent of vibrational energies that are used by the transmitters in mobile phone systems [30].

Table (1.2) the extent of vibrational energies and are used by the transmitters in Mobile Phone Systems

System	Handset	Main Station		
	Frequency Wave	Frequency Wave	Average maximum Power	Frequency Wave
	(MZ)	(MZ)	(w)	(MZ)
GMS900	**880-915**	**0.25**	**20**	**925-960**
GMS1800	**1710 -1785**	**0.125**	**25**	**1805-1980**
UTMS/WCDMA	**1920-1980**	**0.125**	**15**	**2170-2110**

1.7 Cell Phones:

In numerous nations, over a large portion of the populace as of now utilizes cell phones and the market is yet developing quickly. The business predicts that there will be upwards of 1.6 billion cell phones. Along these lines, expanding quantities of versatile base stations have must be introduced. Base stations are low-controlled radio receiving wires that speak with clients' handsets. In the beginning of 2000, there were around 20,000 working base stations in the United Kingdom (UK) and around 82,000 cell locales in the United States of America (USA), with every cell site holding one or more base stations [14].

Given the massive quantities of clients of cell phones, even little antagonistic impacts on health can have significant general health effects [15]. Several important points must be taken into consideration when evaluating possible health effects of the RF fields. One is the rate of recurrence of operation. Current cell phone frameworks work at frequencies in the range of 800 and 1800 MHz It is vital not to confound such RF fields with ionizing radiation, for example, X-rays or gamma beams. Not at all like ionizing radiation, RF fields can't cause ionization or radioactivity in the body. Along these lines, RF fields are referred to as non-ionizing radiation [16].

Mobile phones handsets and base stations present quite different exposure situations. RF experience to a client of a cell phone is far higher than to a man living close to a cell base station. Be that as it may, aside from rare signs used to keep up joins with adjacent base stations, the handset transmits RF energy just while a call is being made, though base stations are continuously transmitting signals [17].

Cell phone handsets are low-powered RF transmitters, emanating most extreme powers in the scope of 0.2 to 0.6 watts. Different sorts of handheld transmitter, for example, "walkie talkies", may radiate 10 watts or more. The RF field quality (and subsequently RF experience to a client) tumbles off quickly with separate from the handset. In this way, the RF introduction to a client of a cell phone found 10s of centimeters from the head (utilizing a "hands free" machine) is far lower than to a client who puts the headset against the head [18,19,20].

Paging and different communication apparatuses, for example, those, utilized by fire police and emergency services, work at comparative power levels as cell base stations, and regularly at a comparative frequency. In many urban areas, television and radio broadcast antennae commonly transmit higher RF levels than that of mobile base stations [21].

1.8 Health Impacts:

RF fields infiltrate exposed tissues to profundities that rely upon the frequency- up to 1 cm at the frequencies utilized by cell phones. RF energy is caught up in the body and creates warm, however the body's typical thermoregulatory operations remove this heat. All settled health impacts of RF exposure are plainly identified with heat. While RF energy can interface with body tissues at levels too low to cause any noteworthy heating, no examination has indicated unfriendly health impacts at exposure levels below the international guideline limits [22].

Most investigations have analyzed the consequences of the short-range, entire body exposure to RF fields at levels far higher than those ordinarily related to wireless communications. With the approach of such apparatus as walkie-talkies and cell phones, it has turned out to be clear that few examinations address the outcomes of limited subjection to RF fields to the head [23].

World Health Organization (WHO) has identified research needs to make better health risk assessment, and it has promoted the research to funding agencies. Briefly, at present time this research indicates the following [24].

Current scientific confirmation shows that subjection to RF fields, for example, those generated by cell phones and their base stations, are probably not going to prompt or advance tumors. A few investigations of creatures presented to RF fields like those emitted by cell phones revealed that there is no proof that RF causes or advances cancer disease. While one 1997 investigation found that RF fields expanded the rate at which hereditarily designed mice created lymphoma, the health ramifications of this outcome is vague. A few investigations are in progress to affirm this finding and decide any significance of these outcomes to growth in individuals. Three late epidemiological examinations found no convincing evidence of increase in danger of malignancy or some other sickness with utilization of cell phones [25].

Researchers have studied different impacts of utilizing cell phones incorporating changes in brain activity, response times, and sleep patterns. These effects are small and have no apparent health significance. More studies are in progress to try to confirm these findings [26]. Research has obviously demonstrated an expanded danger of car crashes when cell phones are utilized while driving [27].

Although the radiation energy emitted from the handset are relatively low, but that the device is very close to the human body when it is used close. In addition, it absorbs electromagnetic radiation, which are transformed into thermal energy, and in extreme cases of high surface temperature of 0.1 ° C brain, it has been shown that such a rise in temperature is not such harmful. In ordinary cases, the change in the temperature of the brain in the range 16 ° C may not cause a temperature rise or any damage to the brain. In contrast, if the rise was 5 degrees Celsius on the surface of the skin temperature and tends to rise slightly more than that, but it remains lower than the temperature rises in the case of the handset.

This did not prove that the equipment's operating system manual GMS causes any negative effects on the human body and in any case, the studies are still going worldwide to check but it is likely that there aren't any effects that may be caused by radiation [31].
The radiation emitted from television sets and broadcast stations operating on the waves very high Ultra High Frequency (UHF) at 10 meters has almost the same effect as that emitted from the main station on the GMS system operating distance of 400 meters [32].

1.9 Health Precautions to Be Considered When Creating Base Stations:

With the growing demand for telecommunications services, the studies started to show some of the implications as appropriate and most commonly. Those are related to the precautions and caveats regarding health when using the Mobile Phone. In addition, the likelihood of subjection to harmful radiation issued by the transmitters located in the main stations were also, in many cases, criticized due to the installation discordant of antennas within the main stations[28]. On the walls and roofs of buildings, especially when we set up such structures in construction with attractive architectural qualities. It is also complaining of high towers or car, which has negative impacts on the landscape of the villages and in some cities. It looks clear that the operators and the regulatory authorities should make more efforts to avoid criticism and public awareness about the issues of radioactivity [29].

1.10 Mobile Radiation Accumulation Through Additivity and Reflectivity Hazard:

The density of mobile users is rapidly increasing. At the point when many cell phones generate radiation, their aggregate power is observed to be like that of a microwave stove or a satellite telecom station. Along these lines, the inquiry emerges: what is the general population subjection level in a range with many sources of electromagnetic wave emission? This level can achieve the reference level for overall population exposure (the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guideline) in day-by-day life. This is caused by the central properties of electromagnetic field, specifically, reflection and additively. The level of exposure is observed to be significantly higher than that which is evaluated by the customary system of examination that assumes that the level quickly diminishes with the converse square distance between the source and the affected person [35].

1.11 Field Power Density Evaluation:

If the detailed electrical structure inside an antenna is known, it becomes easy to perform a more rigorous calculation of power density. By the representation of such a near-field calculation, we will be able to evaluate the precise variation of power density (or field strength) at all distances and in all directions from an antenna near field.

If the total power, fed into an antenna, is known as well as the antenna gain, the power density in the main beam can be calculated by assuming an inverse law dependence upon distance at all distances from the antenna. The following equation is analogous to equation (1.1) and may be used for power density, S, in this way:

$$\boldsymbol{S} = \frac{\mathbf{P_{rad}\ G}}{\mathbf{4\pi\ d^2}} \qquad (1.1)$$

Where d is the distance from the antenna, P_{rad} is the total radiated power and G is the antenna gain (in liner units).

Reflection may increase or decrease the power density from that calculated by equation (1.1) if the path, length travelled by a reflected wave, is comparable with the with the direct distance to an antenna. The most likely situation where this could occur would be expected to increase the electric field strength by a factor of up to two, thus the total power density would be increased by a factor of up to four. The use of equation (1.1) overestimates the power density in directions other than the main beam, because the antenna gain is effectively less in these directions.

1.12 Maximum Radiation Limit Allowed

Table (1.3) shows the maximum limits allowed for human exposure, based on the recommendations of the relevant European organizations.

Table (1.3) the maximum limits allowed for human exposure in Finland.

Type of Main Station	The Maximum degree of the radiation intensity (W/m^2)	
	Ordinary people	**Workers (temporary)**
GSM900	**4.5**	**22.5**
GSM1800	**9**	**45**
UTMS/WCDMA	**10**	**50**

1.13 Construction and the installation of antennas on the Base transceiver station (BTS) towers and on surfaces, especially in Urban Areas:

Construction is often performed by installing antennae on roofs of disparate forms because of the narrow structures from an environmental perspective, especially in urban areas. In most cases, this is the situation when you start to run any mobile phone when the number of subscribers is still a little bit and be part of a large spectrum bandwidth is still available. When installing the antennas and the Base transceiver station (BTS), it can get to the installation of more and smaller cells with the substantial increase in network capacity and in this stage must install more antennas at low altitudes in order to avoid interference with neighboring channels. It is usually, at this stage, the installation of antennas on the walls of buildings to reduce radiation of the curved side of the antenna and to use parts of the mini antenna as cells.

In cases where the network operators can get more areas of the spectrum to increase the capacity of their networks, those practices are not required continuously because it is more expensive for operators to install Multi-Channel Network (MCN) instead of changing the allocation of frequencies in the network which is easier and is considered one of the regular duties for operators.

This can effectively affect the construction to install BTS antennas by measuring the officials of the municipalities to grant building permits by specialists who will put strict conditions on the operators, so they will have to use their construction acceptable aesthetic and environmental in urban areas [34].

The transmitters range effort is from 0.3 to 50 watts according to each individual case. When the use of large cells in rural areas, the energy used up to the highest level. In such cases, they use high-rise towers, which means that no individual can be close to the antenna. In cities and regions main low, the number of transmitters and the required density will be different depending on the cell concerned. The performance will keep transmitters in continuously operating mode on the (broadcast channel) and run other devices only when calls are connected through. The purpose is to keep the energy transmission in the lower pressed to avoid any unnecessary interference.

1.14 Exposure measurement:

Specific Absorption Rate (SAR) is a measure of the rate at which radio frequency (RF) energy is absorbed by the body when exposed to radio-frequency electromagnetic field. The most common use is in relation to cellular telephones. In the United States, the Federal Communications Commission (FCC) has defined limits for safe subjection to RF energy delivered by cell phones and requires that telephones sold in the U.S. have a SAR level at or underneath 1.6 watts per kilogram (W/kg) taken over a volume of 1 gram of tissue. In the Europe (EU), the corresponding limit is 2 W/kg (averaged over ten grams of tissue) [25].

SAR is one of the criteria that is used to place instructions or limitations of any network operator and is defined as the rate of absorption of the mass of the body or any article as the ability of the radioactive base station antenna, and it is calculated from the following equation [36].

$$SAR = \frac{\delta E^2}{2\rho_t} \qquad (1\text{-}2)$$

Where δ (S/m) is the amount of electrical conductivity of the fabric as an example of the frequency of 500 MHz, the conductivity of the liver of the man is 0.148, compared at frequencies of 27 MHz and 2.45 GHz the conductivity of the liver is 0.382 and 1.687, respectively [37]. E(V/m) is the electric field. Strength measured (kg/m^3) is the mass density of the fabric.

By the electric field strength, the conductivity and the mass density of the material, we can easily calculate the value of SAR. If we consider that the electrical conductivity of tissue 0.38 (S/m) and the density of tissue mass in a certain area (kg/m^3) 0.4 and the electric field strength (v/m) 0.4085, the specific absorption rate (SAR) will be 0.1 (W/kg) [38].
This is by the selection of the ICNIRP basic levels of exposure of the two areas in the electric and magnetic frequencies between 10 MHz and 10GHz.

Table (1.4) The ICNIRP guidelines for specific absorption rate value

Exposure quantity	General public
Average SAR on the body for 6 minutes	**0.08 W/kg**
Average SAR on 10 gm of the head And trunk for 6 minutes	**2 W/kg**
Average SAR on 10 gm from the lungs For a period of 6 minutes	**4 W/kg**

We conclude from the above Table (1.4) that the value of specific absorption rate at any point along the antenna must be less than the limits specified by the safety instructions INCIRP or less than 0.08W/kg.

1.15 Safety standards

With a specific end goal to secure the populace living around base stations and clients of portable handsets, governments and administrative bodies adopt safety standards, which translate to limits on exposure levels below a certain value. There are many suggested national and universal guidelines, yet that of the International Committee for Non-Ionizing Radiation Protection (ICNIRP) is the most regarded one and has been embraced so far by more than 80 nations. For radio stations, ICNIRP proposes two health levels: one for occupational subjection, another for all the general population. Currently there are efforts underway to harmonies the different standards in existence [39].

Radio base licensing procedures have been built up in the larger part of urban spaces controlled either at city, state, or national level. Tele-communications are required to obtain construction licenses, provide certification of antenna emission levels and assure compliance to ICNIRP standards and/or to other environmental legislations. Posterior alterations in the level of outflow, number of dynamic antennas or technology guidelines utilized as a part of an introduced antenna cluster may require new licensing procedures [41].

Numerous administrative bodies likewise require that contending broadcast communications attempt to accomplish sharing of towers in order to diminish ecological and restorative effect. Regarding this issue, it is an influential factor of rejection of installation of new antennas and towers in communities. In some cases, camouflaging the towers like tree trunks and other more visually acceptable structures have been tried [40].

1.16 The International Commission on Non-Ionizing radiation protection (ICNIRP)

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an autonomous logical association in charge of giving guidance and exhortation on the health dangers of non-ionizing radiation introduction. ICNIRP was sanctioned in 1992. The Association keeps up a nearby contact and working association with every single worldwide body occupied with the field of non-ionizing radiation protection and represents radiation protection professionals worldwide through its nearby cooperation with the International Radiation Protection Association and its national societies [40].

Work is conducted in conjunction with worldwide and national health and research associations and additionally colleges and other scholastic foundations. ICNIRP has established four standing Committees covering epidemiology, medicine and biology, physics and engineering, and biophysical aspects of optical radiation. ICNIRP international membership comprises individual experts covering the disciplines of medicine, biology, epidemiology, physics, and engineering [41]. ICNIRP has identified reference levels for public subjection to electromagnetic fields in the frequency range between 10MHz to 300GHz [41].

Table (1.5) shows the ICNIRP Reference levels

Frequency range	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (W/m^2)
10 - 400 MHZ	**28**	**0.037**	**2**
400 - 2000MHZ	**1.375f1/2**	**0.0037f1/2**	**f/200**
2 - 300GHZ	**61**	**0.16**	**10**

1.17 The Research problem

According to the previous studies, every day, modern buildings are being built and antennas and transmission lines surround these buildings. Most of them are close to the areas where citizens live. All organizations and countries working in human rights started experimenting and research to find out if there is an effect of the sources (antennas and transmission lines) on health. We hope this research will contribute to these efforts and that is by studying the effect of the exposure to antennas and transmission lines.

1.18 Objective of study

The objectives of this study can be summarized in the following points:

- To evaluate the electromagnetic radiation from communication towers and high voltage lines and compare it with the data of International Commission of Non–ionizing Radiation Protection (ICNRP).
- To determine the safe distance from the source and what conditions should be observed by those who live nearby high voltage areas.

1.19 Layout of the thesis

The first chapter is the introduction which includes the electromagnetic radiation from communication systems and power lines، In addition to previous studies on non-ionizing radiation. The history and development of the communication systems have been reviewed in chapter two has Literature Review for wireless system communication, Towers describe the structure and operation of communication towers and transmission lines Chapter Three, materials and Method, Device used, how can sleeted the date of measurement. contains the measurements of the electromagnetic radiation, taken at different distances from communication towers and high voltage lines, in Khartoum State and Collecting antennas data in Khartoum State according to the telecom operators are discussed in chapter four contains the Results discussion of measurement taken. Chapter Five Conclusion and Recommendations.

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Chapter Two
Literature Review

2.1 Wireless communications systems

2.1.1 Introduction

The rapid technological development has evolved with the wireless communications systems, which have spread widely, and have affected our daily lives. It is difficult to live without the receiving of broadcast TV channels or the cell phones, which become a feature of our times. In addition, wireless communications sector (especially cell phones) is one of the most sophisticated and popular sectors around the world, and it is not limited to voice only, but broad to include the transfer of data, pictures and video.

Wireless can be defined as the exchange of data or power between at least two points that are not associated by an electrical conductor. The most widely recognized wireless innovations utilize radio waves. Radio waves separations can be short, for example, a couple of meters for Bluetooth or can reach the extent of many kilometers for profound space radio communications. It envelops different sorts of settled, versatile, and convenient applications, including two-way radios, cell phones, personal digital assistants (PDAs), and wireless systems administration. Different cases of uses of radio wireless innovation incorporate Global Positioning Satellite System (GPS) units, carport entryway openers, wireless Personal Computer (PC) mice, consoles and headsets, earphones, radio collectors, satellite TV, communicate TV and cordless phones [42].

2.2.2 Conventional Wireless Systems (Single - Cell):

Traditional or conventional wireless systems emerged after World War II, and the main objective of these systems was to ensure communication vehicles and mechanisms in mobile and connected to the public switched telephone networks (PSTN) as shown in Figure (2.1). It is noted that its dependence on the quality of the analogue transmission is weak, and it was confined at first to be used in the military navigation systems in air and sea, and then was used in private uses such as taxis [43].

Figure (2.1) wireless systems (single - cell).

2.2.3 Shortcomings of the conventional systems [44]:

1. High cost (of the device and the access code).
2. The large size and the weight of the mobile devices.
3. Cover a relatively limited area using the tower (one cell).
4. Limited capacity for several participants (approximately 25 channels).
5. The possibility of intrusion of non-use encryption system.
6. Low-quality connection.

2.3 Cellular systems:

The basic principle in cellular systems is to divide the service area to units called cells, and to use the tower to cover each cell using the low energy for each tower to forestall interference on account of utilizing a similar frequency with another cell, as in Figure (2.2) and thus there is no need to use the high energy cellular equipment, as it was possible to increase the capacity of the cellular systems by adding more towers (cells), and it was possible to move between cells, Figure (2.3). This added many services in addition to voice transmission, and featured a number of systems used in the first analogue system known as the first-generation, and then evolved to other systems using the digital systems which is known as the second generation, and these systems are still under development to improve their performance, and to provide many services, including voice video, internet services, and comprehensive geographic coverage using satellites, which is the third generation, and now, we will come with a summary of the most prominent characteristics of these generations [45].

Figure (2.2) the distribution of cells.

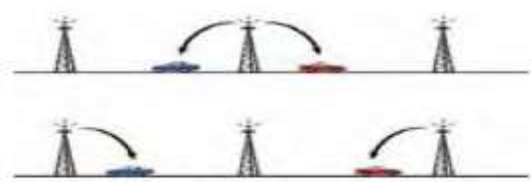

Figure (2.3) the ease of movement between cells.

2.3.1 The First generation G1 1980:

Systems of this generation was the first example to employ the principle of the cell. It started from the late seventies and was used in these services until the early nineties, and it was characterized by using the analogue system. It used the frequency-division multiple access (FDMA) and the system of analogue modulated analog FM. Examples of that: Advanced Mobile Phone System (AMPS) in the United States of America, Nordic Mobile Telephone (NMT-900) in Sweden, and High-Capacity Mobile Telephone System (HCMTS) in Japan [46].

The characteristics of the first generation are:

1. It is not compatible in the system, and relies on different frequencies because of the lack of a unified international standards.
2. Limited capacity and expansion (a weakness in the used technology).
3. Low quality due to the analogue system.
4. Weak protection against the child for not adopting encryption system.
5. Limited to voice services only.

2.3.2 The Second-Generation G2 1992:

This generation system is featured by using the digital technology, after the development of industry and the development of digital circuits for data transfer speed, and it was characterized by high capacitive compared to the first-generation systems. International standards had been set for these systems, that made it easier and more spread.

The used technique: using access techniques, including the time-division multiple access (TDMA) and frequency-division multiple access (FDMA), code-division multiple access (CDMA), digital technology including the quadrature phase-shift keying (QPSK) and Gaussian Minimum Shift Keying (GMSK) in the transmission and reception. Examples of that**:**

(a) Digital-Advanced Mobile Phone Service (DAMPS), United States of America, and it uses TDMA.

(b)GSM, Europe, and it uses TDMA.

(c) IS-95 (CDMA ONE), United States of America, it uses CDMA. Smit M, Leijtens X, Ambrosius [47].

The Characteristics of the second-generation G2 1992 [48]:

1. Capacity expansion and the high possibility of a phone prohibitively.
2. High quality due to its reliance on digital inclusion.
3. Strong protection against the intrusion due to the use of digital encryption techniques.
4. Providing many services, such as moving text SMS, fax, and others.
5. Small devices and low energy consumption.
6. International Roaming Service.

2.3.3 Second-generation developer 1999-2001 G2.5 (Phase 2):

A generation of development and transition to the third generation, where the use of additional systems was adopted to increase the speed of data transfer more than the previous second-generation systems that use TDMA, enabled the use of internet applications, and data transfer and multimedia. The techniques used:

(a) **General Packet Radio Service (GPRS):** to develop and use the Global System for Mobile Communications (GSM).

(b) **Enhanced Data Rates for GSM Evolution (EDGE):** used to develop a system DAMPS GPRS system which uses the GSM systems.

(c) **Contusion 2000 1X**: which are used to develop the IS-95 (CDMA One).

2.3.4 Third-generation 2001 G3:

After the great success of the second-generation systems, especially the GSM system, the research started to move towards the integration of many systems in one system which includes cellular systems, cordless phones systems, and systems of satellites, and they are all incorporated into the unified global system. The international organizations started to develop uniform standards for systems of this generation, and some of these systems appeared in Japan and South Korea and sustained by many of the countries of the world [49].

The technique used the wideband CDMA (WCDMA) system access and modulated the QPSK in the transmission and receiving, such as Universal Mobile Telecommunications System (UMTS) in Europe and Japan.

The Characteristics of the Generation includes [49]**.**

1. A uniform high standard.
2. Global roaming.
3. High-speed data transfer.
4. Acceptable quality of transfer of multimedia.
5. Constant contact with the Internet.

2.3.5 The fourth generation G4 2010:

The basic orientation in this generation is to reach the data transfer speed as high as 100Mbps to serve video applications and the internet. It will use the protocols of networks and address the protocols of internet (IP Address) per user, and it is the closest to the principle of wireless networks, a wireless local area network (WLAN), and its target will be cells local groupings population, offices and companies, and may not exceed the range of cells 100m (pico-cells), and this requires the installation of thousands of cells within the same city [49].

Characteristics of this generation:

Addition of the 3G generation properties [50]

1. Relatively high melting and boiling point.
2. Extensive quantities.
3. Fixed fiber broadband services for the consumer.
4. Very poor partial correlation properties.

2.4 Global system for Mobile Communications (GSM):

To encourage roaming from one nation to another inside Europe utilizing a similar versatile terminal, in 1983 the European Telecommunications Standards Institute (ETSI) formed the Global System for Mobile Communications (GSM) to develop standards for mobile communication system. As the standard has been adapted widely by many countries in Asia, Africa, and the Middle East in addition to Europe, GSM is nowadays referred to as Global System for Mobile Communications. GSM is a cell network, which implies that cell phones interface with it via scanning for cells in the near region [45].

2.4.1 Notable Characteristics of GSM:

The notable characteristics of GSM are:

1-It is dependent on advanced innovation, so security can be incorporated with the framework effortlessly and has all the advantages of the digital communication systems.

2- A higher calling capacity per cell (about 125 calls per cell) as compared to analog systems.
3- Support for international roaming.
4- In addition to the voice services, data services are also supported.
The broad specifications of the GSM system are:

- **Frequency band:** 900MHz band (890-915 MHz for uplink and 935-960 MHz for downlink) (channel numbers from 1 to 124). As the 900MHz band come to be overfilled, 1800MHz band has been designated with 1710-1785 MHz for uplink and 1805-1880 MHz for the downlink. The systems operating in 1800 MHz band are referred to as the distributed control system (DCS) 1800 (channel numbers 512 to 885). GSM 1900 MHz band (1850–1910 MHz for uplink and 1930–1990 for downlink) (Channel numbers are from 512 to 810).
- **Duplex distance** (distance amongst uplink and downlink frequencies): about 45MHz.
- **Channel spacing** (amongst adjoining carrier frequencies): around 200kHz.
- **Modulation:** It is performed using GMSK. GMSK is a unique type of the frequency-shift keying (FSK), ones and zeros are denoted by moving the RF carrier ± 67.708kHz. FSK modulation, in which the bit rate is precisely four times the frequency shift, is referred to as the minimum shift keying (MSK). As the modulation spectrum is decreased by applying a Gaussian pre-modulation filter to elude the spreading energy into the neighboring channels, this modulation is referred to as Gaussian MSK (GMSK).
- **Transmit data rate** (over the air bit rate): 270.833kbps, that is precisely four times the RF frequency shift.
- **Access method:** Time-division multiple access (TDMA) with eight time slots and frequency-division multiplexing (FDM).
- **Speech codec:** 13kbps using residually excited linear prediction (RELP), a derivative of the Linear predictive coding (LPC) technique.
- **Signaling:** Signaling System No. 7 (SS7) is used to carry out signaling. Hence, the radio channels are used efficiently for speech transmission.

2.4.2 GSM System Architecture:

A GSM network consists of several functional entities, whose functions and interfaces are defined. Figure (2.4) shows the design of a generic GSM network. The GSM system can be separated into three expansive parts [49]. The subscriber conveys the mobile station; the Base Station Subsystem (BSS) which controls the radio connection with the mobile station; and the Network Subsystem, the fundamental piece of which is the Mobile Services Switching Center (MSC), plays out the exchanging of calls between the mobile and other settled or portable system clients, and the administration of mobile administrations, for example, validation. The operations and maintenance center, which administers the correct operation and setup of the system, isn't appeared in the Figure.

The mobile station and the Base Station Subsystems link via the Um interface, also referred to as the air interface or the radio link. The Base Station Subsystem links with the network service switching center via the A interface. The new added parts of the GSM architecture (Figure 2.5) contain the functions of the databases and messaging systems such as

- Home Location Register (HLR)
- Visitor Location Register (VLR)
- Equipment Identity Register (EIR)
- Authentication Center (AuC)
- SMS Serving Center (SMS SC)
- Gateway MSC (GMSC)
- Charge Back Center (CBC)
- Operations and Support Subsystem (OSS)
- Transcoder and Adaptation Unit (TRAU)

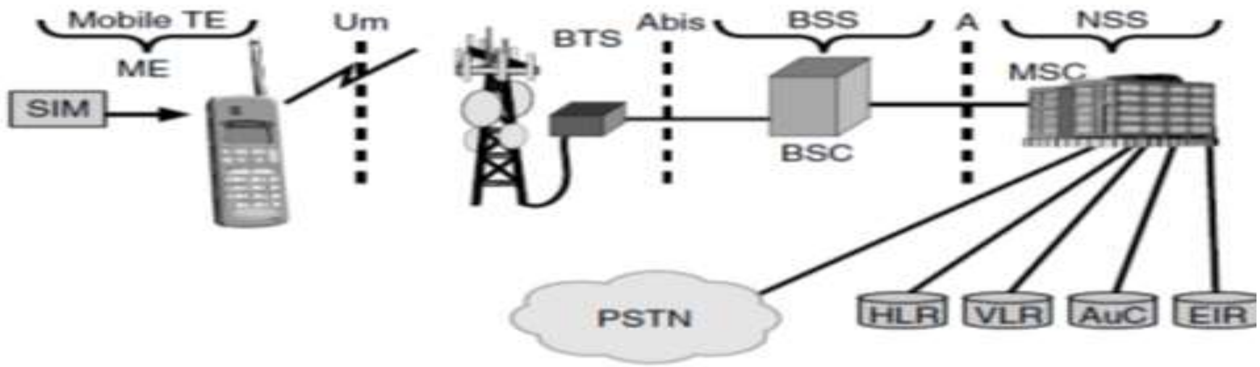

Figure (2.4) The GSM architecture.

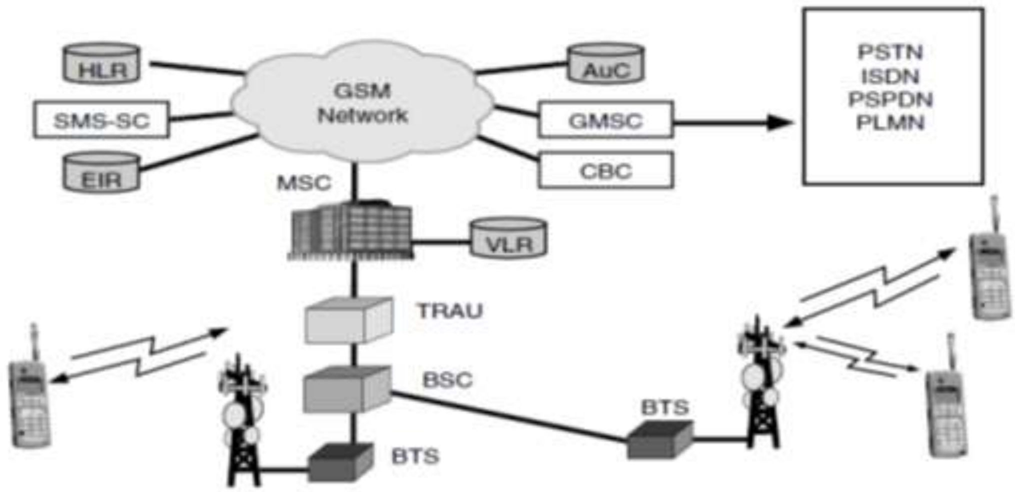

Figure (2.5) the new added parts of a GSM network.

2.5 Mobile Station (MS)

The mobile station (MS) comprises of the physical apparatus, for example, the radio transceiver, display and digital signal processors, and a smart card called the Subscriber Identity Module (SIM). It provides the air interface to the user in GSM networks. In addition, other services are provided, which include [51]**:**

- Voice Teleservices
- Data Bearer services
- Featured Supplementary services

2.5.1 The Base transceiver station (BTS)

The Base Transceiver Station (BTS) (shown in Figure (2.6) houses the radio transceivers that characterize a cell and handle the radio link protocols with the mobile station. In an extensive urban territory, a substantial number of BTSs might be deployed. The requirements for a BTS are [52]:

■ Ruggedness
■ Reliability
■ Portability
■ Lowest fee

The BTS relates to the transceivers and antennas utilized as a part of every cell of the network. A BTS is normally set in the focal point of a cell. Its transmitting power characterizes the cell's size. Each BTS has in the range from 1 to 16 transceivers relying upon the number of clients in the cell. Each BTS assists as a single cell. It additionally incorporates the following capacities [53]:

- Encoding, encrypting, multiplexing, modulating, and feeding the RF signals to the reception apparatus.
- Transcoding and rate adjustment.
- Time and frequency synchronizing.
- Voice services through full- or half-rate.
- Decoding, decrypting, and balancing received signals.
- Random access detection.
- Timing advances.
- Uplink channel estimations.

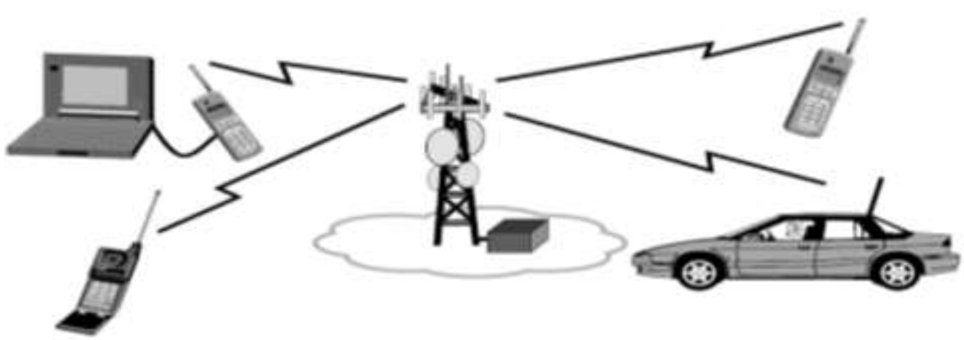

Figure (2.6) The BTS.

The Base Station Controller (BSC) deals with the radio assets for at least one BTS. It handles radio channel setup, frequency jumping, and handovers. The BSC is the link between the mobile and the Mobile administrations witching Center (MSC). The BSC additionally converts the 13-Kbps voice channel utilized over the radio connect to the standard 64-Kbps channel utilized by the Public-Switched Telephone Network (PSDN) or the integrated services digital network (ISDN). The BSC is between the BTS and the MSC and gives radio asset administration to the cells under its control. It allocates and discharges frequencies and time periods for the MS. The BSC additionally handles inter-cell handover. It controls the power transmission of the BSS and MS in its zone. The capacity of the BSC is to dispense the fundamental schedule vacancies between the BTS and the MSC. It is a switching device that deals with the radio assets. Extra capacities include [54]:

■ Control of frequency jumping.

■ Accomplishment of traffic concentration to decrease the lines' number from the MSC.

■ Supplying an interface to the Operations and Maintenance Center for the BSS.

■ Reallocation of frequencies among BTS.

■ Time and frequency synchronization.

■ Power controlling.

■ Time delay measuring of the received signals from the mobile station.

2.5.2 Base Station Subsystem (BSS):

The Base Station Subsystem is made from the Base Transceiver Station (BTS) and the Base Station Controller (BSC). These are connected via the predetermined Abits interface, enabling (as in the rest of the system) operation between components that are made by different suppliers. The radio segments of a BSS may comprise of four to seven or nine cells. A BSS may have at least one BS. The BSS utilizes the bit's interface between the BTS and the BSC. A different rapid line (T1 or E1) is then linked from the BSS to the Mobile Central Office, as appeared in the design in Figure (2.7) [55].

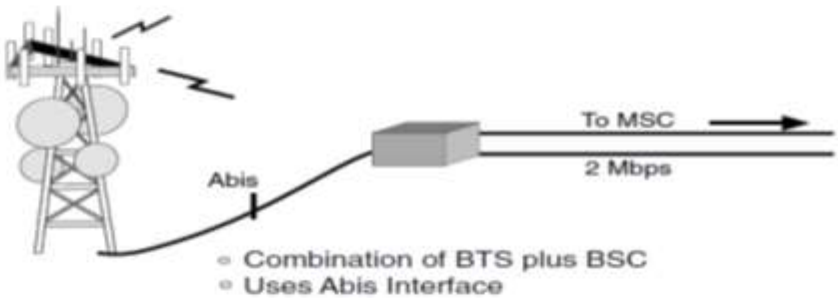

Figure (2.7) The Base Station Subsystem.

2.6 The Transcoder and Adaptation Unit (TRAU):

Contingent upon the expenses of transmission facilities from a cellular operator, it might be taken a toll proficient to have the transcoder either at the BTS, BSC, or MSC. If the transcoder is situated at the MSC, it is functionally still apart of the BSS. This creates a maximum flexibility for the overall network operation. The transcoder receives the 13-Kbps voice or information (at 300, 600, 1,200 bps) multiplexes four of them and converts them to the standard 64-Kbps digital PCM channel. To begin with, the 13-Kbps speech is raised to a 16-Kbps level by embedding extra synchronizing information to compensate for any shortfall of the lower information rate. At that point, four 16-Kbps channels are multiplexed onto a DS0 (64-Kbps) channel [56].

2.6.1 Locating the TRAU:

If the transcoder/rate connector is outside the BTS, the Abis interface can just work at 16 Kbps inside the BSS. The TRAU yield information rate at 64-Kbps standard digital channel limit. Next, 30 64-Kbps channels are multiplexed onto a 2.048-Mbps E1 service if the CEPT standards are utilized. The E1 can convey up to 120 movement and control signals (16–120). The areas can be between the BTS and the BSC whereby a 16-Kbps sub channel is utilized between the BTS and the TRAU and 64-Kbps channels between the TRAU and the BSC. On the other hand, the TRAU can be situated between the BSC and the MSC, as found in Figure (2.8), utilizing

16 Kbps at the BTS to BSC and 16 Kbps between the BSC and the TRAU[57].

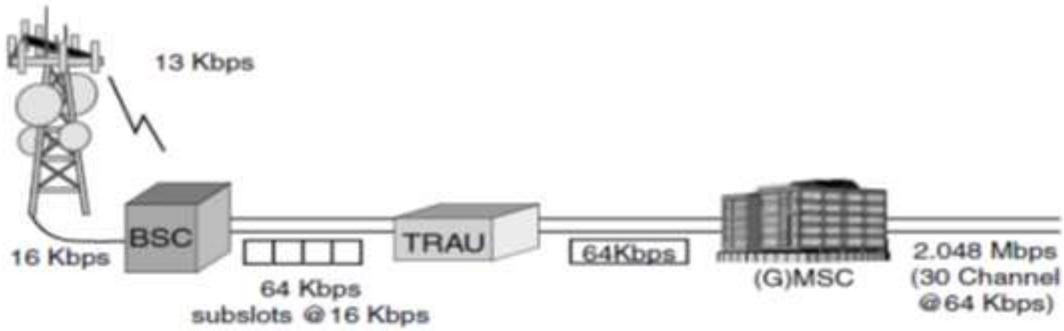

Figure (2.8) The TRAU.

2.6.2 Mobile Switching Center (MSC):

The focal component of the Network Subsystem is the Mobile Services Switching Center (MSC), which is shown in Figure (2.9). It works like an ordinary Class 5 Central Office (CO) in the PSTN or ISDN, and what's more gives the function required to handle a mobile supporter, for example, registration, verification, area update, handovers, and call steering to a meandering endorser. The essential tasks of the MSC include:

- Paging.
- Coordination of call setup for all MSs in its operating site.
- In amongst BSC and MSC.
- Converts GSM coding into PSTN information.

13 Kbps ⟶ 64 Kbps ⟶ 64 Kbps ⟶ 13 Kbps

- Dynamic distribution of resources.

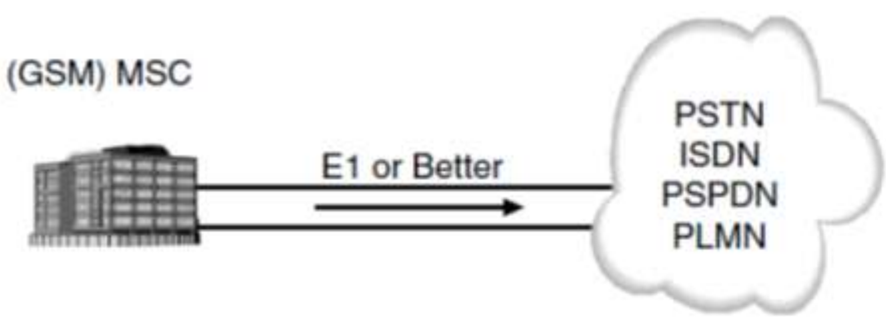

Figure (2.9) The MSC.

- Site registration.
- Interworking tasks.
- Handover management.
- Billing.
- Rearrangement of frequencies to BTSs.
- Encryption.
- Echo cancellation.
- Signaling exchange.
- Synchronizing the BSS.
- Gateway to SMS.

As a CO task, it utilizes the digital trunks as E1 (or bigger) to the next network interfaces, for example,

- PSTN
- ISDN
- Packet-Switched Public Data Network (PSPDN)
- Public Land Mobile Network (PLMN) [58] .

These services are given in conjunction with many functional entities, which together frame the Network Subsystem. The MSC gives the link with the general population settled networks (PSTN or ISDN) and signaling between functional entities utilizes Signaling Framework Number 7 (SS7), utilized as a part of ISDN and broadly utilized as a part of current public networks.

The Gateway Mobile Services Switching Center (GMSC) is utilized as a part of the PLMN. A gateway is a hub linking two networks. The GMSC is the interface between the mobile cellular network and the PSTN. It is accountable for steering calls from the settled network towards a GSM client. The GMSC is often actualized in an indistinguishable machine from the MSC. A PLMN may have several MSCs, yet it has just a single portal access to the wireline network to proceed the network operator. The gateway at that point is the high-speed trucking machine connected via E1 or Synchronous Digital Hierarchy (SDH) to the outside world [59].

2.6.3 Frequencies:

GSM systems can be implemented in any frequency band. However, several bands exist where GSM terminals are available. Besides, GSM terminals may join one or more of the GSM frequency bands recorded in the accompanying area to encourage meandering on a worldwide basis.

Two frequency bands of 25 MHz in every one, have been allotted by ETSI for the GSM framework. These are:

■ The band 890 to 915 MHz has been allotted for the uplink path (transferring from the mobile station to the base station).

■ The band 935 to 960 MHz has been allotted for the downlink path (transferring from the base station to the mobile station).

However, not all countries can use all of the GSM frequency bands. This is primarily due to military reasons and to the existence of previous analog systems using part of the two 25-MHz frequency bands. Figure (2.10) shows the frequencies.

2.7 Primary GSM:

When transmitting in a GSM network, the mobile station to the base station utilizes an uplink. The reverse channel heading is the downlink from the base station to the mobile station. GSM utilizes around 900-MHz band. The frequency band that is utilized 890 to 915 MHz (mobile transmit) and 935 to 960 MHz (base transmit). The duplex channel enables the two-way communications in a GSM network. Because telephony was the primary service, a full-duplex channel is assigned with the two separate frequencies in a 45-MHz separation.

To give the maximum number of user's access, each band is subdivided into 125 carrier frequencies, spaced 200-kHz apart, using FDMA tech-GSM frequencies initially set with 25 MHz (transmit and receive) spaced apart by 45 MHz [60].

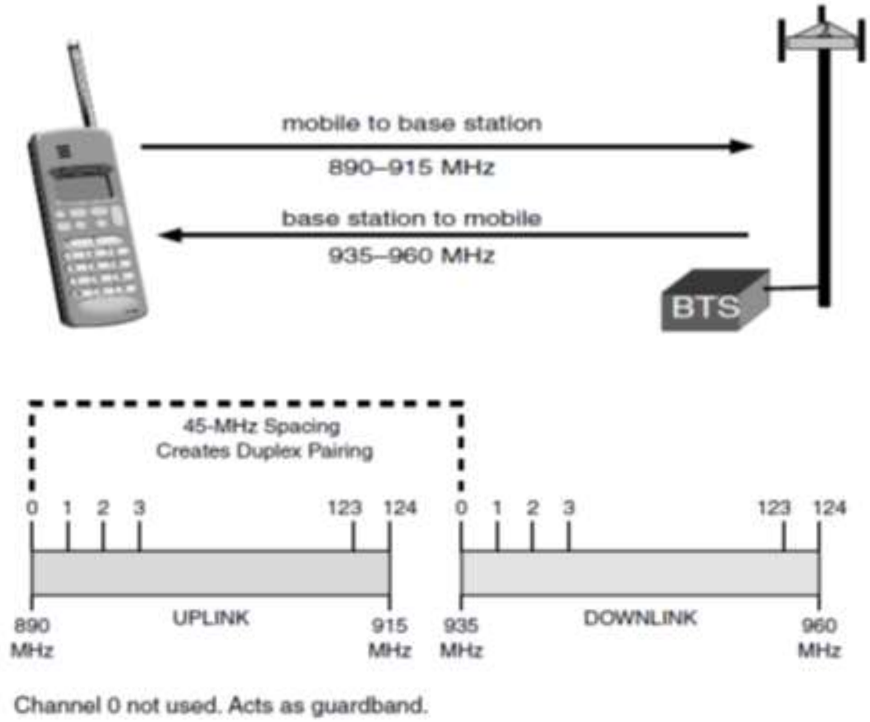

Figure (2.10) The uplink and downlink frequencies.

The spectrum assignment is shown in Figure (2.10). Only 124 channels are used, where channel 0 is reserved and held as a guard band against interference from the lower channels. Each of these carrier frequencies is additionally subdivided into time slots utilizing TDMA. The frequency bands are usually split between two or more providers who then build their networks. The channels are set at the 200 kHz each. The International Telecommunication Union (ITU), which manages the worldwide assignment of radio spectrum (among the different functions), allotted the bands for mobile networks in Europe [61].

2.7.1 Radio Assignment

Each BTS is allotted a collection of channels with which to proceed. Any frequency can be assigned to the BTS, as they are frequency agile. This enables the system to reallocate frequencies as needed to handle load balancing. Normally, the BTS can bolster upwards of 31 channels (frequencies); in any case, in real operation, the operators generally dole out from 1 to 16 channels for every BTS. This is a commercial and commonsense issue. The Absolute Radio Frequency Channel Number (ARFCN) is used in the channel assignment at each of the frequencies [62].

2.7.2 Frequency Pairing

The pairing is shown as the way of handling the 45-MHz separations. Remember that channel 0 was not used. It was reserved as a guard band from the lower frequencies to prevent interference.

2.7.3 Extended GSM Radio Frequencies

After the ETSI is assigned the initial block of frequencies, a later innovation was to assign an additional block of 10 MHz on the bottom of the original block. The reasoning was that future demands would require this capacity. This meant that the frequencies from 880 to 890 MHz for the uplink and 915 to 925 MHz were executed. This made an extra 50 carriers. The carriers were numbered 974 to 1,023 so that the channel assignments would not be confused with the initial GSM standard. When the extra channels were executed, the extra channels were still matching at 45-MHz separation.

■ Channel 974 was not used; it became the guard band for the lower frequencies below 880 MHz and 925 MHz

■ The initial channel 0 in the primary GSM band is now used because of this shift, as shown in Figure (2.11).

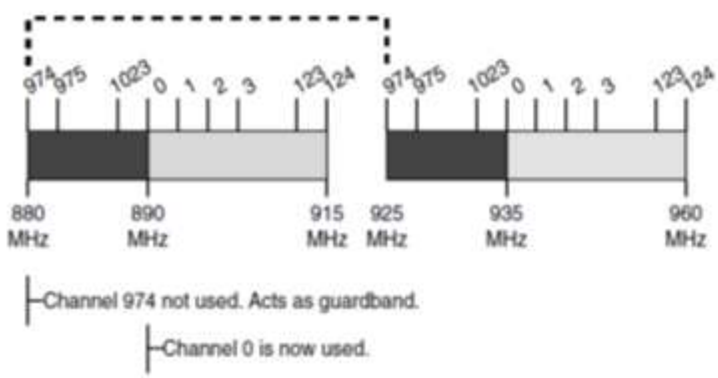

Figure (2.11) the extended GSM.

2.7.4 Modern technologies used in cellular phone systems (Technology GPRS)

GPRS technology is a technology development towards the third generation G3 and this system has become a fundamental part of the GSM of the modern systems. In addition, its data transfer rate is acceptable.

The used technique:

1. Channels TDMA is used where it is required a reservation for more than one path in the single channel ranging from the speed of data transfer between 30 Kbit/s, and 80 Kbit/s (using 4 paths) and can increase the speed of data transfer by increasing the number of paths to reach the transfer speed between160 Kbit /s and 236 Kbit /s.
2. Packet switching technology is used where multiple users can share a single channel transport.

Technical features:

1. Data transfer speed of an interview with the GSM system normal.
2. It is used in many applications, such as the transfer of information, for example the internet and multimedia.
3. It is inexpensive and suitable for simple applications (surfing the Internet and e-mail) [63].

2.7.5 Code Division Multiple Access (CDMA)

CDMA is a channel transmission standard that enables some transmitters to send data at the same time through a single communication channel. This guarantees that the accessible bandwidth is utilized as a part of a streamlined way. It is a type of multiplexing and is utilized for wireless communication. Radio communication makes utilization of 2 resources: frequency and time. In the event that individual frequencies are allotted of the spectrum all inside the band constantly, the outcome is Frequency Division Multiple Access (FDMA). If a similar frequency channel is shared by separating the signal into various time slots, the outcome is Time Division Multiple Access (TDMA). FDMA in this way considers division by frequency and TDMA takes into consideration division by time. CDMA then again enables every frequency to be dispensed the whole range constantly. This procedure is known as multiplexing and enables many clients to share a specific measure of bandwidth. Each channel, thus, makes utilization of the full accessible range. CDMA has diverse standards. CDMA One offers a transmission speed of up to 14.4 Kbps in its single channel frame and up to 115 Kbps in an eight-channel shape. Other CDMA standards including CDMA 2000 and wideband CDMA offer much faster data transmission [64].

CDMA works by allotting one kind of spreading codes before information transmission. Many codes can accommodate the same channel which is lower than the noise level. The signal is then transmitted through this channel and the receiver uses a correlator to dispread the signal through a filter. Codes are sent in one – zero configurations and keep running at a speedier rate than the information being transmitted. The rate of a spreading code is called a chip rate. The codes themselves are fundamentally used to give uniqueness to data identification. There are two basic types of CDMA: Direct-sequence Code Division Multiple Access (DS-CDMA) and Frequency Hoping Code Division Multiple Access (FH-CDMA) [64].

2.7.6 EDGE technology:

This technique is used to improve the functioning of GPRS, and sometimes called EGPRS, and running on any GSM network operating GPRS system. It improved the technique of the work of the services provided by the GPRS and it provided for the high data transfer speed of up to 236.8 Kbit/s, which meets the lowest conditions for the 3rd generation of cell phones, so most operators go directly to UMTS (third generation).

In addition to the GMSK technique, EDGE technology modulated 8 Phase-Shift Keying (PSK), which provides extra number of used paths, and increases the speed of the data transfer [65].

2.7.7 (IMT 200 – UMTS) G3 Technology:

It started with the third-generation systems running since 2001 in Japan and South Korea and then spread to many countries of the world. It became the basic standard of companies It and provides high rate of data transfer. It can introduce additional technologies to speed up the transfer of data in the receiver to the14.4 Mbit /s (currently in Japan).

The system operates within the UMTS 1900 MHz bandwidth in the transmission and the receiver, and uses the bandwidth of 5 MHz per channel in the transmission and the receiver, and uses modern WCDMA access technology, and it is characterized by including the following [66,67]:

1. Ease of development of the current GSM systems to operate this system due to the presence of many of their common equipment.
2. Optimal use of bandwidth for adoption on systems in WCDMA access technologies.
3. High-speed data transfer.
4. Efficient transfer of multimedia (video transfer and viewing of live speakers).
5. Permanent contact with the internet.
6. Feature of global roaming and can be used as mobile units enabled UMTS/GSM Dual Mode to work on GSM networks in the absence of coverage UMTS.

2.8 Communication Towers:

The towers and high buildings communication masts specially are designed to carry wireless communication antennas. These connections include wireless broadcast television radio GSM mobile phones and the Internet [68]. Masts and towers are used in many applications of wireless networks, ranging from fast networks and links between the point-to-point networks and the end of the Land Mobile Radio (LMR). It is required that on wireless networks to the towers and masts, the antennas should be raised on the level of trees and buildings to achieve line of sight links.

This unit is a general guide, and it focuses on practical aspects to build communications towers or masts. The ideas contained in this unit can be implemented on each of the self-supported towers and masts guiding [69].

2.9 Definitions of Towers and Masts:

A self-supported tower structure is used in custom engineering, while the mast needs to be supported by pads or braces. The tower is self-supporting, while the mast is supported by using pads or braces.

2.10 Types of communication Towers:

The distinctive sorts of communication towers are based upon their structural action, their cross-section, the kind of sections utilized and on the placement of tower. A brief description is given below [70]:

2.10.1 Structural action of the Tower:

Towers are arranged into three noteworthy gatherings based on the structural action. These groups are guyed towers, monopole, and self-supporting towers.

The towers that are bolstered on ground or on buildings are called self-supporting towers. Most of the televisions (TVs) , Microwave (MW) , Power transmission, and surge light towers are self-supporting towers, Fig2.12 [71].

Figure (2.12) An image of Self-supporting towers.

a. Guyed Towers

Guyed towers give height at a much lower material cost than self-supporting towers, because of the effective utilization of the high-quality steel in the guys.

Guyed towers are ordinarily guyed in three ways over an anchor radius of normally 2/3 of the tower height and have a triangular lattice section for the focal mast, Fig. 3.2. Tubular masts are additionally utilized, particularly where icing is very heavy and lattice sections would ice up completely. These towers are considerably lighter than the self-supporting, but they need an extensive free space to anchor guy wires. At whatever point vast open space is accessible, guyed towers can be given. There are different limitations to mount dish antennae on these towers and need big anchor squares to hold the ropes [72].

Figure (2.13) an image of a Guyed Tower.

b. Monopole

It is a single self-supporting pole and is by large put over roofs of high buildings, when low number of antennae is needed or the required tower is less than 9 m, Fig.2.14 [73].

Figure (2.14) The Monopole.

2.10.2 Cross section of the Tower:

Towers can be categorized, depending on their cross section, into square, rectangular, triangular, delta, hexagonal and polygonal towers. Open steel lattice towers represent the most effective utilization of the material and empowers the development of to a great degree lightweight and firm structures by offering less presented area to wind loads. Most of the power transmission, telecommunication and broadcasting towers are lattice towers. Triangular Lattice Towers are of less weight however they offer less stiffness in torsion. With increasing the number of faces, it is watched that weight of tower is increased. The increase is 10% and 20% for square and hexagonal cross sections, respectively. If the supporting action of the nearby beams is viewed as, the consumption incurred for hexagonal towers is less [74].

2.10.3 Sections of the Towers:

Depending on the sections utilized for creation, towers are ordered into angular and hybrid towers (with tubular and edge bracings). Lattice towers are typically made of darted angles. Tubular legs and bracings can be of low cost, particularly when the anxieties are sufficiently low to permit generally straightforward connections. Towers with tubular individuals might be not as much as the half of the heaviness of point towers as a result of the lessened wind stack on circular sections. However, the extra cost of the tube and the more complicated connection details can exceed the savings of steel weight and the foundations [75].

2.10.4 Tower in Rural and Urban Areas:

Depending on the placement, the communication towers are classified as in Table 2.1:

	Green Field Tower	Roof Top Tower
Erection	Erected on natural ground with suitable foundation	Erected on existing building with raised columns and tie beams.
Height	30 – 200 m	9 – 30 m
Usual Location	Rural Areas	Urban Areas
Economy	Less	More

Table (2.1) the classification the communication towers.

2.10.5 Segments of the Tower:

The towers are grouped depending on the quantity of segments as Three incline tower; Two slant tower; Single slant tower; and Straight tower [76].

2.11 Special conditions specific to telecommunications Towers:

The following telecommunications towers shall be allowed as uses permitted outright [77]:

1. Towers outlined and built for placement for placement of a single telecommunications service provider, not to exceed 90 feet.
2. Towers outlined and built for placement of two telecommunications service providers, not to surpass 120 feet.
3. Towers outlined and built for placement of 3 or more telecommunications service providers, not to surpass 150 feet.
4. Antennas attached to the pre-existing structures.

2.12 Accessories for Towers:

For the tower, it is required several antennas to operate the transmitter and receiver signal mobile phone, as well as the installation of several appliances microwave that communicate with each other and they must be guided towards each other directly, without deviation or insulators, the so-called line of Seth, and without that, the site does not work and become isolated from the network [78].

2.12.1 Antenna and Microwave:

Devices, which transmit or receive radio frequency, are of several different types, and they are mounted on towers or roofs of buildings or facilities [79]. Figure (2.15) shows some of these sorts.

Figure (2.15) Images of some types of antennas installed on roofs.

2.12.2 Cells Structure:

In cellular frameworks, the coverage area of an operator is partitioned into cells. A cell is the area that one transmitter or a small gathering of transmitters can cover. The cell's size is determined by the transmitter's power. The idea of cellular frameworks is the utilization of low-power transmitters with a specific end goal to empower the productive reuse of the frequencies. The most extreme size of a cell is around 35 km (radius), providing a round-trip communications way from the portable to the cell site and back. On the off chance that the transmitters are powerful, the frequencies can't be reused for several kilometers, as they are restricted to the coverage area of the transmitter [80].

In the past, when a portable communications framework was installed, the coverage was hindering the reuse past the 25-mile coverage area and was making a hallway of interference of an extra 75 miles. The frequency band, apportioned to a cellular portable radio framework, is appropriated over a gathering of cells and this conveyance is rehashed in most of an operation's coverage area. The whole number of radio channels accessible would then be able to be utilized as a part of each gathering of cells that shape the operator's coverage area. Frequencies utilized as a part of a cell will be reused a few cells away. The separation between the cells using a similar frequency must be adequate to evade interference. The frequency reuse will increase the limit in the quantity of clients extensively [81]. The patterns can be a four-cell design or different decisions. The typical clusters contain 4, 7, 12, or 21 cells [82].

In order to work properly, the power level of a transmitter within a single cell must be limited, keeping in mind the end goal to decrease the interference with the transmitters of the nearby cells. The interference won't cause any harm to the framework if a separation of around 3.5 to 3 times the diameter of a cell is saved between transmitters. The receiver filters should likewise adjust [83].

Neighboring cells can't have the same channels. To decrease the interference, the frequencies should be reused just within a certain extent [84]. The extent may likewise be a seven-cell design, which is appeared in Figure (2.16).

To exchange the data expected to maintain the communication links within the cellular network, many radio channels are saved for the signaling data. Occasionally we utilize a 12-cell design with a repeating succession.

The 12-cell design is extremely a grouping of three four-cell clusters, as appeared in Figure (2.17). The bigger the cell design, the more the coverage areas tend to work. When all is said in done, the bigger cell designs are utilized as a part of different reuse patterns to remove most of the rare radio sources as would be prudent. The 21-cell design is by a long shot the biggest repeating design in utilize today. The cells are gathered into clusters. The quantity of cells in a cluster determines whether the cluster can be repeated continuously within the coverage area.

The quantity of cells in each cluster is very significant. The littler the quantity of cells per cluster, the more prominent the quantity of channels per cell [85].

In this manner, the limit of every cell will be increased. Notwithstanding, a balance must be found keeping in mind the end goal to maintain a strategic distance from the interference that could happen between neighboring clusters. This interference is created by the little size of the clusters (the cluster's size is defined by the quantity of cells per cluster) [83].

The aggregate number of channels per cell relies upon the quantity of accessible channels and the kind of cluster utilized.

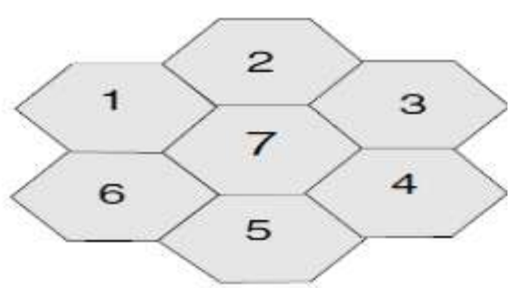

Figure (2.16) the seven-cell pattern.

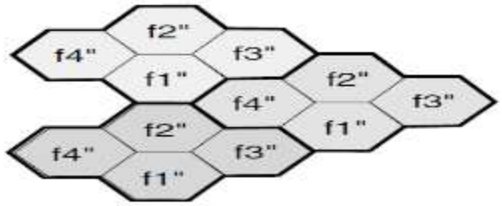

Figure (2.17) The 12-cell pattern.

2.13 Cells

The density of population in a country is so varied that different types of cells are used:

■ Macro-cells
■ Microcells
■ Selective or sectored cells
■ Tiered Cells
■ Umbrella cells
■ Nano cells
■ Pico cells

2.13.1 Macro-cells

Microcells are large cells for remote and sparsely populated areas. These cells can be as large as 3 to 35 km from the center to the edge of the cell (radius). The bigger cells put more frequencies in the center, but since the area is provincial, the macro (large scale) cell regularly has restricted frequencies (channels) and higher-power transmitters. This is a confinement that keeps different destinations from being firmly neighboring this cell. Figure (2.18) shows the Macro-cell [86].

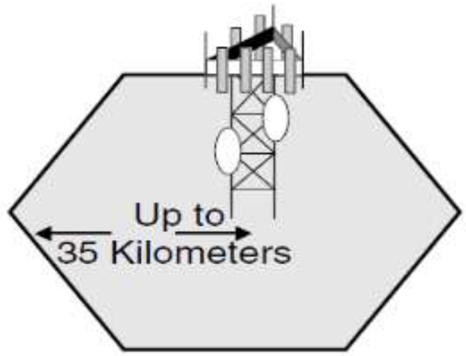

Figure (2.18) the macro-cell.

2.13.2 Microcells

These cells are used for densely populated areas. By splitting the existing areas into littler cells, the quantity of accessible channels and the limit of the cells are increased. The power level of the utilized transmitters as a part of these cells is then diminished, reducing the likelihood of interference between the neighboring cells. A portion of the micro-cells might be as little as 0.1 to 1 km based on the need. Often the cell splitting will use the reduced power and the greater coverage to satisfy hot spots or dead spots in the network. Another need may well be an underneath the-rooftop cell that fulfills an affectionate gathering of individuals or fluctuated clients. The pico-cell will be in a building, and it is typically a smaller version of the microcell. The distances covered with a pico-cell are approximately from 0.01 to 1 km. These are utilized as a part of office buildings for shut in calling, some portion of a Private Branch Exchange (PBX) or a wireless Local Area Network (LAN) application today. A small group of users will share this cell because of the proximity to each other and the larger cells around. Nano-cells also fall into below-the-rooftop domain where the distances for this type of cell are from 0.01 to 0.001 km. These are just smaller and smaller segments that are built within a building, as an example Figure (2.19) shows a combination of a microcell and pico-cell.[87].

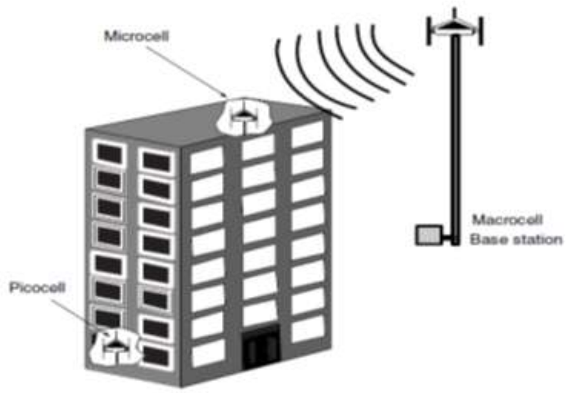

Figure (2.19) the microcell and pico-cell.

2.13.3 The Selective Cells or the Sectorized Cells

It is not always useful to define a cell within a full coverage of 360 degrees. At times, cells with a specific shape and coverage are required. These cells are called particular cells. Cells are regularly the cells that might be situated at the entrances of tunnels where 360 degrees' coverage isn't required. For this situation, a selective cell with coverage of 120 degrees is used [87]. This selective cell is shown in Figure (2.20).

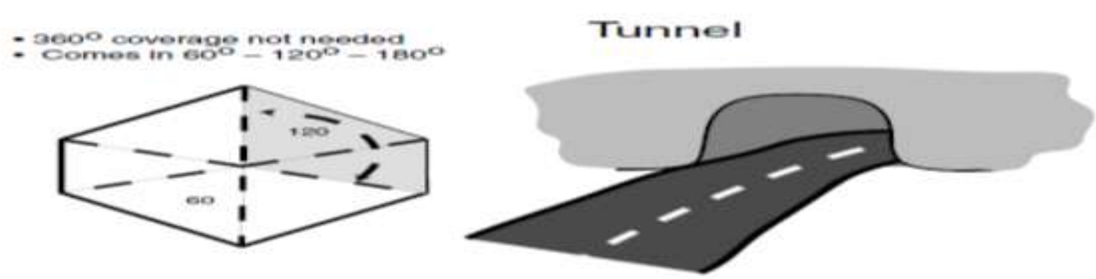

Figure (2.20) the selective cell.

2.13.4 Tiered Cells

A tiered cell is one where an overlay of radio hardware works in two distinct frequencies and utilizes diverse parts. The tiered cell is additionally a type of the selective cell [87].

2.13.5 Umbrella Cells

Close by of a fast freeway, crossing little cells creates an overabundance of handovers among the diverse little neighboring cells.
To solve this issue, the idea of umbrella cells was introduced. An umbrella cell covers a few microcells, as appeared in Figure (2.21). The power level within an umbrella cell is increased contrasted with the power levels utilized as a part of the microcells that shape the umbrella cell. How does the cell know when to move from a microcell to an umbrella cell? At the point when the speed of the cell is too high, the cell is handed off to the umbrella cell. The cell will at that point remain longer in the same cell (for this situation, the umbrella cell). This will lessen the quantity of handovers and the work of the network. An extensive number of handovers demands, and the proliferation qualities of a mobile can record its high speed. The radio equipment is no longer forced to constantly change hands from cell to cell when using this umbrella. This meets the goal of GSM in that the effective utilization of the radio frequency (RF) spectrum is what is being achieved [87].

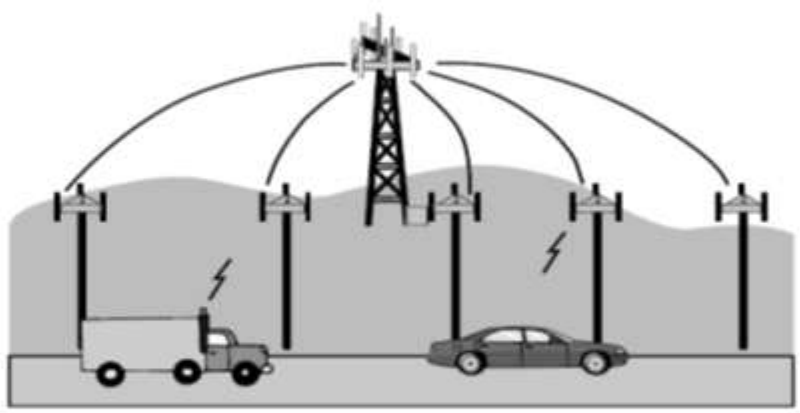

Figure (2.21) the umbrella cell.

2.14 The Base Station

Small tanks or room areas do not exceed (25) square meters are installed on the ground next to the communications towers or on the roofs of buildings, and they contain the hardware and the communication equipment required to operate the antennas. Figure (2.22) shows the species of base stations.

Figure (2.22) a picture of types of base stations attached to towers.

Antennas are devices that broadcast and receive radiofrequency and have several different types of towers. They are mounted on roofs of buildings or facilities as in the Figure (2.15). The intervention of power collected by the antenna cable are proceeded in the form of radio waves transmitted outside the tower where they spread in air, and they are diminished with the distance from the antenna. The basic function of the BSS is to connect the mobile phone network and to send and receive the radio signals as it processes all the functions [88].

2.14.1 Components of the base station

The main components of the base station are [89]:

(a) **The Transceiver Unit**

It is the most important unit in the station transmitter/receiver in terms of sub-signal processing part, and it is composed of low-frequency digital signal processing and high-frequency part of the amendment, and the adjustment to remove the rest of the station is not much related to the sender/receiver.

(b) **Operation and Maintenance Unit**

It consists of a small central unit that manages the rest of the station transmitter/receiver sub, so they are directly related to the status of the conversion through the main channel specific and this allows the unit to process the coming commands from the center of the conversion directly in the main station and to report the results. In addition, it contains the central unit to the program operations and the order of the sender/receiver.

(c) **Input and Output Filters**

They are used to determine the bandwidth of the signal(transmitter/receiver). Income candidate has a narrow bandwidth in the uplink direction, which determines the bandwidth of the output signal b (200 KHz). Unit maintenance and operations run candidates in the case of changing frequency.

2.14.2 The Creation/ Configuration of the Base stations (BTSs)

The creation of such plants relies on the number of users and the nature of the area to be covered to provide optimal coverage. There are several ways to create:

(a) **Standard Configuration**

Standard configuration, determined for each cell base station, is different. The number of base stations (in some cases, base stations and only one) space is deterministic. Figure (2.22) shows three spaces with deterministic initial base stations, and the second one with three base stations, while the latter with five base stations. This method of configuration is the most used method. In urban areas, there are other ways to create such configuration [90].

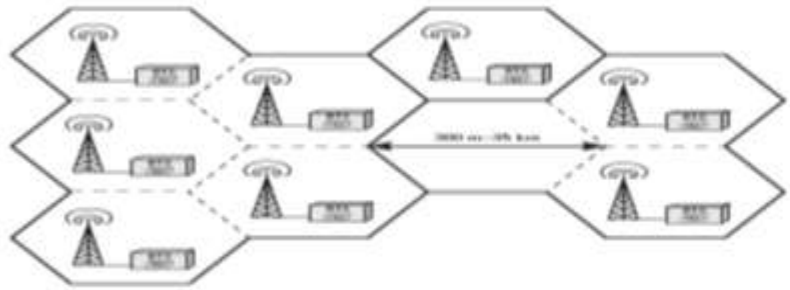

Figure (2.23) a standard configuration of a base station.

(b) **Creating/Configuration of an Umbrella Cell**

Umbrella cell contains the base station and one with high transmit power as shown in Figure (2.23), where the antenna is installed in the area to serve the high number of cells umbrella covering by small base station with low transmit power.

This method of configuration does not allow the use of frequency by small umbrella cells because it leads to an interference, but this method also has advantages in certain cases such as the ease pressure on the base station and one is working on improving the network [91].

Figure (2.24) The Umbrella cell.

(c) **BTS Sectors**

In this way, the antenna is directed to provide coverage for specific sectors, for example, 120 degrees or 60 degrees. Figure (2.24) illustrates the method of division. Stations have a low transmit power with a small number of devices the sender/receiver. When the division into 120 degrees occurs, it allows the re-use of frequency in one section and facilitates the process of applying the frequency [92].

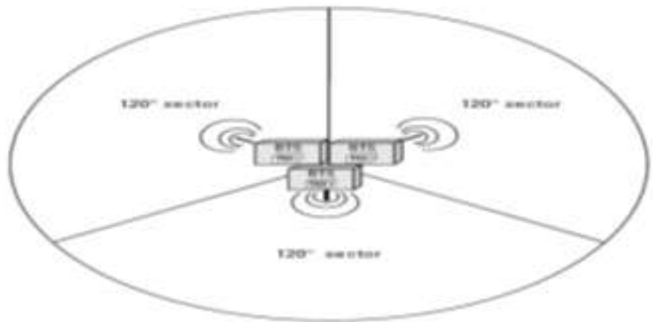

Figure (2.25) the process of division.

2.12.3 Base Station Controller (BSC)

It controls the number of base transceiver stations, as shown in Figure (2.26) and sets a group of radio channels. The BSC measures the signal strength received from the mobile phone where the controls to the installation and operations of the base station happens in the process of transfer of communication channel to the other monitor [93]:

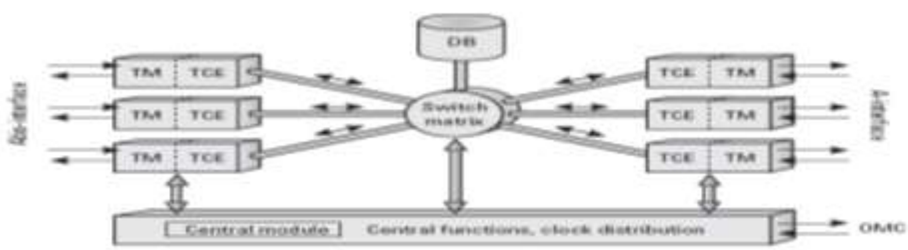

Figure (2.26) Monitor installation of base station.

2.14.4 Monitor the installation and operations of the base station

(a) **Controls for terminal Abis Interface**

It communicates with the base stations via the control’s peripherals. The number of these elements depends on the number of base stations and these elements are responsible for the management of the resources of the radio stations [94, 95].

(b) **Controls terminal for Air Interface**

The communication between the observer and the base station is the main switching center through the air. Although any observer to the status can convert one major but it needs to be many these elements to support the Air Interface [94, 95].

(c) **Central Unit**

The main task is to determine the way toward converting a channel of communication to another observer, as one of the functions of the base station and it can do the job without reference to the main switching center in addition to being in control of radiated power from the base station .

(d) **Contact with the Center for maintenance and operations**

The central unit that is in contact with the main switching center and the center manages and supervises a base station via the observer of the base station [94, 95].

2.14.5 Transcoder and Rate Adaptation Unit (TRAU)

The function of TRAU

Mission speed data transfer between the mobile and the TRAU can transform the speed of the sound data from 64 Kbps to 16 Kbps and vice versa.

2.14.6 Locations of the TRAU

Although the aim of the sound pressure is the conservation of resources through the air, but it also keeps the cost of the line when used in land lines, as shown in Figure (4.17). When you install the TRAU, the main switching center MSC in the highest form of (4.17), the audio channel is used only when calling from 16Kbps Monitor base station to the center of the main conversion. The inauguration at the base station BTS and the main switching center MSC, it uses the 64 Kbps of the channel between the Base Station Controller (BSC) and the main switching center (MSC) at the bottom of the form (2.27).

Most of the time to be set when the main switching center gets the most benefit possible from the pressure [96].

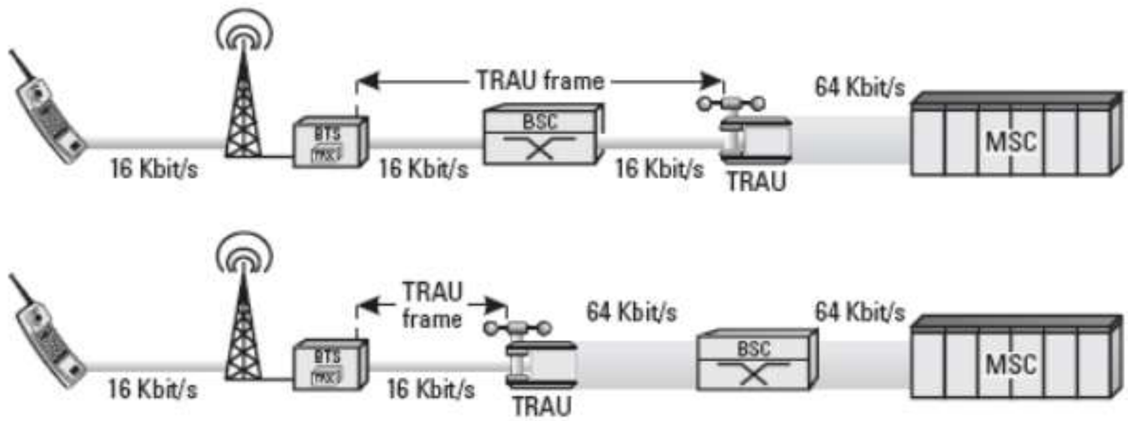

Figure (2.27) The Locations of the TRAU.

2.15 Choosing the Appropriate Type of the Tower

You should pay attention to the four key points when choosing the type of the tower to be **appropriate for your project:**

1-Antenna Load

2-Tower Footprint

3-Height of the Tower

4-Budget

2.15.1 Antenna Load

The carrying capacity of the tower for antennas is based on the structure of the tower. The greater the surface area of antennas, wire core, rules and other equipment mounted on the tower and exposed to the wind, the greater the conditions of the stability of the tower.

You must guess the effective capacity of the tower to withstand winds in order to ensure that pregnancy resulting from the used equipment to be smaller than the maximum load of the tower. Appropriate wind load is proportional to the area of the structure exposed to the wind and higher installed a distance from the surface of the earth. Resistant forms curved and perforated (Such as Grids for example), less wind, while the solid dishes show considerable resistance to the wind and therefore should be avoided in environments of high winds.

You should also take the average wind speeds at the site into consideration during the test antenna towers. Average wind speed depends on the geographical impact of the project, the height above sea level and the nature of the surrounding environment (urban or rural). There is some statistical information over the Internet from sites meteorological institutes.

There are several methods to calculate the wind load and to differentiate between them in terms of the quality of the results. The specifications of the standard IEA-222 are the most recent and perhaps the most accurate methods at all.

2.15.2 Tower Footprint

The tower's land base is the required floor area for the installation of the tower. The size of this space is based on the type and the structure of the tower.

Masts need to be stretched (which increases the height to 100 feet or 30 meters) to 10-15 meters from the base of each mast zipper, so the mast with three guys, at each level, will need 90-200 square meters base floor area.

2.15.3 The Height of the Tower

You can save the expenses and the installation work guys if the height of the structure does not exceed 40 feet. Possibly, instead, in this case, the tower can be installed on the roof of a building or even a garage. Adding to the structure of what the guys as we have already made available to build towers to reach higher.

2.15.4 Budget

The basic rule in the general account budget is: "The smaller the area of base of the tower, the greater the cost of the purchase and the installation of the tower."

Columns have single-base area of the youngest of the different types of towers, making it the most expensive species, followed by a self-supported towers and masts, and tight, which requires the maximum area. You'll also depend on the sort of tower you select and the specific tools and cranes for the construction of the tower, which should be considered during the calculation of the budget.

2.16 The Tower site

You should pay attention to some important things in your choice of the physical location of the (tower/mast). You start to ensure the availability of adequate floor space for the installation of the tower, then see the specifications of the tower or the mast you want to purchase to make sure of the area of base of the (tower/mast).

The land should be flat as the flat sites are more suitable for the installation of towers or masts. In any case, you can use any relatively flat surface providing enough space for the installation of the rules of the tower/mast. The site should not contain any ground obstacles such as trees or buildings, for example. However, it is not enough to meet this requirement within the territory to which the antenna will be installed and included, but it should also be achieved in the space surrounding this spot because you will need some additional space during the installation of the (tower/mast) [97].

Remember that the roots of trees hidden under the ground, and the drilling of a crowded area of the roots of trees is not easy at all. Towers and masts require usually high and medium length dug to build a large concrete foundation. You should make sure to always carry out a survey of the services installed under the ground to make sure that there are no extensions of infrastructure under the ground at the site of installation of the tower or mast [98]. Also, make sure, if, the tower that you want to install, up to verify the laws in force in the concerned State, as it is necessary to obtain a license/ registration to build the tower from the relevant authorities. Usually, it is necessary to follow the laws if the location of the tower is near the airport.

2.17 The Base of the Tower

All towers need to rely on a fixed base. The base is aimed at building to avoid the sinking of the tower due its weight in addition to the pressure of the self-tensile wire (if used). Most towers and masts are above the rules of Concrete, and the Concrete Bases contains lump or screw for installation. Of solutions of the less-used parts also is to install a tower within the concrete base. The first solution is characterized by using extrusion or screw installation with the following:

a) Does not require the amendment of the lower part of the tower.

b) Does not warrant concern from a pool of water in the bottom of the tower (the water would flow towards the bottom of the tower and go through the holes in the dedicated base of the tower).

This gives some flexibility for the tower from a direction of rotation to another to absorb the impact of the strong winds (leading to a reduced stress on the bottom of the tower) [99].

Warrant does not concern of how to install the bottom of the tower with the fit within the concrete base. You need a self-supported tower (masts, not tight) to the basis concrete and one that has several points to install the structure of the parties to the tower. The self-supported tower with three parties will need to install the three points in the concrete base.

The tight mast needs to a special rule for each base of each Shaded in addition to the central base of the mast itself.

2.18 Controls at the communications towers

The Controls at the communications towers aimed at:

1. The towers and base stations and antennas used in wireless communications business look appropriate for technical and coordination of distribution in cities and villages.
2. achieve the minimum technical requirements to meet the license to construct and operate these facilities.
3. to protect the population and the environment from the impacts of the uses of wireless communications, or the risk of the collapse of its facilities [100].

2.19Application Areas of Such Controls

1. Regulations apply to new and existing sites.
2. These controls do not include wireless communication devices that are used for security and medical uses, or special uses such as (broadcast television receivers of satellite television antennas, etc.) [100].

2.20 Requirements of the sites [101]

1. Allows the installation of towers, receivers and broadcasting radio frequencies used for commercial purposes only in the following locations:

a) Sites allocated for such uses in the approved plans.

b) To land the space allocated for investment or for commercial use or residential uses.

   a) Areas designated for industrial uses.

   a. Areas designated for agricultural uses, considering environmental considerations issued by the competent authorities.

   b. On the sides of highways and regional links between cities and villages outside the structural schemes considering that area outside the precincts of the road.

1. That the site is on supported commercial streets.
2. Does not permit to install towers and base stations or antennas, or any other equipment for wireless communications sites for residential uses.

1. must bounce towers retina or single stand-alone from all sides a distance equal to half the height along the tower size from the base's center of the tower, the towers stretched the cable a distance higher than 3 meters measured from the wedge of installation.
2. Should be coordinated with the Department of the Airport tower sites or devices to be set up near the campus of the airport.

2.21 Technical requirements [97]:

1. Must not surpass the height of the wireless communications tower in the areas designated for industrial uses or highways or regional areas, for 90 meters.
2. Must not surpass the height of the wireless communications tower built on the plots in areas earmarked for investment or used for commercial or agricultural purposes, for 60 meters.

3. Allow the establishment of wireless communications devices on the roofs of buildings and structures in areas designated for residential use of trade, to bounce more than 6 meters from the top supplements in these facilities.
4. Must not surpass the height of wireless communications devices installed on the roofs of buildings or structures in areas designated for residential uses of trade, or on the land space, the upper limit of the allowable heights of buildings in the region, plus 6 meters.
5. Prepare engineering plans for the architectural towers and base stations sectors, showing the necessary details of elevations, plans and construction of the facility and the rules, and plans necessary electrical and safety requirements, by a registered consultant, for review and approval by the municipality.
6. prepare a technical report by a registered specialist is beneficial to bear the facility to be established by the construction of the weights of the fixed devices that send or receive on the surface and carried by the wind and other loads.
7. Must enclose the tower site and its relay station to plug holes railing height of not less than (2.5) m, and not exceeding an area of the holes on the ($7 \times 7\ cm^2$).
8. Must be considered when designing the towers to absorb more devices from the service provider or operator.
9. all specifications and construction of buildings and equipment must be used according to Building Code as adopted and conform to the Saudi Standards or international standards in force, and the metallic structures must not be rust.
10. Shall not exceed an area of the terminal building of the fortification towers for (25) square meters.
11. Must not cause interference in the wireless devices or interfere with any other communication devices.
12. Would not be issued for any sounds of wireless devices.
13. That the towers and antennas painted with an appropriate non-shiny and do not reflect sunlight, preferably gray.
14. does not allow lighting towers, except as required by the competent authorities warning signals over the towers higher than (30) meters in

accordance with the specifications determined by those bodies, or safety lighting to be within the boundaries of the site.

15. is not allowed to do any billboards or advertising on the tower, except the painting of the tower tariff or warning signs, of the service providers or operators.
16. The towers, antennas and accessories must be consistent with the adjacent buildings, and do not allow for any residential or office within the site.
17. To be implemented under the supervision of a registered consultant.
18. All the work, tools, electrical and electronic devices must be compliant with the terms of security and the occupational safety.
19. All grounding connections, hardware and electrical equipment must be reasonable for the type and the nature of the soil.
20. It is strictly prohibited to make any extensions or electrical systems exposed at the site.
21. In the case of needing a generator or a source of electrical energy for use of the devices used on the site, they must be in coordination with the Saudi Electricity Company.

22. the drawing and the painting guidance of the metal towers and the base stations and antennas with the name or logo of the service provider or operator size (80 cm × 80 cm), as well as panel warning metal size (50 cm × 50 cm) to keep away from the towers and base stations.

2.22 Transmission line

2.22.1 EMF Contamination

Electromagnetic radiations that come from high voltage power lines can influence the health of individuals in both the urban and the rural areas. Solid, artificial EMFs that are emitted from power lines can scramble and meddle with the body's natural EMF, influencing everything from the rest cycles and feelings of anxiety to the invulnerable reaction and the DNA! [102].

Researchers and doctors are making medical developments in cancer treatment nearly consistently. Be that as it may, the weight of cancer in the United States is yet staggering. According to the National Cancer Institute at the National Institutes of Health, in 2016, about 1,685,210 new patients of cancer will be diagnosed and 595,690 individuals will pass away from the disease [103].

While researchers keep on making strides in revealing why one person is infected by the disease and another doesn't, many individuals may feel afraid and anxious of the obscure reasons.

Distinctive kinds of power lines serve to transfer electricity from the generation site to the end-clients. Most ordinarily, and for effectiveness reasons, the electricity is transferred for long distances as alternating current at 50 or 60 Hz, carried overhead or underground utilizing high voltage power lines or cables. Over long distances or underwater, transmission happens now and again with high voltage direct current (HVDC) [104].

Power lines transmitting alternating current (AC) are encompassed by low frequency electric and magnetic fields. HVDC lines radiate static electric and magnetic fields. The quality of the fields produced by these lines depends mainly on the transmitted current and line voltage [105].

Materials, for example, block and clay are extremely productive at shielding the electric field. In underground lines, the construction configuration is with the end goal that the electric field is totally shielded. The static electric field from overhead HVDC lines can expand further into the around environment compared to the AC lines (corona impacts). In contrast, the magnetic field passes unhampered through most of materials. Be that as it may, the fields' intensity lessens rapidly with distance from the line.

The wave propagation is unguided. The uniform plane wave exists all through the space and EM energy accompanied by the wave spreads over a broad area. Wave propagation in unbounded media is utilized as a part of radio or television broadcasting, where the data being transmitted is meant for everybody who may be intrigued. Such means of wave propagation won't assist in a situation like phone conversation, where the data is gotten privately by one person. Another means of transmitting power or information is by guided structures. Guided structures serve to manage (or direct) the propagation of energy from the source to the load. Some examples of these structures are the transmission lines and the waveguides.

Transmission lines are ordinarily utilized as a part of power distribution (at low frequencies) and in communications (at high frequencies). Various sorts of transmission lines, for example, the twisted-pair and the coaxial cables (thinnet and thicknet) are utilized as a part of PC systems, for example, the Ethernet and the web [106].

A transmission line comprises primarily of at least two parallel conductors used to interface a source to a load, Fig. (2.28). The source may be a hydroelectric generator, a transmitter, or an oscillator; the load may be a factory, an antenna, or an oscilloscope, individually. Typical transmission lines incorporate coaxial cable, a two-wire line, a parallel-plate or planar line, a wire above the directing plane, and a small-scale strip line. These lines are portraying [107]:

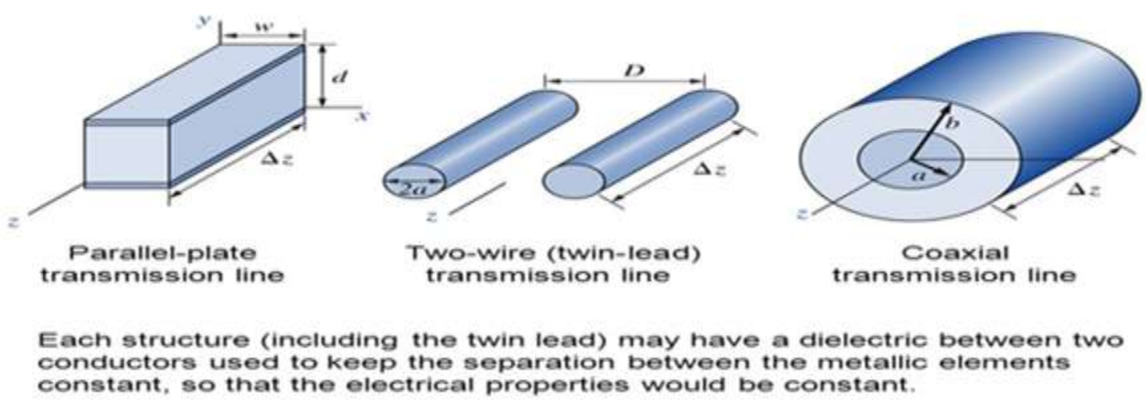

Figure (2.28) the common sorts of the transmission lines.

Notice that every of these lines involves two conductors in parallel. Coaxial cables are routinely used in electrical laboratories and in connecting TV sets to TV antennas. Micro strip lines are particularly important in the metallic integrated circuits.

2.23 Transmission line Parameters:

To depict a transmission line as far as its line parameters, which are its resistance per unit length R, inductance per unit length L, conductance per unit length G, and capacitance per unit length C. Each of the lines appears in Figure (2.29) has equations for discovering R, L, G, and C. [108].

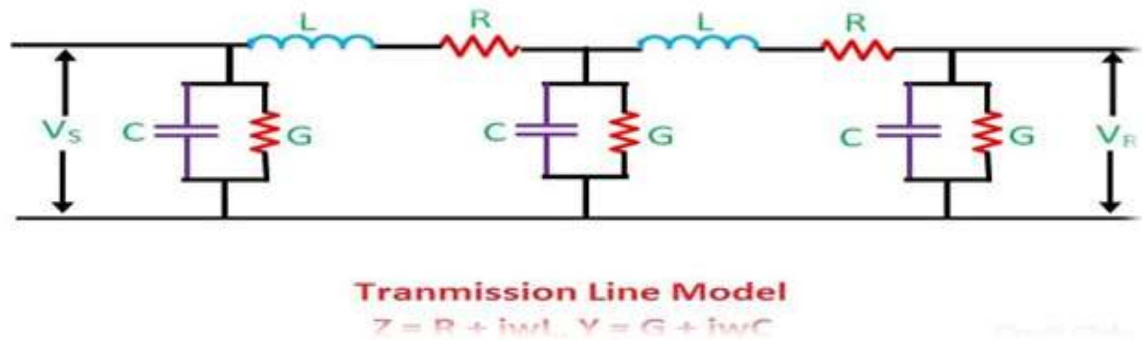

Figure (2.29) the parameters of the transmission lines.

1. The line parameters (R, L, G, and C) are not discrete or lumped but rather circulated as appears in Figure (3.18). By this, we mean that the parameters are uniformly distributed along the entire length of the line.
2. For each line, the conductors are characterized by $\boldsymbol{\sigma_{c}}, \boldsymbol{\mu_{c}}, \boldsymbol{\epsilon_{c}} = \boldsymbol{\epsilon_\circ}$, and the homogenous dielectric separating the conductors is described by $\boldsymbol{\sigma}, \boldsymbol{\mu}, \boldsymbol{\varepsilon}, \boldsymbol{\varepsilon_\circ}$.
3. G ≠ 1/R; R is the AC resistance per unit length of the conductors containing the line, and G is the conductance per unit length due to dielectric media separating the conductor.
4. For each line,
5. LC=$\mu\varepsilon$ and $\frac{G}{C} = \frac{\sigma}{\varepsilon}$

2.24 Transmission Line Equation:

A two-conductor transmission line underpins a transverse electromagnetic wave (TEM wave); that is, the electric and magnetic fields on the line are transverse to the direction of wave propagation. A significant property of TEM waves is that the electric (E) and magnetic (H) fields are exceptionally associated with the voltage V and current I, individually [109]:

$$v = -\int E.\, dI,\ I = \oint H \cdot dI$$

In perspective of this, we will utilize circuit elements V and I in solving the transmission line issue rather than solving field quantities E and

H (i.e., resolving Maxwell's equations and boundary conditions). The circuit model is easier and more convenient.

$$\gamma = \alpha + J\beta = (R + j\boldsymbol{\omega}L)(G + j\boldsymbol{\omega}C)\ V$$

$$\frac{d^2V_S}{dz^2} - \gamma^2 V_s = 0\text{-}$$

$$\frac{d^2I_S}{dz^2} - \gamma^2 I_s = 0\text{-}$$

These two equations show the wave equations for voltage and current.

2.24.1 The characteristic impedance $Z_\circ$

The characteristic impedance is defined as the ratio of the positively traveling voltage wave to current wave at any point on the line, as shown in the following equation [109]:

$$Z = \frac{V_\circ^+}{I_\circ^+} = \frac{V_\circ^-}{I_\circ^-} = \frac{R + J\omega L}{\gamma} = \frac{\gamma}{G + J\omega C}$$

2.25 Transmission Line Characteristics

2.25.1 Lossless Line (R = 0 = G)

A transmission line is considered lossless if the conductors of the line are perfect and the dielectric medium separating them is lossless ($\sigma \cong 0$) [109].

$$Z_\circ = R_\circ = \sqrt{(L/C)}$$

2.25.2 Distortion less Line (RL = G/C):

A signal ordinarily comprises of a band of frequencies; wave amplitudes of various frequency segments, will be attenuated contrastingly in a loss line as α is frequency dependent. This results in distortion.

2.25.3 Distortion less line

It is one in which the attenuation is frequents and independent, while the phase constant is linearly dependent on the frequency.

$$\frac{R}{L} = \frac{G}{C}$$

$$Z_{\circ} = \sqrt{\frac{R}{G}} = \sqrt{\frac{L}{C}} = R_{\circ}$$

Lossless line also represents a distortion-less, but the distortion less line is not necessarily lossless. Although lossless lines are described in power transmission line, telephone lines are required to be distortion less.

2.26 Input Impedance, Standing Wave Ratio (SWR), and the Power

Consider a transmission line of length **L**, characterized by 'γ and Z_0 linked to a load Z_L as appeared in Figure (4.19). By investigating the line, the generator sees the line with the load as an input impedance Z_{in}. It is our aim in this area to decide the input impedance, SWR, and the power stream online.

$$Z_{in} = Z_{\circ} \left[\frac{Z_L + Z_{\circ} \tanh \gamma l}{z_{\circ} + z_l \tanh \gamma l}\right] \text{ (lossy)}$$

$$Z_{in} = Z_{\circ} \left[\frac{Z_L + jZ_{\circ} \tan \gamma l}{z_{\circ} + jz_l \tan \gamma l}\right] \text{ lossless}$$

2.27 The voltage reflection coefficient

The voltage reflection coefficient is defined as the ratio of the magnitude of the reflected voltage wave to that of the incident wave at the load at any point on the line [110] as shown in the following equation,

$$\Gamma(z) = \frac{V_0^- e^{\gamma z}}{V_0^+ e^{-\gamma z}} = \frac{V_0^-}{V_0^+} e^{2\gamma z}$$

2.28 The current reflection coefficient

The current reflection coefficient is defined as the negative of the voltage reflection coefficient at that point. Thus, the current reflection coefficient [111] at the load at any point on the line is given by:

$$S = \frac{V_{max}}{V_{min}} = \frac{I_{max}}{I_{min}} = \frac{1 + |\Gamma_L|}{1 - |\Gamma_L|}$$

Just as we did for plane waves, we characterize the standing wave ratios (SWR) as S.

2.29 Average Power (P_{av})

Transmission line is utilized as a part of transferring power from the source to load [112]. The average distance L from the load is given by the equation:

$$P_{ave} = \frac{|V_o^+|^2}{2Z_o}(1 - |\Gamma|^2)$$

2.30 Types of electromagnetic fields (EMFs)

There are three main sorts of the electromagnetic fields (EMFs). All three have been connected to significant biological impacts in the logical research, and each sort of the EMF is measured with a different device of test instrument.

1. ELF Magnetic Fields

ELF Magnetic Fields are the EMF part that is most frequently connected to dangerous health impacts, for example, youth leukemia and other cancers, in the research. Regular sources comprise power lines, electrical wires, light installations, appliances and most other electrical gadgets. Wiring blunders and stray electricity in pipes can in some cases create shockingly high levels. Magnetic fields are detected by an ELF* Gaussmeter, in units called "milligauss" (mG) [113].

2. ELF Electric Fields

ELF Electric Fields have also been connected to significant biological impacts, however, have been investigated less in the research. Anecdotally, they are often included when individuals feel "sensitive" to electromagnetic sources. Electric fields are usually caused by shrouded electrical wiring inside walls, by nearby power lines for lamps and instrument, and now and then from overhead power lines. Electric fields induce measurable voltages onto the skin, which are easily detected with a Body Voltage Meter, in units of “AC Volts” (VAC).

1. Radio Frequency (RF) Fields (including microwaves)

RF Fields (including microwaves) have been connected to several sorts of tumours and health issues. RF fields are transmitted from many remote and electronic gadgets – cell towers, PDAs, cordless telephones, television/radio broadcast towers, Smart Meters, Wi-Fi, wireless computers and components, baby monitors, microwave ovens, radar, etc. In the US, they have usually measured in units of “microwatts per centimeter squared” ($\mu W/cm^2$). (Sometimes, the ELF electric and magnetic fields will also carry some added RF frequencies because of the utilization of dimmers, fluorescent lightning, PCs, Wi-Fi, Smart Meters, and so forth. This is referred to as "Dirty Electricity".) [114].

2.31 Radio frequency power transmission:

It is the transmission of the output power of a transmitter to an antenna. When the antenna is not situated close to the transmitter, special transmission lines are required.

The most common type of transmission line for this purpose is large diameter coaxial cable. At high-power transmitters, cage lines are utilized. Cage lines are a sort of overhead lines that are similar in design to the coaxial cables. The inside conductor is held by insulators mounted on a circular gadget in the center. On the circular gadget, there are wires for the other pole of the line.

Cage lines are utilized at high-power transmitters in Europe, like longwave transmitter Topolna, longwave-transmitter Solec Kujawski and some other high-power transmitters for long-, medium- and shortwave.

For UHF and VHF, Goubau lines are sometimes used. They comprise of an insulated single wire mounted on insulators. On a Goubau line, the wave travels as longitudinal currents surrounded by transverse EM fields. For microwaves, waveguides are used [115].

2.32 Transmission and Distribution

For homes near transmission rights-of-way, transmission lines can be important sources of magnetic fields. Classic values for the magnetic fields from transmission lines (EPA 1992). At maximum usage, the magnetic fields can be 2 times the average values appeared in the table. Note that the fields fall off generally as the inverse square of the distance from the line, and the magnetic field is higher for the higher-voltage lines. There are two causes for the magnetic field to be higher for the high-voltage lines: higher-voltage lines usually have thicker wires to transfer more current (magnet the ic field is directly proportional to current), and high-voltage lines have a long separation between wires to evade arcing. The magnetic fields created by the 3 conductors of a three-phase transmission line usually cancel each other. Greater wire spacings result in less cancellation; nearer spacings cause less cancellation. If the three phases could possess the same space, the fields would exactly cancel each other and a balanced (in current and phase angle) three-phase transmission line would create zero magnetic fields. That situation is approximated when the wires are insulated and placed together in an underground pipe.

The electric power lines, ordinarily seen in neighborhoods, are usually not transmission lines as depicted above but are lower-voltage distribution lines. The magnetic fields, near distribution lines, are generally around 0.5 µT (5 mG), but in some densely populated areas, field levels as high as 5.0 µT (50 mG) have been measured.

There are two main sorts of underground power lines: direct burial (the individual wires are covered separately) and pipe-type cables (all the wires are placed in a one metal pipe). Direct-burial underground power lines can generate ground-level magnetic fields as large as equivalent capacity overhead lines (but on a more constrained area). Although the underground wires may be nearer together than overhead wires (tending to decrease the field), they are covered at a profundity of just about 5 ft and, thus, are significantly nearer to the surface of the ground than overhead lines (a fact that tends to increase the field). In underground pipe-type transmission lines, the nearby spacing of the wires in the pipe and the metal pipe itself diminish the magnetic field, with the goal that the subsequent ground-level field is typically less than 0.1 μT (1 mG) [116].

2.33 Occupational Magnetic Fields

2.33.1 Workplace:

The magnitude of in the office condition is like that for the home; in any case, contrasts may exist in the extent and pattern of exposure to electric devices. Typical magnetic fields from workplace equipment (EPA 1992). Note that the fields for a particular type of device (e.g., copy machines) vary greatly starting with one machine to another due to the amount of current utilized and other outline features. The information is absent for the least field fluorescent light as its field was not as much as the background field. Compact fluorescent lights, which are being utilized broadly in the workplace as a more proficient replacement for incandescent lights, produce negligible magnetic fields at 2 ft because of their compact size and low current use [117].

2.33.2 Typical Magnetic-Field Levels Measured Near Workplace Devices

2.33.2.1 Transportation

Some transportation systems, including subways and intercity trains, operate on alternating current and generate electric and magnetic fields. Magnetic fields in transportation surroundings are to a great degree variable.

The temporal and spatial variations are great, and for some trains, large frequency variations occur as the speed of the trains change [117].

2.33.2 Residential

The primary theory investigated in most residential epidemiologic investigations of electric-or magnetic-field impacts is that the nearness of the power lines near the house and their relation to the occurrence of diseases. With a few numbers of special exceptional cases, the examinations have concentrated on the indirect estimates of the magnetic fields rather than electric fields. At low frequencies, for example, 60 Hz, electric fields are substantially shielded by the walls of a house and by the encompassing trees, so residential exposure to electric fields is hard to depict and nearly difficult to demonstrate with any accuracy. In the examination by London et al. (1991), nearby power lines appeared to have no impact on indoor electric fields.

Then again, magnetic fields are largely unaffected by interceding structures and thus may reflect all the more directly the operation of nearby power lines. Exposure assessments in the residential studies (e.g., wire codes and distance to power lines) have been seen as estimates or indirect measurements of some aspect of magnetic-field exposure experienced by the subjects before their disease was diagnosed. Because of limitations in instrumentation or available data, the magnetic-field characteristic examined is usually a short-or long-term average field. Each of the exposure assessment techniques has its strengths and weaknesses. The following sections briefly describe the major types of used exposure assessment [117, 118].

2.33.3 Safe Living Distance from Power Lines

Several examinations worldwide have demonstrated that living alongside high voltage power lines and other parts of the power transmission organize increases your danger of cancer and other health issues

The nearer you are, the more you are exposed to dangerous EMFs. The electrical power network utilizes a "step down" arrangement of distribution, highest near the generating station and substations, lowest at the end.

Increasingly, the medical community is perceiving the danger to health that these power lines can cause. For instance, many studies explain that living near high-voltage power lines can increase the frequency of several sorts of cancer, as well as other diseases.

As stated by research and publications performed by the World Health Organization (WHO), EMF, for example, from power lines, can cause headaches, fatigue, anxiety, insomnia, prickling and/or burning skin, rashes, and muscle pain [119, 120].

2.33.4 Securing Yourself and Your Family

Power lines are virtually all over the place. Be that as it may, safe space offers a range of compelling, affordable items that can enable you to secure yourself and your friends and family against the risks of hallmarks of the modern world.

2.33.5 Safe Distance from Power Lines

It is hard to anticipate a safe distance from power lines, as the EMFs can be different greatly relying on the situation. The best advice is to measure with a gaussmeter to decide the actual levels of magnetic fields and the distance required in your specific case. (Special note: magnetic fields are particular EMF segment frequently connected to health impacts in the investigations. They are measured with a specific device called gaussmeter.)

The strongest magnetic fields are usually transmitted from high voltage transmission lines the power lines on the huge, tall metal towers. To make sure that you are decreasing the exposure levels to 0.5 milligauss (mG) or less, a safety distance of 700 feet may be required. It could be significantly less, yet occasionally more. You should test with a gaussmeter to ensure.

It's much harder to anticipate a safe distance from neighborhood power distribution lines the sort typically found on wooden shafts. For example, homes with a nearby transformer will here and there have higher EMFs because the transformer is a center point, and the power lines carry greater electricity for a gathering of homes. The problem is complicated by the fact that there can be a stray of electricity streaming in the metal water benefit pipes of the area, increasing the magnetic fields from both the power lines and from the covered pipes [121].

In this manner, there is no reliable safety distance for neighborhood power lines. In general, a magnetic field level of 0.5 mG will be reached somewhere close to 10 and 200 feet from the wires. In any case, you cannot tell by basically gazing toward the power lines. You must test nearby with a gaussmeter certainly.

If the electrical power lines are installed underground, the magnetic fields may be similarly as solid, or considerably more grounded. This is because the power lines could be nearer to you when just covered a few feet down, rather than up 20 or 30 feet overhead. For neighborhoods with covered power lines, you should always test with a gauss meter [122].

Power lines also release electric fields. The electric fields from high voltage transmission lines (metal towers) can be extremely strong outside near the wires and stretch out for over a thousand feet. However once inside the home, the building walls usually give some shielding, and the electric fields from electrical wires will usually be significantly stronger than that from the power lines [123].

2.34 The significance of the reactive power in the transmission lines

Electric power is defined as the rate at which the electric energy is transferred by an electric circuit. It is transformed to other types of power when electric charges travel through an electric potential difference, which happens in electrical parts in the electric circuits.

In AC circuits, the electrical parts, which are the inductors and capacitors, may go under a periodic change in the direction of energy stream. This thus offers ascend to the Active and Reactive power [124].

The part of power that, averaged over a total cycle of the AC waveform, brings about net transfer of energy in one direction is known as active power (real power). The part of power resulting from the stored energy, which comes back to the source in each cycle, is referred to as the reactive power [125].

When we pass an electric current through a wire, it clearly delivers magnetic field around it. At the point when this field alternates between opposite peak values both in time and space, an induced voltage is created in any of the conductors lying in the path of this field. This particular field can also react with any other magnetic field established by any other conductor and a mechanical power is created between the two conductors. This alternating field delivered by an alternating current is the basis that enables us to utilize electric power broadly. A DC current with a steady, non-alternating field, does not offer this advantage [126].

The alternating flux posed several issues and one of them being the reactive power. It is the power needed to establish and maintain an AC fluctuating magnetic flux, without which no energy transfer can occur. Against this, we have an active power, which converts power into an electrical, mechanical, thermal or any shape we desire.

Reactive power is a need. Without which the framework won't work properly yet it is the one posing a major problem. The problem area linked with the AC fields are reactance’s, arcs, surges, resonances, skin effect, and hunting torque. To solve these issues, the capacitor is a compelling tool.

At the point when a voltage is primarily placed across a coil, a magnetic field develops, and it takes a period for the current to reach full value. This results in the current to lag the voltage in phase; subsequently, these instruments are considered to be sources of lagging reactive power.

A capacitor is an AC device that stores energy as an electric field. At the point when current is driven through the capacitor, it takes a period for a charge to develop to deliver the full voltage difference. On an AC network, the voltage across a capacitor is constantly changing – the capacitor will contradict this change, causing the voltage to lag the current. In other words, the current causes the voltage in phase; subsequently, these gadgets are sources of leading reactive power [127].

Electric generators provide reactive power (with the active power) that is devoured by the client load [128].

2.35 The main task of the Reactive Power

- Synchronous generators, Static Var Compensator (SVC) and several kinds of other distributed energy resource (DER) device are utilized to keep the values of the voltage’s constant all through the transmission framework. Injecting reactive power into the framework raises voltages, and absorbing the reactive power brings down voltages.
- Voltage-bolster necessities are an element of the locations and magnitudes of generator yields and customer loads and of the configuration of the DER transmission framework.
- These necessities can differ substantially from a location to another and can change quickly as the location and magnitude of generation and load change. At low levels of framework load, transmission lines act like capacitors and increase voltages. At high levels of load, be that as it may, transmission lines absorb reactive power and thereby bring down voltages. Most transmission-framework devices (e.g., capacitors, inductors, and tap-changing transformers) are static but can be changed to respond to changes in voltage-bolster requirements.

System operation has three goals when managing reactive power and voltages [129]:

First, it must maintain adequate voltages all through the transmission and distribution framework for both current and contingency conditions.

Second, it looks to limit blockage of real-power flows.

Third, it looks to limit real-power losses.

2.36 Exposure limits of transmission lines

Alternating fields with a too great degree low frequency create an electric current in the body. On the off chance that the alternating fields are sufficiently strong, this generated current can upset the working of nerves and muscles in the body and cause flashes of light in the field of vision. According to the recommendation of the Committee 1999/519/EC, the accompanying edge values must not be surpassed by the fields with the goal that these impacts don't happen:

• for the electric field, the limit is 5 kilovolt per meter (5000 V/m or 5 kV/m).

• for the magnetic field, the limit is 100 micro-Tesla (100 μT).

The electric and magnetic fields, which encompass us in our life, are often far underneath these cutoff limits. You can read more in the following about the exposure to these fields in daily life and how the recommendations of the council were applied in the Belgian regulations. The main reason for as far as possible is to anticipate immediate the harmful impacts at the level of the nervous system. There is as yet insufficient logical information whether there are other (harmful) impacts that are conceivable over the long term [130].

2.37 Types of Transmission lines

One of the main issues in the design of a transmission line is that there should be as little loss of energy as conceivable, either by radiation, or by heating in resistances or in nearby conductors or dielectrics. There are many sorts of transmission lines whose losses are small:

(1) The *open-wire* line comprising of two parallel wires.

(2) The *twisted-pair* line of the two insulated wires are twisted together.

(3) the *concentric cable* or coaxial line, where a central wire is mounted along the axis of a metal tube, (a) with insulating spacers in most cases, *(b)* with persistent electric insulation along the line (usually utilized with an adaptable outer metal mesh); and

(4) a *single-wire* feeder, where the radiation is kept low by maintaining a small current in it, the ground serves as the return wire.

To keep the losses at small values, transmission lines have their go and return wires near each other when comparing with the wavelength. Then the magnetic and electric fields of one wire cancel or nearly cancel those of the other and radiation does not happen in considerable amount.

For the open-wire line a spacing of 2 to 6 inches utilized, the smaller values used at the higher frequencies. The line should be electrically symmetrical related to its environment; a transposition framework is sometimes utilized. The method proves more useful on longer than on shorter lines, i.e., when the line has a length greater than one or two wave-lengths.

2.38 The Grid input

At the power stations, the power is produced at a relatively low voltage between about 2.3 kV and 30 kV, depending on the size of the unit. The generator terminal voltage is then stepped up by the power station transformer to a higher voltage (115 kV to 765 kV AC, different by the transmission system and by the nation) for transmission over long distances.

In the USA, power transmission is, variously, 230 kV to 500 kV, with under 230 kV or more than 500 kV being local special exceptional cases. For example, the Western Framework has two primary interchange voltages: 500 kV AC at 60 Hz, and ±500 kV (1,000 kV net) DC from North to South (U.S.- Canada border to U.S.- Mexico border).

The 287.5 kV (Hoover to Los Angeles line, via Victorville) and 345 kV (APS line) being local standards, both of which were executed before 500 kV became practical, and thereafter the Western System standard [131].

2.39 Losses

Transmitting electricity at high voltage decreases the fraction of energy lost to resistance, which is different relying upon the particular conductors, the current flow, and the length of the transmission line. For instance, a 100 mi (160 km) span at 765 kV carrying 1000 MW of power can have losses of 1.1% to 0.5%. A 345 kV line carrying the same load across the same distance has losses of 4.2%. For a given amount of power, a higher voltage diminishes the current and consequently the resistive losses in the conductor. For instance, raising the voltage by a factor of 10 lessens the current by a relating factor of 10 and therefore the losses by a factor of 100, giving the same estimated conductors that are utilized as a part of the two cases. Regardless of whether the conductor size (cross-sectional area) is lessened ten times to match the lower current, the losses are still diminished ten times. Long-distance transmission is typically done with overhead lines at voltages of 115 to 1,200 kV. At greatly high voltages, more than 2,000 kV exists amongst the conductor and the ground, corona discharge losses are large to the point that they can offset the lower resistive losses in the line conductors. Measures to lessen corona losses incorporate conductors having larger diameters; often empty to save weight, or packs of at least two conductors.

Factors that influence the resistance, and in this way loss, of conductors utilized as a part of transmission and distribution lines incorporating temperature, spiraling, and the skin impact. The resistance of a conductor increases as a function of the temperature. Temperature changes in electric power lines can have a significant impact on power losses in the line. Spiraling, which alludes the way by which stranded conductors spiral about the middle, also adds to increases in conductor resistance. The skin impact causes the viable resistance of a conductor to increase at higher alternating current frequencies [131].

Transmission and distribution losses in the United States were estimated at 6.6% in 1997 and 6.5% in 2007. Generally, losses are estimated from the discrepancy between power delivered (as detailed by power plants) and power sold to the end users; the distinction between what is created and what is consumed constitute transmission and distribution losses, assuming no utility theft happens.

As of 1980, the longest financially savvy distance for direct-current transmission was resolved to be 7,000 kilometers (4,300 miles). For alternating current, it was 4,000 kilometers (2,500 miles), however all transmission lines being used today are substantially shorter than this.

In any alternating current transmission line, the inductance and capacitance of the conductors can be significant. Currents that stream exclusively in 'reaction' to these properties of the circuit, (which together with the resistance characterize the impedance) represent the reactive power stream, which transmits no 'real' power to the load. These reactive currents, in any case, are real and result in extra heating losses in the transmission circuit. The ratio of 'real' power (transmitted to the load) to 'apparent' power (the result of a circuit's voltage and current, without reference to phase angle) is the power factor. As reactive current increases, the reactive power increases and the power factor decreases. For transmission frameworks with low power factor, losses are higher than for frameworks with high power factor. Utilities add capacitor banks, reactors and other parts, (for example, phase-moving transformers; static VAR compensators (SVC); and flexible AC transmission System (FACTS) all through the framework assist in compensating for the reactive power stream, decreasing the losses in power transmission and stabilize framework voltages. These measures are all things considered called 'reactive support" [132, 133].

2.40 Power Line Signs

Heads up! When you're working close to the overhead power lines, send a message to keep your workers out of risk. Your trained personnel know how to perceive hazards or properly manage them, but data signs and graphics assist everyone stay safe [134,135,137].

• Begin with the correct signal word (caution, warning, or danger) to refer the seriousness of a risk.

• Caution specialists away from overhead power lines, warn them about operating gear near transmission lines, or call attention to high voltage areas.

• Materials oppose fading, abrasions, rust, and chemicals. Perfect inside and outside.

Chapter Three
Materials and Methods
3.1 Introduction
In this chapter, the data collected for operators in Khartoum State until November 2019 by region. Based on the collected data, each company was divided according to the total number of antennas, to the latitude and longitude in addition to the status of each site, the technology used, and the energy emitted from each site for all companies.
3.2 Devices
The device used is the Active Log Per measurement magnetic field by Aaronia Hyper LOG 4040 X. It can cover a frequency range from 400MHz to 4GHz with high ability in analysis and measurements. This range of frequency covers the radio frequency ranges, which makes it applicable in field-strength and EMC measurements. Also, its high precision enables researchers to use it in laboratories or in open-field applications. The selected area for the present study demonstrates the use of various types of transmission lines, antennas, and measurements at different distances. Measurements were performed at distances from 1m to 100 m far from the transmission lines while a GPS device was used to locate the coordinates of the antennas of the transmission lines. At each location, the sort of the transmission lines was determined using accompanied software (Aaronia Lcs analyzer). The devices (Hyper LOG 4040 X) that were used in the measurements were connected to a laptop with the purpose of calibration and to analyze the spectra.

3.3 Data Collected of BTs in Khartoum State for Company A Company A

Table (3.1) to Show the Number of antennas for Company **A** for Locations of Khartoum State

No	Locations	Number of BTs	Percentage of BTs
1	**Khartoum**	**231**	**0.32**
2	**Jabl Awlia**	**113**	**0.15**
3	**Karri**	**82**	**0.11**
4	**Khartoum North**	**113**	**0.15**
5	**Ombda**	**97**	**0.13**
6	**Omdurman**	**95**	**0.13**
7	**Sharge Al- Nile**	**96**	**0.13**
Total		**731**	**%100**

All location of company A is 731 locations divide by seven Region, in view of the general form, we find that the highest value of antennas in Khartoum followed by Khartoum North and Omdurman and accordingly were sampling on the areas where the greatest number of antennas.

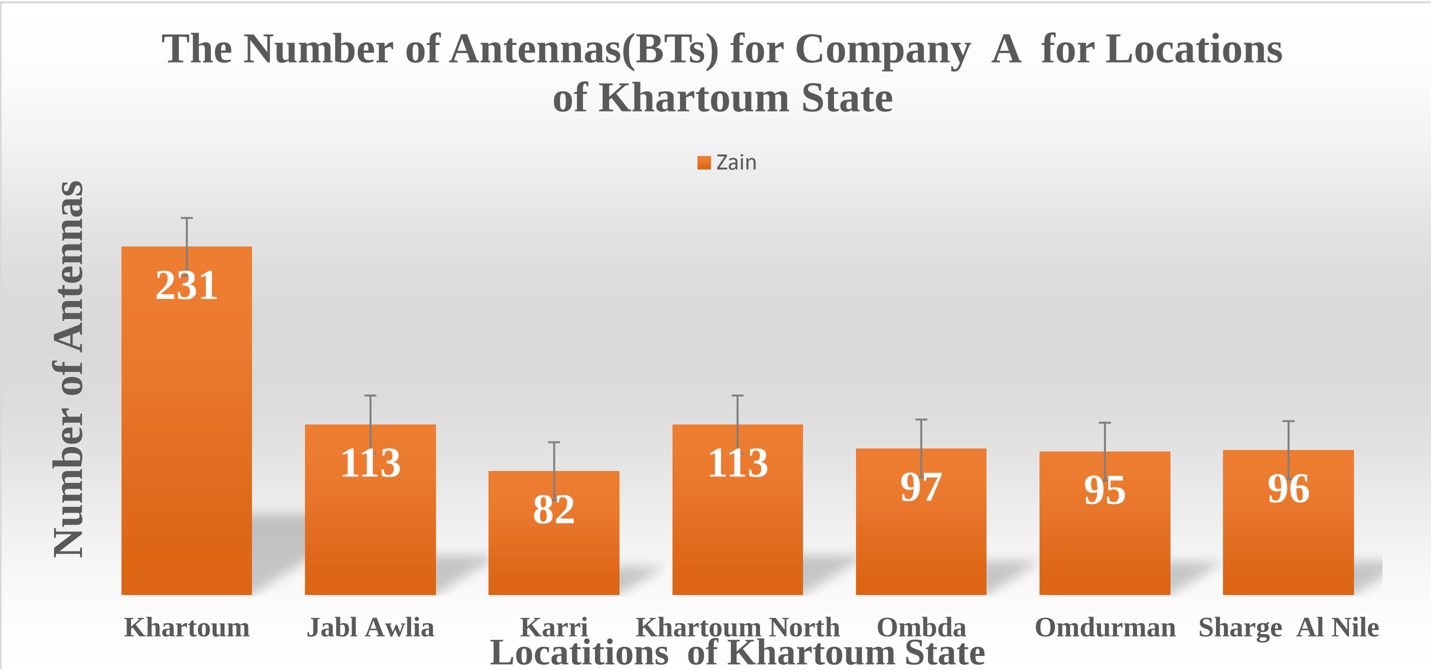

Fig (3.1) to show the number of antennas for Company A for Locations of Khartoum State

Table (3.2) to show the number of Share and not -share antennas for Company **A** for Locations of Khartoum State

NO	Locations	Share Locations	%	Not share	%	Total
1	**Khartoum**	4	0.4	227	0.28	231
2	**Jabl Awlia**	2	0.2	111	0.14	113
3	**Karri**	1	0.1	81	0.10	82
4	**Khartoum North**	1	0.1	112	0.14	113
5	**Ombda**	0	0	97	0.12	97
6	**Omdurman**	2	0.2	93	0.11	95
7	**Sharge Al -Nile**	0	0	96	0.12	96
Total		10		817		827

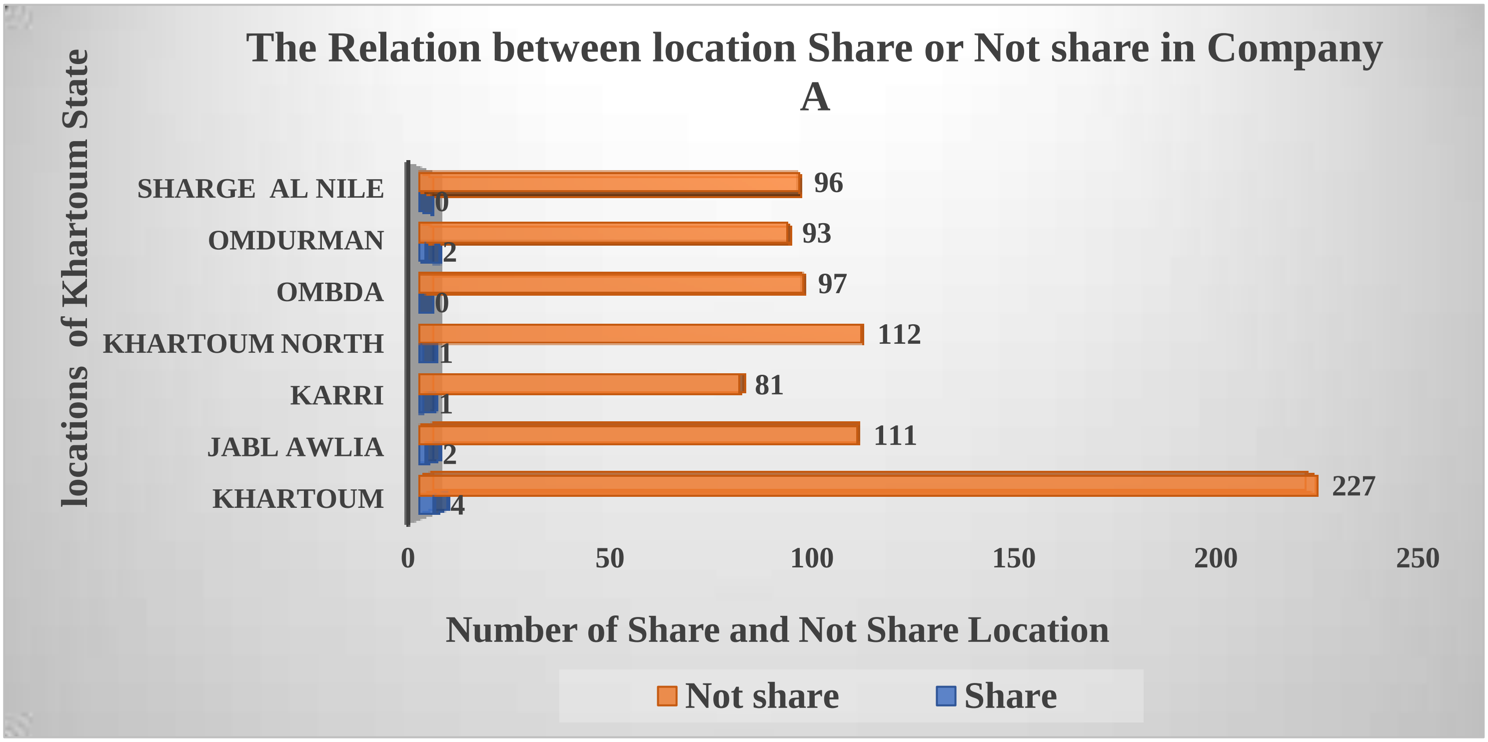

Figure (3.2) showing the number of Share and Not -share antennas for Company A for Locations of Khartoum State

In the table and shape, we can see information about the numbers between the non-shared sites compared to the share sites in Khartoum states for company **A** since November of 2019. In general, view of table, the number of antennas in Khartoum Not share is the biggest 28%, but the Karri area is less than possible. For the Not share locations, the Jabl Awlia and Khartoum North two regions are exactly equal in value 14%. In the Sharge AL-Nile not all locations are share for another company.

Company B

3.4 Data collected of BTs in Khartoum State for Company B

Table (3.3) Show the Number of Antennas for Company **B** for Locations of Khartoum State

No	BTs	Number BTs	%
1	Khartoum	151	0.31
2	Jabal Awala	62	0.13
3	karari	48	0.10
4	Khartoum North	71	0.14
5	Ombda	54	0.11
6	Omdurman	55	0.11
7	Sharge Al-Nile	51	0.10
Total		492	%100

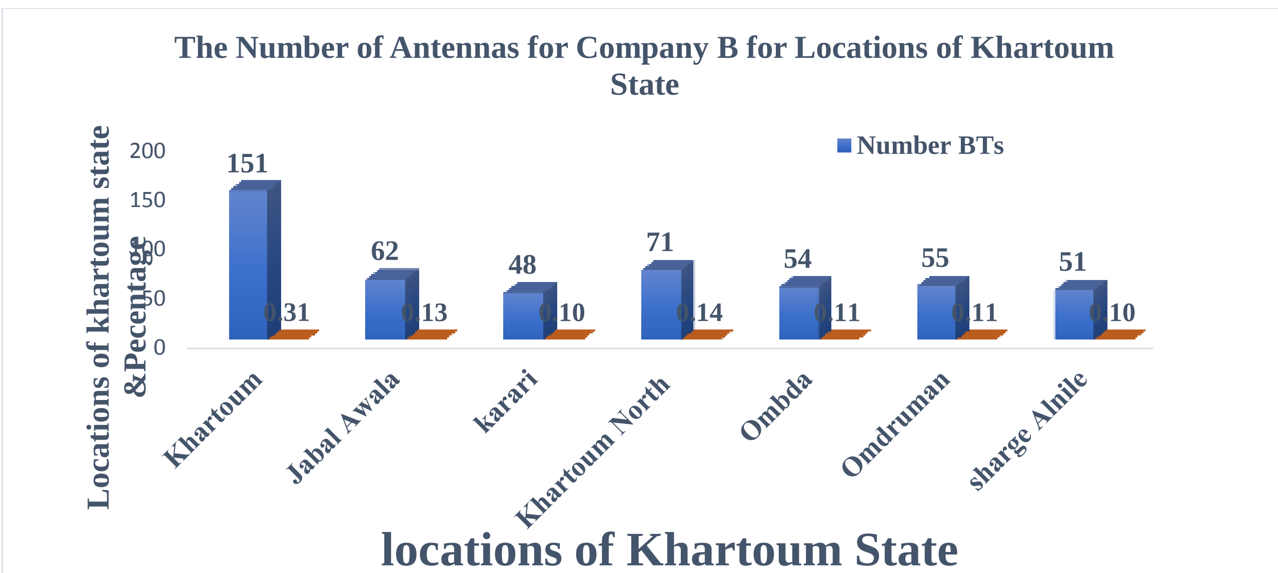

Figure (3.3) The Number of Antennas for Company B for locations of Khartoum State

Table (3.4) show the number of Share and not -share antennas for Company B for locations of Khartoum State

No	Locations	Share	Not Share	Total	%
1	**Khartoum**	10	141	151	0.31
2	**Jabal Awala**	44	18	62	0.13
3	**karari**	33	15	48	0.10
4	**Khartoum North**	38	33	71	0.14
5	**Ombda**	42	12	54	**0.11**
6	**Omdurman**	25	30	55	0.11
7	**Sharge Al-Nile**	41	10	51	0.10
Total		233	259	492	100
%		0.47	0.53		% 100

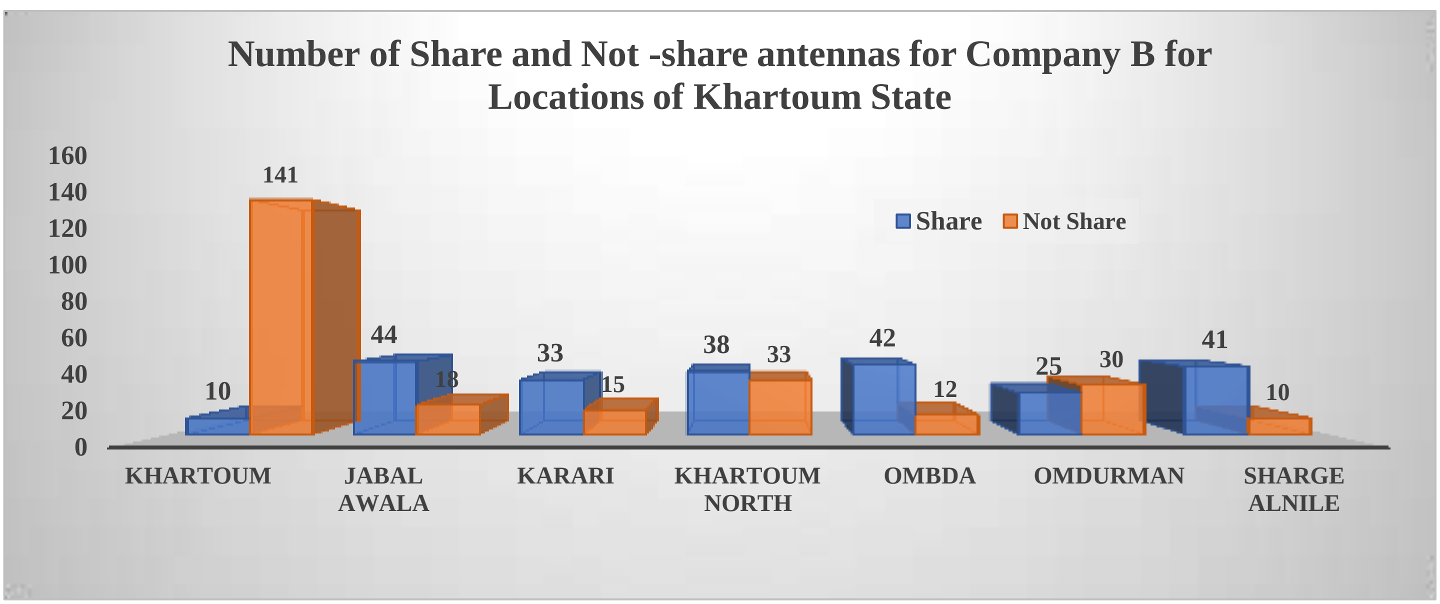

Figure (3.4) showing the number of Share and Not -share antennas for Company B for Locations of Khartoum State

Company C

3.5 Data collected of BTs in Khartoum State for Company C

Table (3.5) showing the number of antennas for Company **C** for Locations of Khartoum State

No	Area of Sits	Total Number of antennas at Company C in Khartoum State	%
1	Khartoum	284	32%
2	Jabal Awila	106	12%
3	karai	76	8%
4	Khartoum North	131	15%
5	Omdurman	104	12%
6	Ombda	85	9%
7	Sharg Al-Nile	109	12%
Total		895	100%

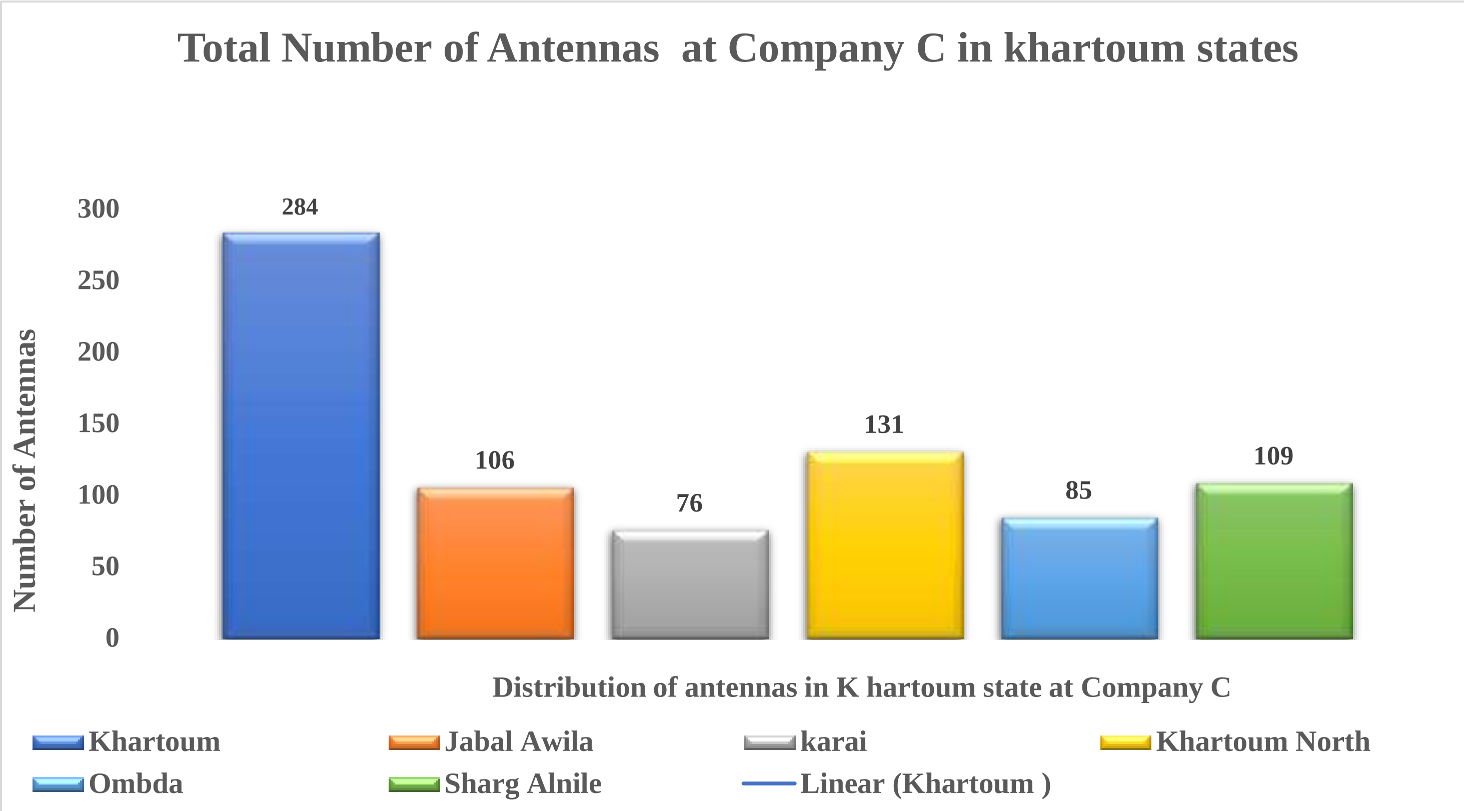

Figure (3.5) to show the number of antennas for Company C for locations of Khartoum State

Table (3.6) show the number of Share and not -share antennas for Company **C** for locations of Khartoum State

No	Locations	Share	%	Not Share	%	Total
1	Khartoum	212	31%	72	0.36	284
2	Jabal Awila	73	11%	33	0.17	106
3	Karai	76	11%	0	0.00	76
4	Khartoum North	108	16%	23	0.12	131
5	Omdurman	84	12%	20	0.10	104
6	Ombda	67	10%	18	0.09	85
7	Sharg Al-Nile	75	11%	34	0.17	109
Total		695	100%	200	1.00	895

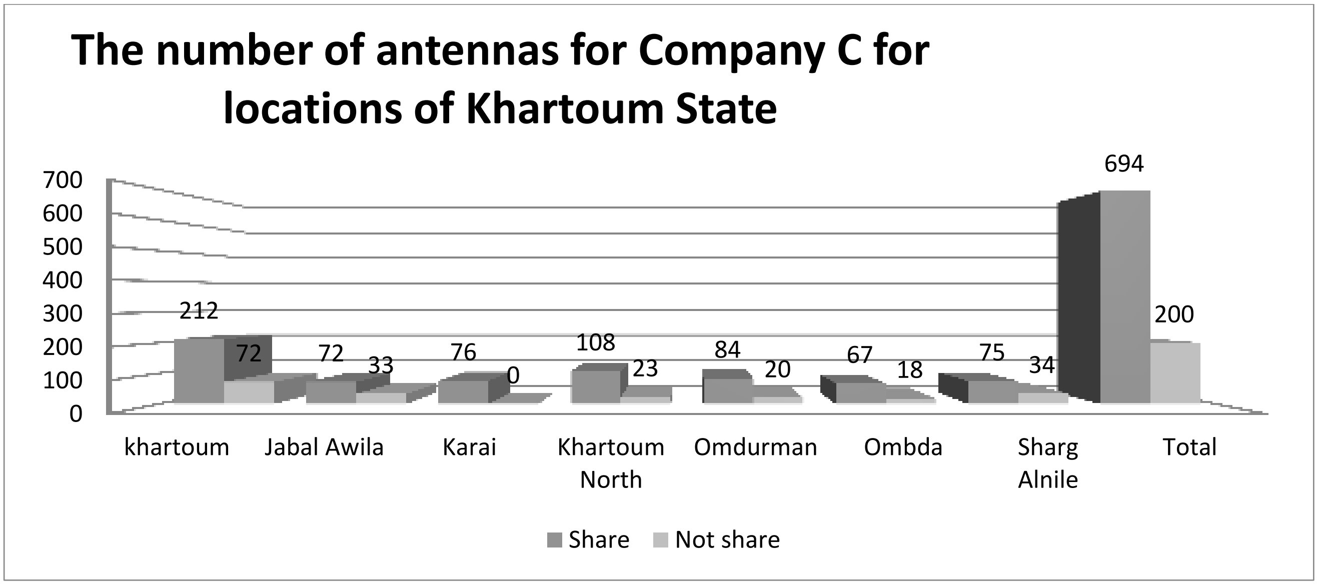

Figure (3.6) to show the number of antennas for Company C for Locations of Khartoum State

The general view and comparison Between share antennas and non-common sites we found that the number Not share antennas in the state of Khartoum has the largest number is equal to 72 by 40%, while the lowest number of non-common towers is located in the region of Karari there are no high residential buildings in these areas. On the other hand, in the Share antennas we find that the number of antennas in Khartoum the highest value of 212 antennas by 35%, while the lowest number of antennas are in the area of Ombda 67 antennas by 11%. For the regions of Karary and Jabal Awile, they are equal in the number of antennas by 12%. Overall, the total number of share antennas is 611 much greater than the number of non-shared antennas equal to 180, with an estimated three times the number of common antennas.

Summary of data collection of Sites

3.6 Summary of data collection of sites

Table (3.7) **to shows a summary of the number of antennas in Khartoum State for operators' companies**

No	BTs	A	B	C	Total	%
1	Khartoum	231	151	284	515	0.23
2	Jabal Awala	113	62	106	281	0.13
3	karari	82	48	76	206	0.09
4	Khartoum North	113	71	131	315	0.14
5	Ombda	97	54	85	236	0.11
6	Omdurman	95	55	104	254	0.11
7	Sharge Al-Nile	96	51	109	256	0.12
Total		827	492	895	2214	%100

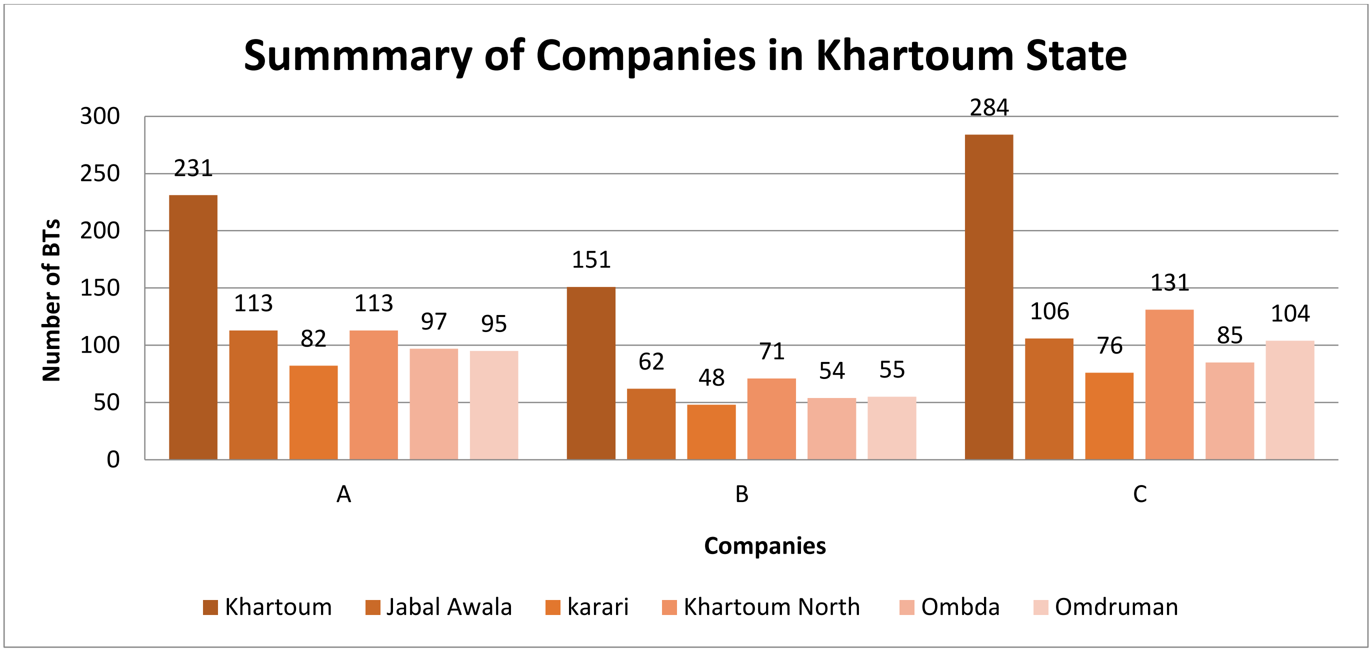

Figure (3.7) Summary of the number of antennas in Khartoum State for operators' companies

Note the table and diagram above we find that all the data collected since 2019, we found that the number of antennas is in the state of Khartoum, Omdurman and Khartoum North are occupying a large reservation in the number of antennas by. range 23%, 14% and 11% respectively .In addition, these areas represent the vital capital of Sudan and the high density of population compared to other regions 7,152,102 million for the Last census of Khartoum Stat

Chapter Four
Results and Discussion

4.1 Introduction
In this Section B, the work is divided into two parts. The first part includes the exposure from communication towers and the second part is about the exposure from high voltage lines. The measurements were taken in Omdurman, Khartoum North, and Khartoum. 50 communication towers and 50 sites with high voltage lines were selected at random in each town. The measurements were taken at distances up to 100 m from the source.

4.2 Exposure from Antennas
4.2.1 Measurements at Khartoum
Measurements were performed at distances from 10m to 100 m far from the antennas, while a GPS device was used to locate the coordinates of the antennas. The setup of the instruments used is show in Fig. 4.1.

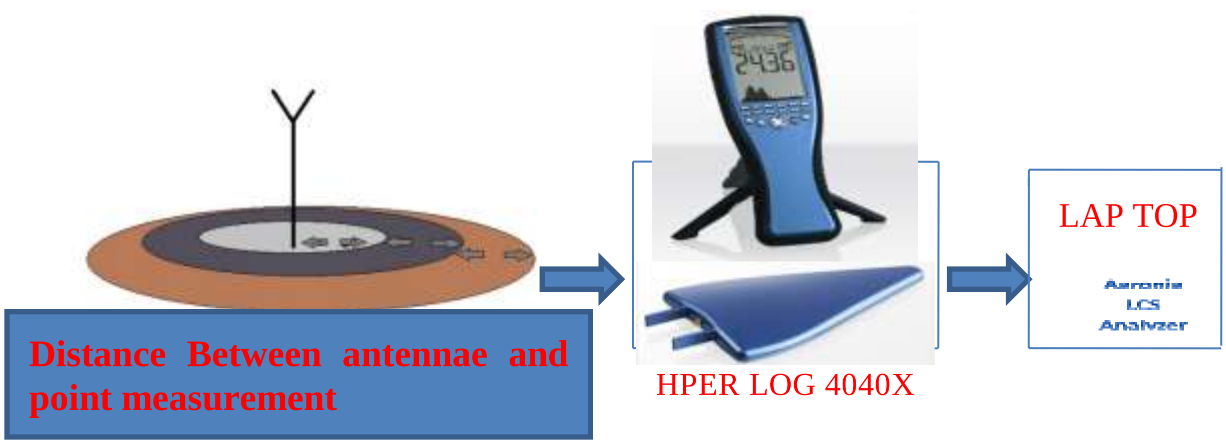

Figure (4.1) The setup of measurement from antennas

The average values of the exposure, from 50 antennas, at frequencies 1800 and 900 MHz, are shown in Table 4.1. Figure 4.2 shows the average exposure from 50 antennas in Khartoum at different distances at frequency 1800 MHz at the distance of 10 meters the exposure is very high and it decreases fast with distance to be become negligible at a distance of about 100 m.

Fig. 4.3 shows the exposure of GSM 900 in Khartoum. At 10 m the exposure is about 22.3nWm^{-2}, but it becomes nearly zero at 20 m from the antenna.

Table (4.1) Average readings of the exposure from 50 antennas in Khartoum at different distances and at frequencies 1800 and 900 MHz

Distances (M)	**Exposure (nW/m^2) at 1800 MHz 10^{-4}**	**Exposure (nW/m^2) at 900 MHz 10^{-4}**
10	**4900**	**22300**
20	**925**	**197**
30	**798**	**53**
40	**623**	**197**
50	**512**	**53**
60	**185**	**197**
70	**892.2**	**53**
80	**343.2**	**197**
90	**325**	**53**
100	**0.12**	**197**

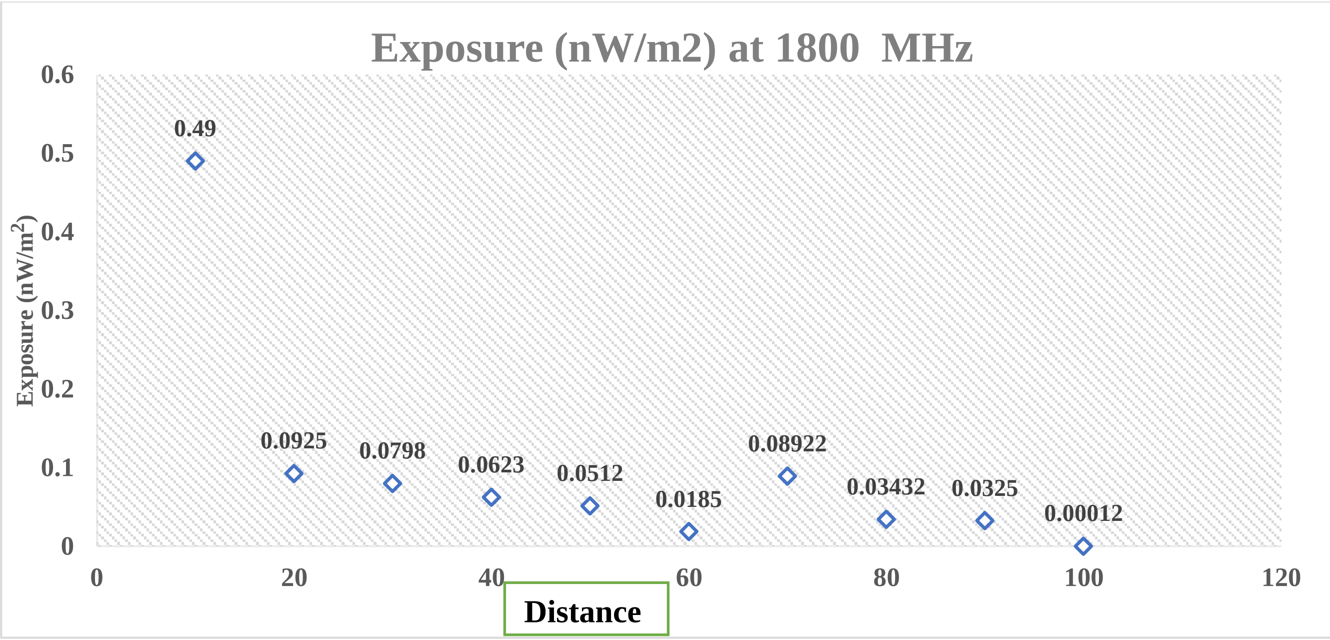

Figure (4.2) Relationship between distance from the antenna and the exposure at 1800 MHz in Khartoum

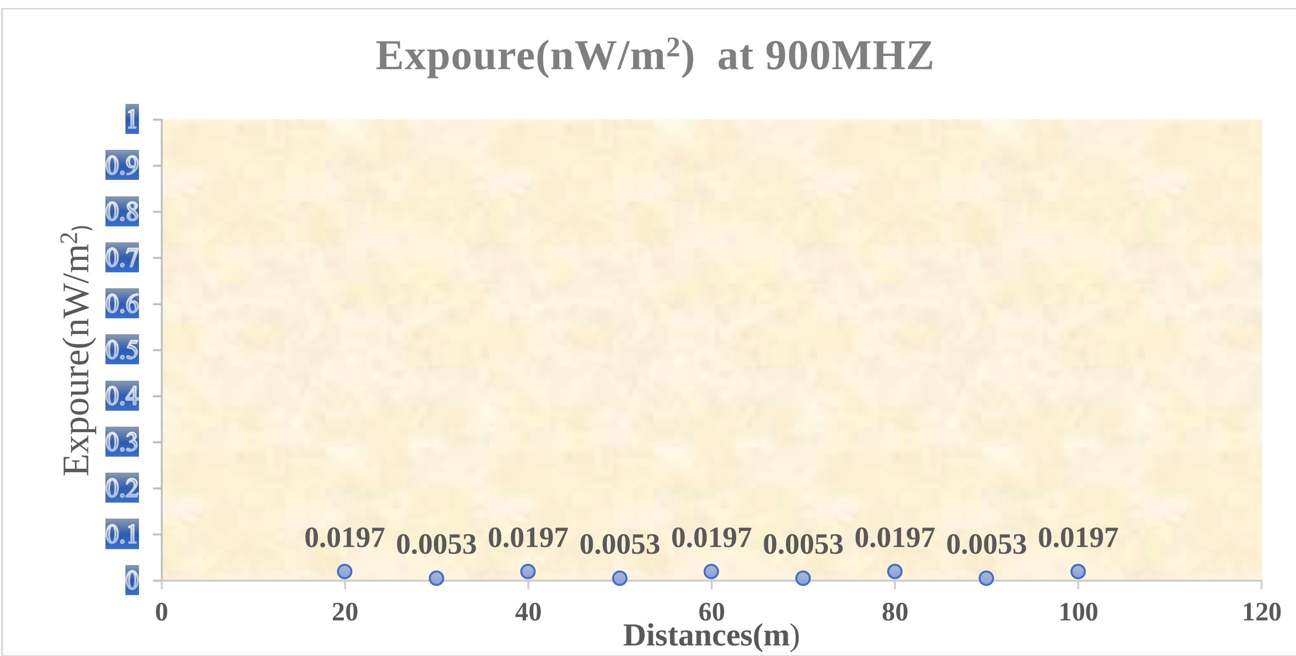

Figure (4.3) Relationship between distance from the antenna and the exposure at 900 MHz in Khartoum

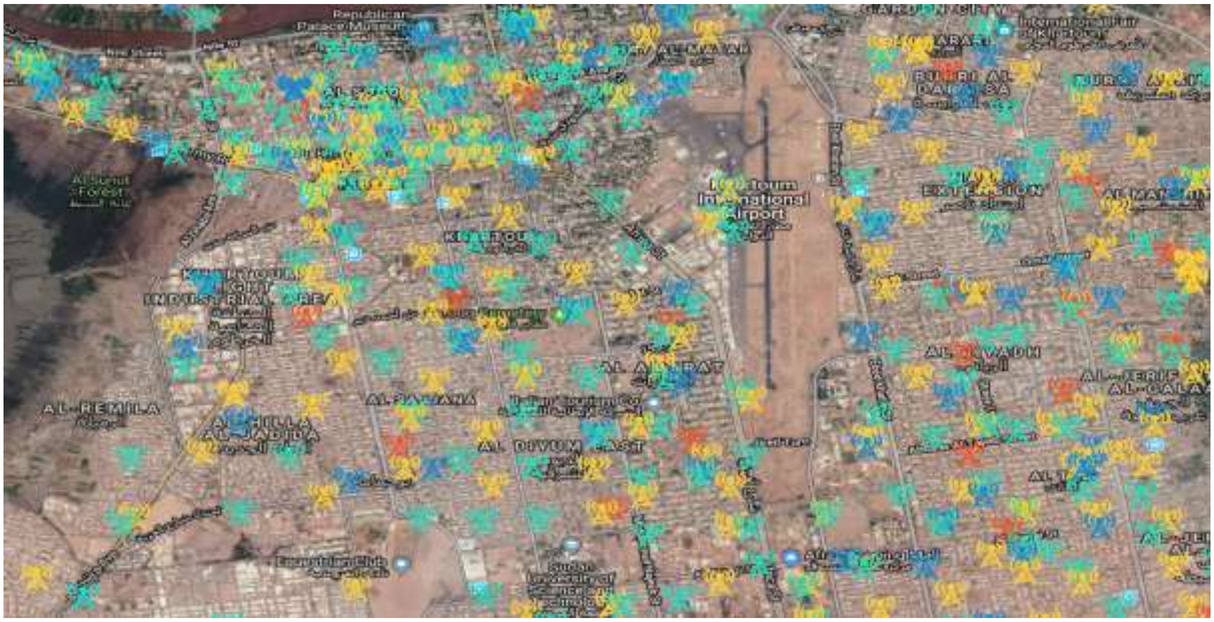

Figure (4.4) Distribution of BTs in Khartoum

4.2.2 Measurements at Omdurman

The measurements of the exposure at 1800 and 900 MHz, at distances of 10-to100 m from the antennas, are shown in Table 4.2. The exposure at 1800 M Hz is shown in Fig. 4.4. It deceased from 0.12 nWm^{-2} at the distance of 10 m to nearly zero, within the error of measurement, at the distance of 100 m. The exposure at 900 M Hz is shown in Fig. 4.5. The values decrease quickly to a value of about zero at a distance of about 30 m.

Table (4.2) **Average readings of the exposure from 50 antennas in Omdurman at different distances and frequencies 1800 and 900 MHz**

Distance(m)	Exposure (nW/m^2) at 1800 MHz 10^{-4}	Exposure (nW/m^2) at 900 MHz 10^{-4}
10	**1200**	**1550**
20	**900**	**1000**
30	**890**	**530**
40	**770**	**197**
50	**690**	**760**
60	**680**	**623**
70	**560**	**12.5**
80	**500**	**19.7**
90	**443**	**21.5**
100	**0.006**	**0.0197**

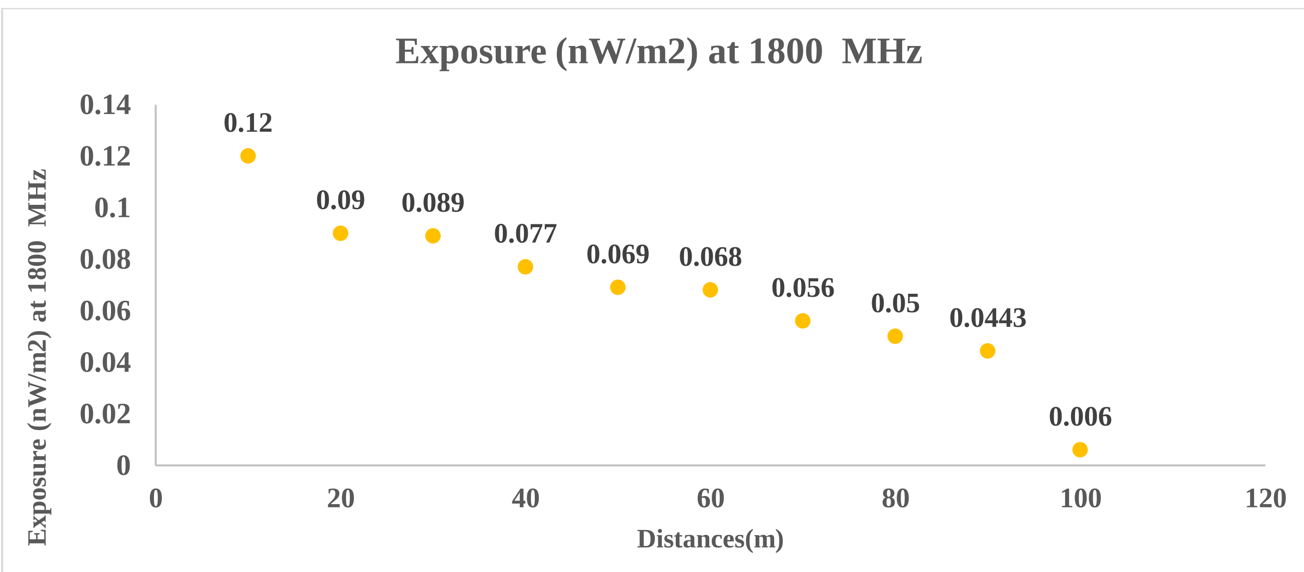

Figure (4.5) Relationship between distance from the antenna and the exposure at 1800 MHz in Omdurman

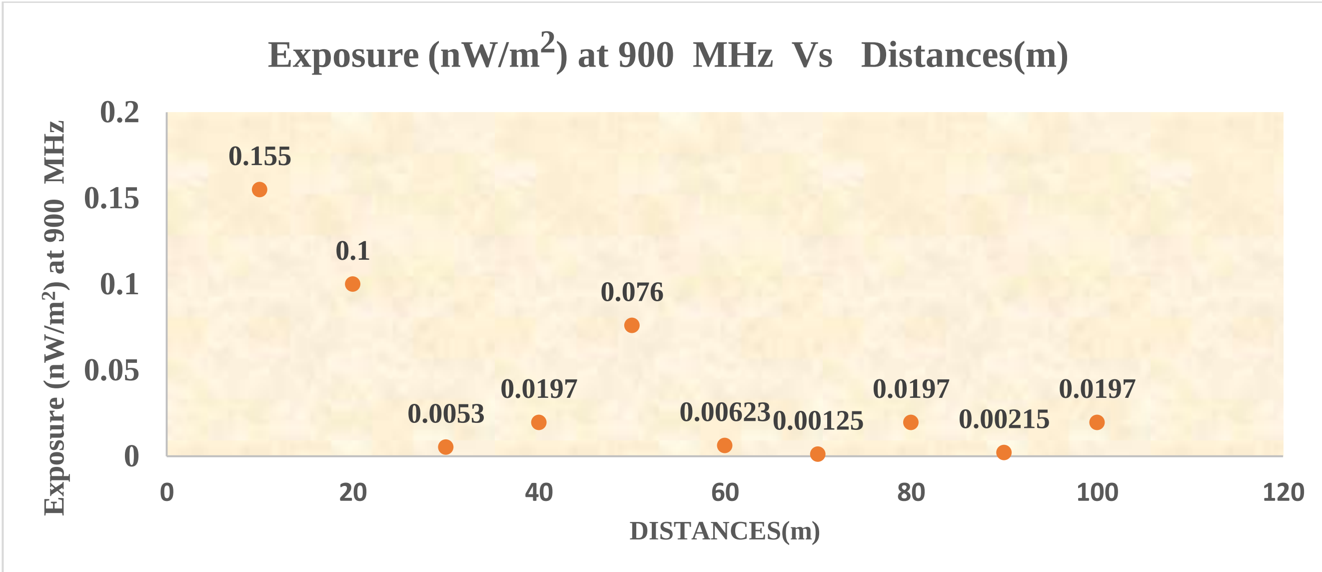

Figure (4.6) Relationship between distance from the antenna and the exposure at 900 MHz in Omdurman

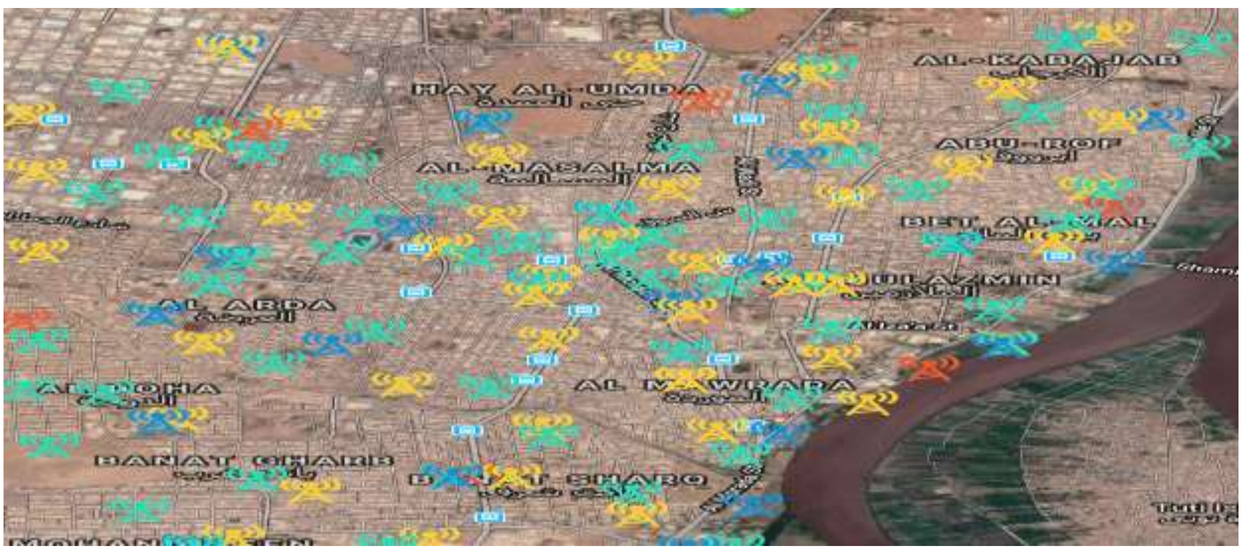

Figure (4.7) Distribution of BTs in Omdurman

4.3.3 Measurements at Khartoum North

The city of Khartoum North is in the west bank of the Nile. The average of measurements from 50 communication towers, at 1800 and 900 MHz, at distances of 10-to100 m from the antennas, are shown in Table 4.3. The exposure at 1800 M Hz is shown in Fig. 4.6. It deceased from 0.86 nWm^{-2} at a distance of 10 m to nearly zero at 90 m from the antenna. Fig. 4.8 shows the exposure, at 900 M Hz, variation with distance from the antenna. It deceased from 0.77 nWm^{-2} at the distance of 10 m to nearly zero at 30 m from the antenna.

Table (4.3) Average readings of the exposure from 50 antennas in Khartoum North at different distances and frequencies 1800 and 900 MHz

Distances (m)	Exposure (nW/m^2) at 1800 MHz 10^{-4}	Exposure (nW/m^2) at 900 MHz 10^{-4}
10	8600	7700
20	7630	250
30	660	53
40	530	197
50	550	250
60	450	132
70	420	240
80	420	120
90	23	530
100	23	120

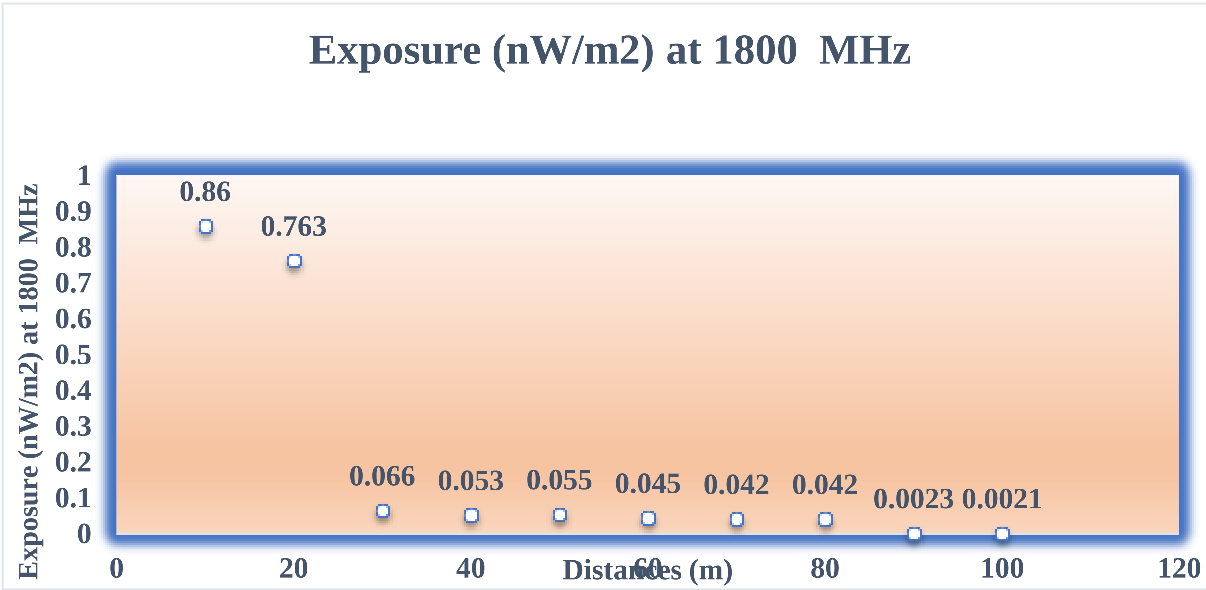

Figure (4.8) Relationship between distance from the antenna and the exposure at 1800 MHz in Khartoum North

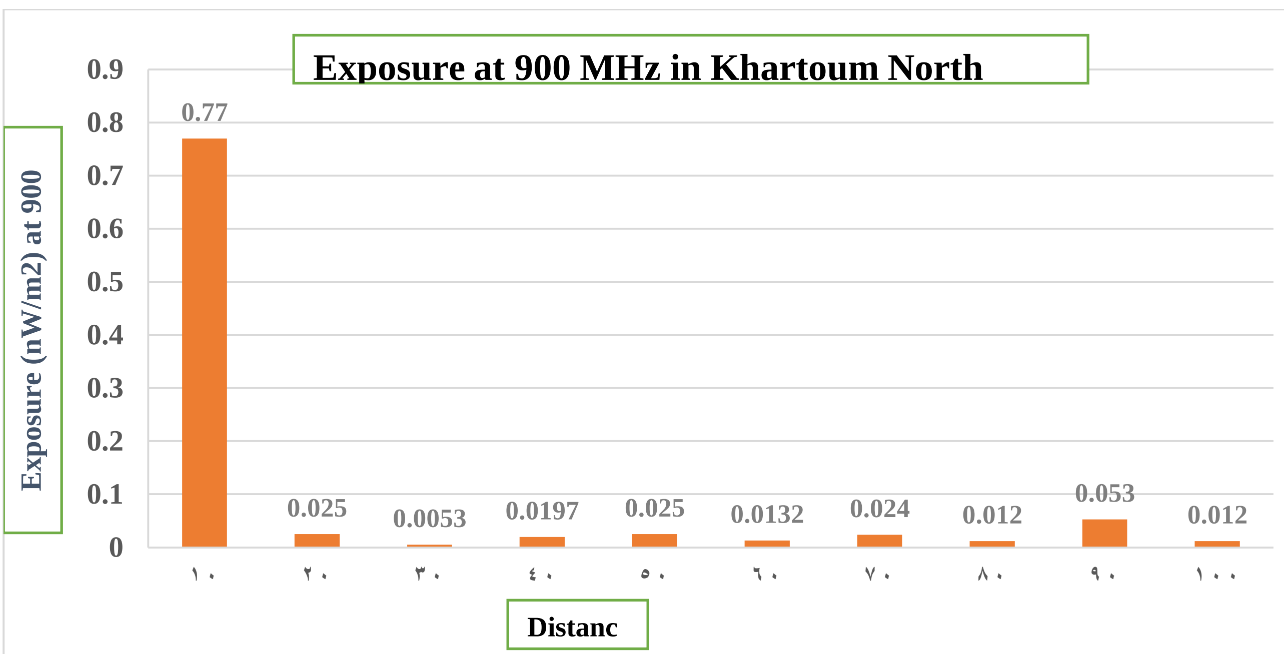

Figure (4.9) Relationship between distance from the antenna and the exposure at 900 MHz in Khartoum North

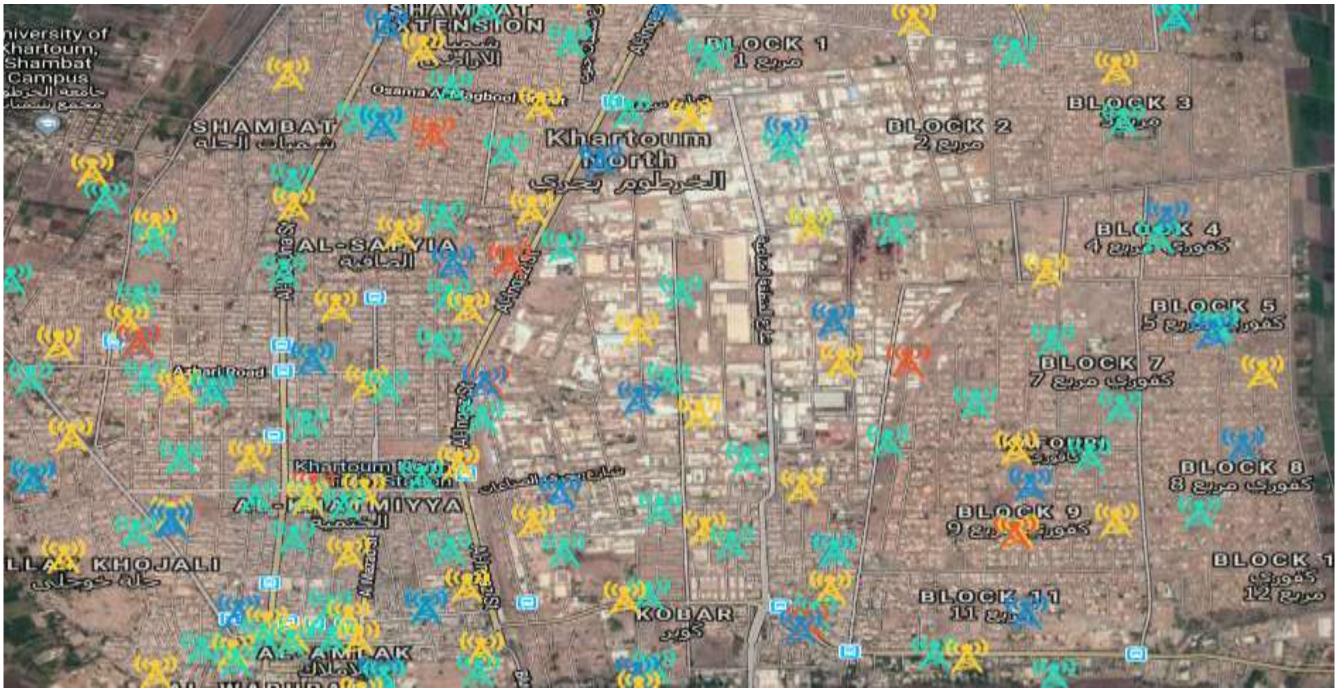

Figure (4.10) Distribution of BTs in Khartoum North

4.5 Exposure from Transmission lines

4.5.1 Measurement from Transmission lines in Khartoum

In Khartoum town, we collected the mean values of the magnetic field from the surroundings of 50 transmission lines at different distances from transmission lines. The values are shown in Table 4.4 and Fig. 4.11. At a distance of 70 m from the lines, the field decreases to about 3% of its value at 10 m from the lines.

Table (4.4) Average reading of the magnetic field in Khartoum, at different distances from transmission lines

Distances (m)	10	20	30	40	50	60	70
Magnetic Field (nT)	42.59	18.33	27.39	21.7	16.3	4.78	1.37

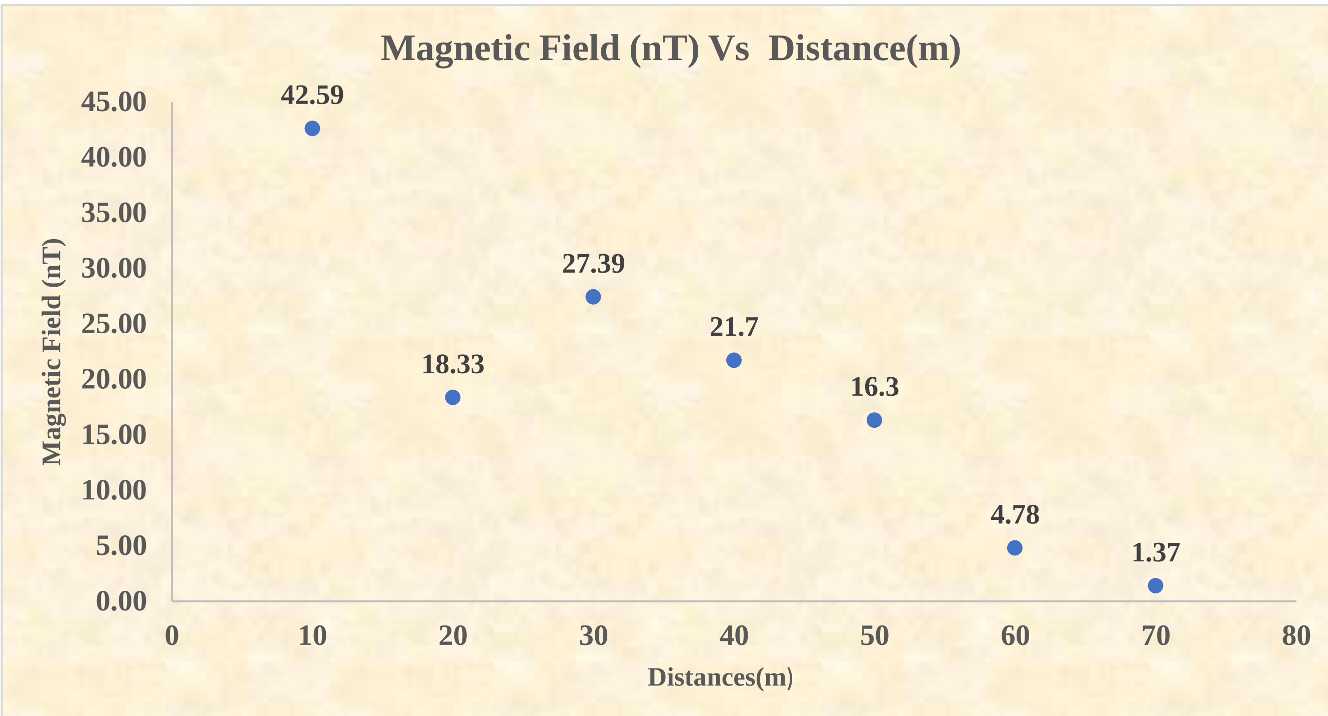

Figure (4.11) Relationship between Magnetic Field in Khartoum at different distances.

4.5.2 Measurement from the Transmission lines in Omdurman

The mean values of the magnetic field from the surroundings of the transmission lines at different distances are shown in Table (4.5) and Fig. 4.12. At a distance of 70 m from the lines, the field decreases to about 4% of its value at 10 m from the lines.

Table (4.5) Average reading for Magnetic Field in Omdurman at different distances from the transmission lines

Magnetic Field (nT)	**38.33**	**22.12**	**23.12**	**26.33**	**20**	**3.95**	**1.37**
Distances(m)	**10**	**20**	**30**	**40**	**50**	**60**	**70**

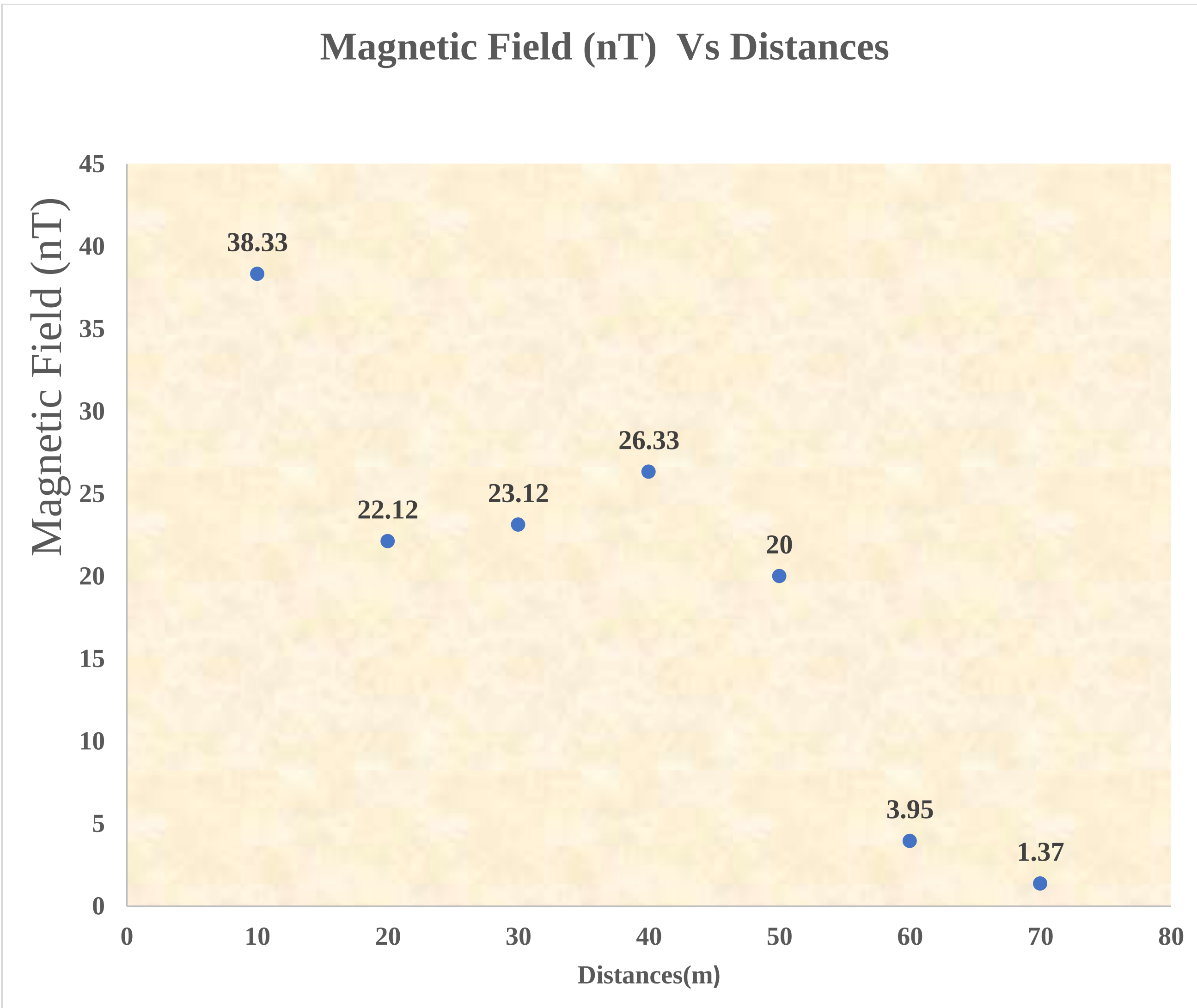

Figure (4.12) Relationship between Magnetic Field in Omdurman at different distances.

4.5.3 Measurement from the Transmission lines in Khartoum North

The mean values of the magnetic field from the surroundings of the transmission lines at different distances are shown in Table 4.6 and Fig. 4.13. At a distance of 70 m from the lines, the field decreases to about 11% of its value at 10 m from the lines.

Table (4.6) Average reading for Magnetic Field in Khartoum North with different distances from transmission lines

Magnetic Field (nT)	29.33	18.12	20.12	23.3	23.05	6.95	3.37
Distances(m)	10	20	30	40	50	60	70

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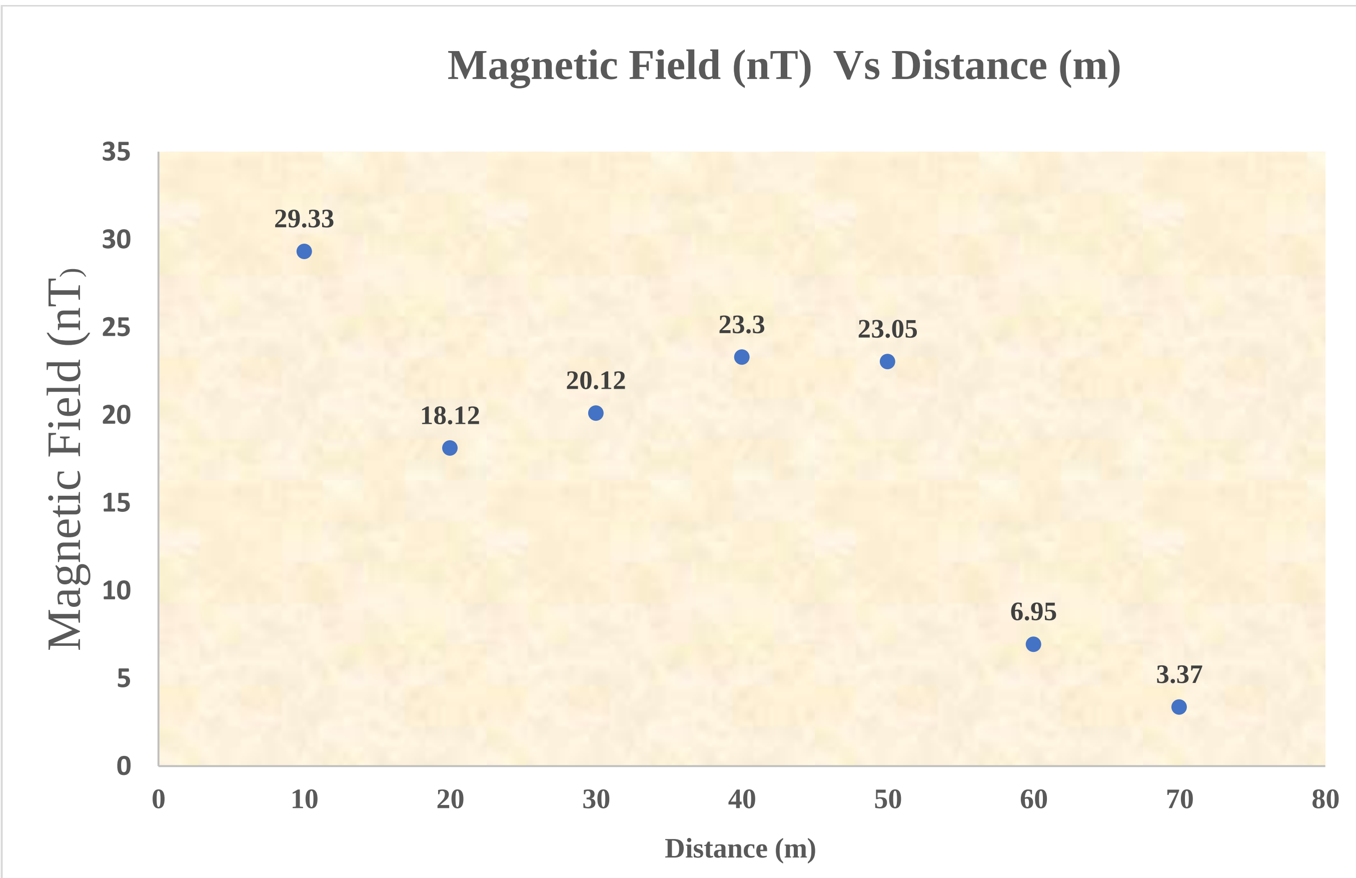

Figure (4.13) Relationship of the magnetic field in Khartoum North at different distances

Table (4.7) Measurement from the Transmission lines in Khartoum at 50 locations

No	Locations	latitude	Longitude	Details of Locations
Residential Areas				
1	Al-Hamadab Ashilaq Albulis 3	**15.32707404 ° N**	**32.3079524 ° E**	On the main street on 20 m of residential areas
2	Al-Hamadab Ashilaq Albulis 4	**15.323337 ° N**	**32.3033516 ° E**	On the main street on 20 m of residential areas
3	Jabrat Janub 1	**15.3050.3244° N**	**32.3115748° E**	On the main street on 20 m of residential areas
4	Jabrat Janub 2	**15.3050.4252° N**	**32.3116568 ° E**	On the main street on 20 m of residential areas
5	Jabrat Janub 3	**15.3038808° N**	**32.3016392° E**	On the main street on 20 m of residential areas
6	Jabrat Janub 4	**15.3041004° N**	**3230297468° E**	On the main street on 20 m of residential areas
7	Jabrat Janub 5	**15.30447264° N**	**32.305337° E**	On the main street on 20 m of residential areas
8	Jabrat Janub 6	**15.30504144° N**	**32.3128852° E**	On the main street on 20 m of residential areas
9	Jabrat Janub 7	**15.30524124° N**	**32.31410628° E**	On the main street on 20 m of residential areas
10	Jabrat Janub 8	**15.30542088° N**	**32.31525882° E**	On the main street on 20 m of residential areas
11	Jabrat Janub 9	**15.3055998° N**	**32.32337284° E**	On the main street on 20 m of residential areas
12	Al-Suwq Al-Mahaliyu -Sharie Al-Hawa' 1	**15.3057888° N**	**32.32154572° E**	On the main street on 20 m of residential areas

13	Al-Suwq Al-Mahaliyu -Sharie Al-Hawa' 2	**15.3059.7636° N**	**32.32271248° E**	On the main street on 20 m of residential areas
14	Al-Suwq Al-Mahaliyu -Sharie Al-Hawa' 3	**15.3121216° N**	**32.324164° E**	On the main street on 20 m of residential areas
15	Al-Suwq Al-Mahaliyu -Sharie Al-Hawa' 4	**15.313432° N**	**32.3250136° E**	On the main street on 20 m of residential areas
16	Al-Suwq Al-Mahaliyu -Sharie Al-Hawa' 5	**15.313432° N**	**32.3250136° E**	On the main street on 20 m of residential areas
17	Al-Suwq Al-Mahaliyu -Sharie Al-Hawa' 6	**15.316.6144° N**	**32.33135432° E**	On the main street on 20 m of residential areas
18	Al-Suwq Al-Mahaliyu -Sharie Al-Hawa' 7	**15.17177° N**	**32.33251784° E**	On the main street on 20 m of residential areas
19	A Fra Mall 1	**15.33347004° N**	**32.3317828° E**	On the main street on 20 m of residential areas
20	A Fra Mall 2	**15.33355428° N**	**32.33173988° E**	On the main street on 20 m of residential areas
21	Al-Sahat AL-khadra'	**15.33368388° N**	**32.33211248° E**	On the main street on 20 m of residential areas
22	Arkwyt 1	**15.3375084° N**	**32.3324624° E**	On the main street on 20 m of residential areas
23	Arkwyt 2	**15.3239.7836° N**	**32.33363276° E**	On the main street on 20 m of residential areas
24	Tuqatie AL-Sharqi	**15.334032° N**	**32.334242426° E**	On the main street on 20 m of residential areas

25	Tuqatie Sharie Muhamad Najib with Dar Sawatil	**15.33358056° N**	**32.33111564° E**	On the main street on 20 m of residential areas
26	Al-Rumayla1	**15342.7228° N**	**32.3037.8576° E**	On the main street on 20 m of
27	Al-Rumayla2	**15.348364° N**	**32.30403488° E**	On the main street on 20 m of residential areas
28	Al-Rumayla3	**15.34111144° N**	**32.3042.318 ° E**	On the main street on 20 m of residential areas
29	Al-Rumayla4	**15.34200604° N**	**32.30419184° E**	On the main street on 20 m of residential areas
30	Doha Jabra 1	**15.31285708° N**	**32.3043164° E**	On the main street on 20 m of residential areas
31	Doha Jabra 2	**15.31463788° N**	**32.33044964° E**	On the main street on 20 m of residential areas
32	Doha Jabra 3	**15.31517116° N**	**32.30648° E**	On the main street on 20 m of residential areas
33	Doha Jabra 4	**15.31576588° N**	**32.307848° E**	On the main street on 20 m of residential areas
34	Al-Hamadab Ashilaq Al-Bulis 1	**15.3214028° N**	**32.3080172° E**	On the main street on 20 m of residential areas
35	Behind the Nile Sports Club 2	**15.33366588° N**	**32.36232668° E**	100 m to the residential area
36	Presidency of Sondos Agricultural Project	**15.35518148° N**	**32.303578° E**	100 m to the residential area
37	Al-Rumayla 8	**15.3449.9656° N**	**32.3036756° E**	On the main street on 20 m of residential areas
38	Al-Rumayla 5	**15.3427822° N**	**32.30403884° E**	Within 10 meters residential areas

In the Industrial Zone				
39	Al-Rumayla 6	**15.34353496° N**	**32.303897° E**	In the industrial zone Khartoum 20 meters from residential areas
40	Al-Rumayla 7	**15.344205064° N**	**32.30382716° E**	In the industrial zone Khartoum 20 meters from residential areas
41	Al-Rumayla 9	**15.3505352° N**	**32.30351504° E**	In the industrial zone Khartoum
42	Al-Shajara 1	**15.3730738° N**	**32.28446124° E**	In the industrial zone Khartoum
43	Al-Shajara 2	**15.334644° N**	**32.3049752° E**	In the industrial zone Khartoum
Hospital				
44	Behind the Nile Sports Club 1	**15.331044° N**	**32.3070797° E**	On 150 m from Best Care Hospital
Power Station				
45	Power station on Air Street with Jabra Street	**15.30389988° N**	**32.3084924° E**	Main Power Station
46	Yathrib 1	**15.30441216° N**	**32.3081416° E**	On the main street on 20 m of residential areas
47	Yathrib 2	**15.30549108° N**	**32.3068364° E**	On the main street on 20 m of residential areas
48	Yathrib 3	**15.316.4416° N**	**32.30612° E**	On the main street on 20 m of residential areas
49	Yathrib 4	**15.31175188° N**	**32.30657° E**	On the main street on 20 m of residential areas
Schools				
50	Al-Hamadab Ashilaq Al-Bulis 2	**15.3222884° N**	**32.3088092° E**	20 m from the school Hammadab

Table (4.8) Summary of Measurement from the Transmission lines in Khartoum at 50 locations

No	Areas study In Transmission line	Number of Transmission Line	%
1	Residential areas	38	0.76
2	Industrial zones	5	0.1
3	Hospitals	1	0.02
4	Power Stations	5	0.1
5	schools	1	0.02
Total		50	%100

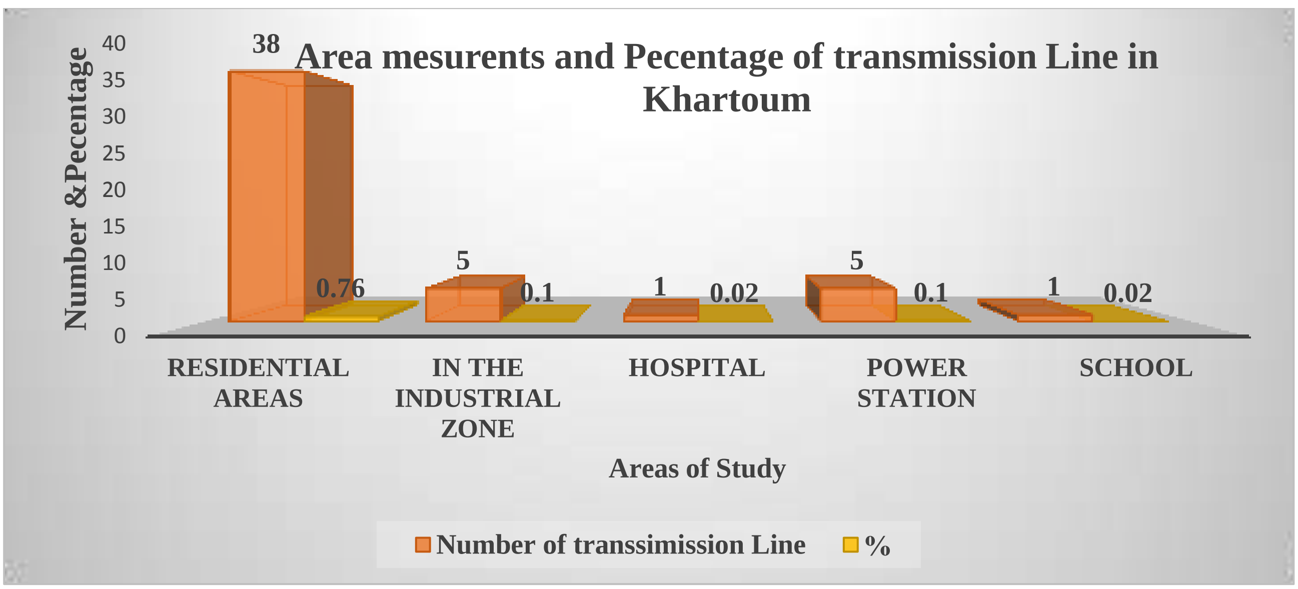

Fig (4.14) Summary of Measurement from the Transmission lines in Khartoum at 50 locations

Table (4.9) Measurement from the Antennas in Khartoum at 50 locations

No	locations	Longitude	Latitude	Details
Residence areas				
1	Al-Mamorah 58	15.53456° **N**	32.57189 ° **E**	Residential area.
2	Yathrib 10	15.52965° **N**	32.49605° **E**	Residential area.
3	Al-Ameriah	15.52187° **N**	32.49572° **E**	Residential Area.
4	Al-Azhary 11	15.51089° **N**	32.57119° **E**	Residential Area.
5	Gabrah 19	15.52788° **N**	32.5316° **E**	Residential Area.
6	Gabrah 4	15.52828° **N**	32.52817° **E**	Residential Area.
7	Al-Engaz 1	15.5184° **N**	32.56189° **E**	Residential Area.
8	Al-Engaz 12	15.51231° **N**	32.56244° **E**	Residential Area.
9	Al-Azhary 11	15.51096° **N**	32.5686° **E**	Residential Area.
10	Al-Aosharah 8	15.54586° **N**	32.52634° **E**	Residential Area.
11	Al-Hamadab Ganoob 4	15.5333° **N**	32.49464° **E**	Residential Area.
12	Al-Shagarah 3	15.54006° **N**	32.49517° **E**	Residential Area.
14	Al-Sahafa 41	15.53219° **N**	32.55329° **E**	Residential Area.
15	Al-Sahafa 39	15.54133° **N**	32.55246° **E**	Residential Area.
16	Al-Mamorah 69	15.53944° **N**	32.57156° **E**	Residential Area.
17	Al-Mamorah 72	15.53629° **N**	32.57634° **E**	Residential Area.
18	Al-Mamorah 72	15.5362° **N**	32.57512° **E**	Residential Area.
19	AL-Eamarat-Badi Abu Doken Stree	15.34272964° **N**	32.32333484 ° **E**	Residential Area.
20	Awmak Street 1	15.35173724° **N**	32.3419992° **E**	On the main street / transportation area
21	Awmak Street 3	15.35126816° **N**	32.3352326 ° **E**	On the main street / transportation area
22	Tuqatie AL-Mushtal	15.345277° **N**	32.33372204 ° **E**	transportation area

23	Al Jarif Al Sitiiyn Street near Al Swahly Street	15.33471816° **N**	32.34145596 ° **E**	On the main street transportation area 200 m
24	Al-Nozha 2	15.33208692° **N**	32.3216.3032 ° **E**	a residence area is 200 meters away
25	Arkwyt 2	15.3252.2924° **N**	32.3348.4058 ° **E**	On the main street / residential complex
26	Al-Sahafat Zult Block 29 Mahatat 7	15.3235.8044° **N**	32.32236364° **E**	Location is located on the main street there is a transportation pool
Schools				
27	Al-Sahafa 30	15.54107° **N**	32.54601° **E**	School at 30 m
28	Al-Sahafa 3	15.54043° **N**	32.49582° **E**	School at 150m
29	Al- Al-Sahafa Zult Block37	15 .3244.606° **N**	32 .33115092° **E**	Near the mosque 37 there are schools behind the antennas / there is the Future University 250 m and there are schools Saad Ali after 250 m
30	Arkwyt 1	15.32496788° **N**	32.33321264° **E**	There are in hotel apartments / behind schools complex / there is a heart hospital at 300 m
31	Sudan International University	15.332448° **N**	32.3352128° **E**	Above the university building
32	Arkwyt bank AL-Eumma	15.33266544° **N**	32 .3350864 ° **E**	30 m from Furqan Secondary School

33	Al-Nozha -1	15.334.3128° **N**	32.32150716° **E**	Near to Nile Secondary School 400 m
34	AL-Firdaws	15.339.3816° **N**	32.34227568° **E**	Near the basic Aljawda school about 200 meters / there is a kindergarten at 200 meters
35	AL-Diym - 1 near the Hijazi Mosque...	15.33527544° **N**	32.32106836° **E**	Near the school Aldim about 400 m
36	Al-Farabi College	15.3326544 ° **N**	32.3351848° **E**	Near Al-Farabi College, 150 m
37	Africa university	15.52702° **N**	32.56577° **E**	It is 200 meters from the campus university
38	Al-Manshih- Behind the mosque Sanhour	15.3533468° **N**	32.34305868 ° **E**	Ibn Khaldun College, 50 m, Ibn Sina University, 400 m
Hospitals				
39	Bashir Al-Nafidi Street next to Dream Hospital 1	15.3542018° **N**	32.3424816 ° **E**	Next to Dream Hospital 100 m
40	Bashir Al-Nafidi Street next to Dream Hospital 2	15.354218° **N**	32.3424492 ° **E**	Next to Dream Hospital 100 m
41	Mecca Eye Hospital	15.34371172° **N**	32.33398805 ° **E**	100 m away from Mecca Eye Hospital / University of Science and Technology 300 m
42	Tuqatie AL-Sharqi	15.33445896° **N**	32.334842 ° **E**	Transportation areas

43	Al-Emara- 1	15.3312.084° **N**	32.32177792 ° **E**	350 m away from the Academic Teaching Hospital
44	AL-Emarat -near Ice Cream 41	15.3437784 ° **N**	32.32551868 ° **E**	100 m - area in the evening from 5 to 12 at night...
45	AL-Eamarat -Mohamed Naguib Street	15.355.2404° **N**	32.32281184 ° **E**	Restaurants area
46	Khartoum 2 -Modern Medicine Center	15.35421728° **N**	32.32251124 ° **E**	in the hospital
Al-Suq				
47	Al-Soug AL-Markazy 1	15.53055° **N**	32.5532° **E**	High intensity area during the day
48	Al-Soug AL-Markazy 2	15.52783° **N**	32.55011° **E**	High intensity area during the day
49	Al-Soug AL-Markazy 3	15.52602° **N**	32.55748° **E**	High intensity area during the day
50	Al-Soug AL-Markazy 4	15.52438° **N**	32.54289° **E**	High intensity area during the day
Area of Antennas				
51	Al-Sahafa 23	15.53172° **N**	32.53477° **E**	area of antennas

Table (4.10) Summary of Measurement from the Antennas in Khartoum at 50 locations

No	Area of Measurement	Number of Antennas	%
1	**Residence area**	**26**	**0.51**
2	**Schools**	**12**	**0.24**
3	**Hospitals**	**8**	**0.16**
4	**Al-Suq**	**4**	**0.08**
5	**Area of Antennas**	**1**	**0.02**
Total		51	%100

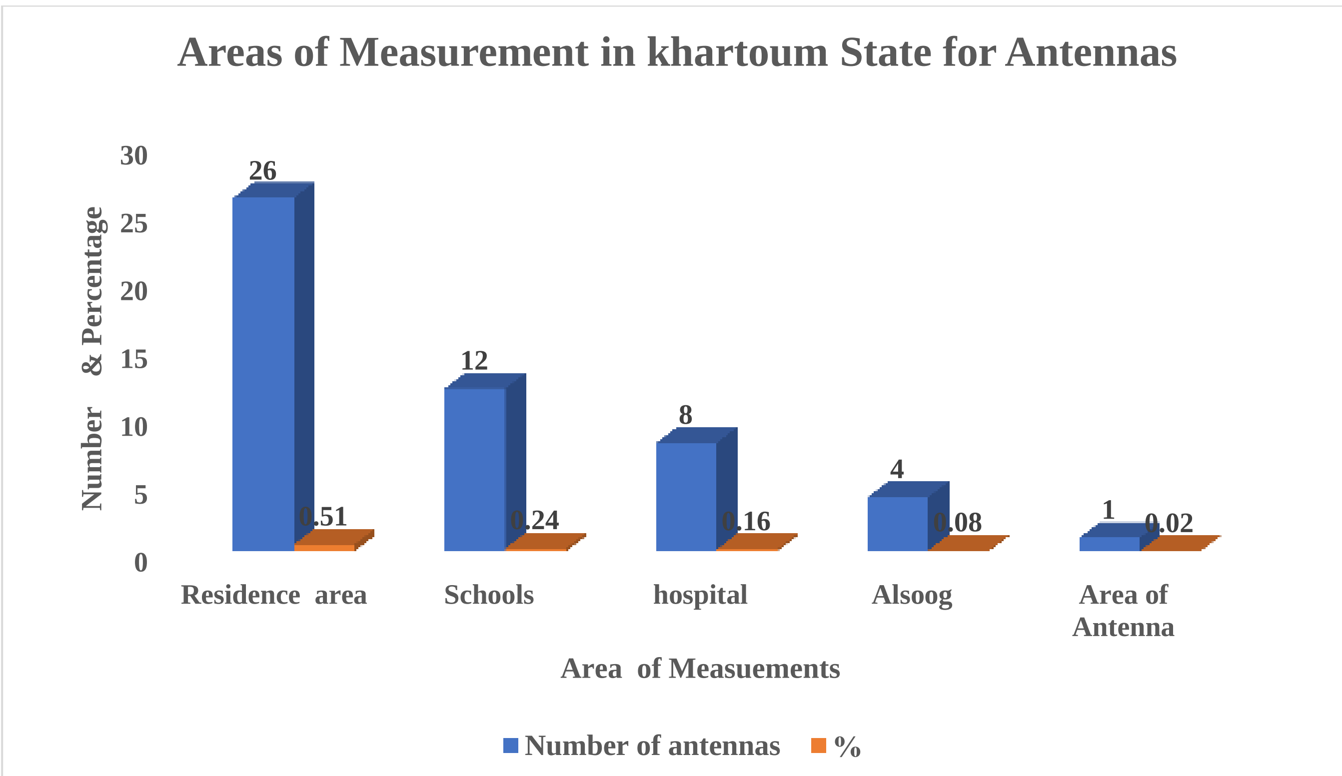

Figure (4.15) Summary of Measurement from the antennas in Khartoum at 50 locations

Table (4.11) Measurement from the Transmission lines in Khartoum North at 50 locations

No	Locations in Transmission line in Khartoum North	Latitude	Longitude	Details
Industrial Area				
1	Industrial Area - Qattan Bags Factory 1	153947.2284° **N**	32.3347268° **E**	Industrial Area
2	Industrial Area - Qattan Bags Factory 2	153947.2284° **N**	32.3347268° **E**	Industrial Area
3	Industrial Area- Ready Mix Concrete Factory	153912.5858° **N**	32.33522744° **E**	Industrial Area
4	Industrial Area - Geely Automotive	153912.5856° **N**	32.33553791° **E**	Industrial Area
5	Industrial Area - National Paints	153929.1744° **N**	32.33494532° **E**	Industrial Area
6	Industrial Area-Memo Meat Factory	153937.1988° **N**	32.3348456° **E**	Industrial Area
7	Industrial Area-Kubir	15.38439764° **N**	32.33509688° **E**	Industrial Area
8	Kafwry 7-Factory Brayt	15.3837428° **N**	32.33864796° **E**	Industrial Area
9	Kafwry 8 -Al Safwa Automotive Company	153828.4712° **N**	32.35424584° **E**	Industrial Area
10	Kafwry 9- Faisal Islamic Bank	153815.6876° **N**	32.33404856° **E**	Industrial Area
11	Al -Ezba - Intersection of Al Ezba with Kaffouri	153957.5784° **N**	32.33505224° **E**	10 m from a residential area
12	Al -Ezba -1	15.4095592° **N**	32.33506196° **E**	11 m from a residential area
13	Al- Ezba -2	15.4030792° **N**	32.33502416° **E**	10 m from a residential area
14	Al- Ezba -3	15.4043608° **N**	32.33525636° **E**	11 m from a residential area
15	Al- Ezba- 4	15.4043608° **N**	32.33525636° **E**	12 m from a residential area
16	Al -Ezba -5	15.4043608° **N**	32.33525636° **E**	13 m from a residential area
17	Kafwry- 1	15.3916.6048° **N**	32.343388° **E**	200 m from residential areas

18	Kafwry -2	15.39166048° **N**	32.343388° **E**	200 m from residential areas
19	Kafwry- 3	15.3916704° **N**	32.34223536° **E**	200 m from residential areas
20	Kafwry 4- Sharie AL-Mazarie 1	15.320322° **N**	32.34451812° **E**	201 m from residential areas
21	Kafwry 5- Sharie AL-Mazarie 2	15.320322° **N**	32.34451812° **E**	202 m from residential areas
22	Kafwry 15 - sweet Kafwry	15.3737.028° **N**	32.3400804° **E**	60m from residential areas
23	Kafwry 16 Center Shwl Medical	15.37364872° **N**	32.3497572° **E**	20m from residential areas- 20m from center Medical
24	Kafwry 17-online cafe	15.37369912° **N**	32.3415504° **E**	20m from residential areas
25	Kafwry 18	15.3737236° **N**	32.34275454° **E**	20m from residential areas
26	Kafwry -Military Police 1	15.3733352° **N**	32.34299892° **E**	25 meters from the police station
27	Kafwry -Military Police 2	15.3733352° **N**	32.34299892° **E**	25 meters from the police station
AL- Souq				
28	Souq Al -Ezba	15.4020208° **N**	32.33504864° **E**	Inside the AL-souq - 20 m from the residential areas
Military Area				
29	Industrial Zone - Central Laboratory for Calibration	15.38498048° **N**	32.335.054° **E**	Industrial and military zone
30	Industrial Zone - Central Laboratory for Calibration	15.38498048° **N**	32.3354054° **E**	Industrial and military zone
31	Industrial Zone - Central Laboratory for Calibration	15.38498048° **N**	32.3354054° **E**	Industrial and military zone
32	Station AL-Eizbat AL-Tahwiliat 1	15.398884° **N**	32.345002° **E**	Industrial and military zone
33	Station AL-Eizbat AL-Tahwiliat 2	15.3940656° **N**	32.3450916° **E**	Industrial and military zone
34	Station AL-Eizbat AL-Tahwiliat 3	15.3940656° **N**	32.340916° **E**	Industrial and military zone
Agricultural Area				
35	Kafwry 6- Sharie AL-Mazarie 3	15.39220068° **N**	32.34571836 ° **E**	Agricultural area
36	Kafwry 7-Sharie AL-Mazarie 4	15.39220068° **N**	32.34571836° **E**	Agricultural area
37	Kafwry - Sharie AL-Mazarie 5	15.31241956° **N**	32.3579908° **E**	Agricultural area

38	Kafwry 4- Sharie AL-Mazarie 6	15.31241956° **N**	32.3579908° **E**	Agricultural area
39	Kafwry 4- Sharie AL-Mazarie 7	15.31241956° **N**	32.3579908° **E**	Agricultural area
40	Kafwry 10-Bashayer Station	15.389114° **N**	32.33436248° **E**	20m from residential areas
41	Kafwry 11-Alwaed Engineering Works	15.3758962° **N**	32.35428652° **E**	20m from residential areas
Schools				
42	Kafwry -12club Kafwry	15.37496452° **N**	32.33410886° **E**	20 m away from Sports kafwry Club - there are schools and AL-Mawahibt schools 20 m
43	Kafwry 13-Mosque AL-Nuwr 1	15.37420384° **N**	32.33412164° **E**	20 meters from Al Noor Mosque - 20 meters from residential area
44	Kafwry 13-Mosque AL-Nuwr 2	15.37369192° **N**	32.33452196° **E**	20 meters from Al Noor Mosque - 20 meters from residential area
45	Kafuri -14-awfardus	15.37370128° **N**	323352.6644° **E**	20 m from AL-quds schools
Power Station				
46	Hulat kwkw-transformer station 1	15.3721.05472° **N**	32.3429856° **E**	Power station - houses within 20 m
47	Hulat kwkw-transformer station 2	15.372105472° **N**	32.3429856° **E**	Power station - houses within 20 m
48	Hulat kwkw-transformer station 3	15.372105472° **N**	32.3429856° **E**	Power station - houses within 20 m
49	Hulat kwkw-transformer station 4	15.372105472° **N**	32.3429856° **E**	Power station - houses within 20 m
50	Hulat kwkw-transformer station 5	15.372105472° **N**	32.3429856° **E**	Power station - houses within 20 m

Table (4.12) Summary of Measurement from the Transmission lines in Khartoum North at 50 locations

No	Area measurement of transmission line in Khartoum North	Number	%
1	Industrial Areas	10	0.2
2	Residential Areas	17	0.34
3	The Al-Souq	1	0.02
4	Schools	4	0.08
5	Agricultural Areas	7	0.14
6	Military	6	0.12
7	Power Stations	5	0.1
Total		50	100%

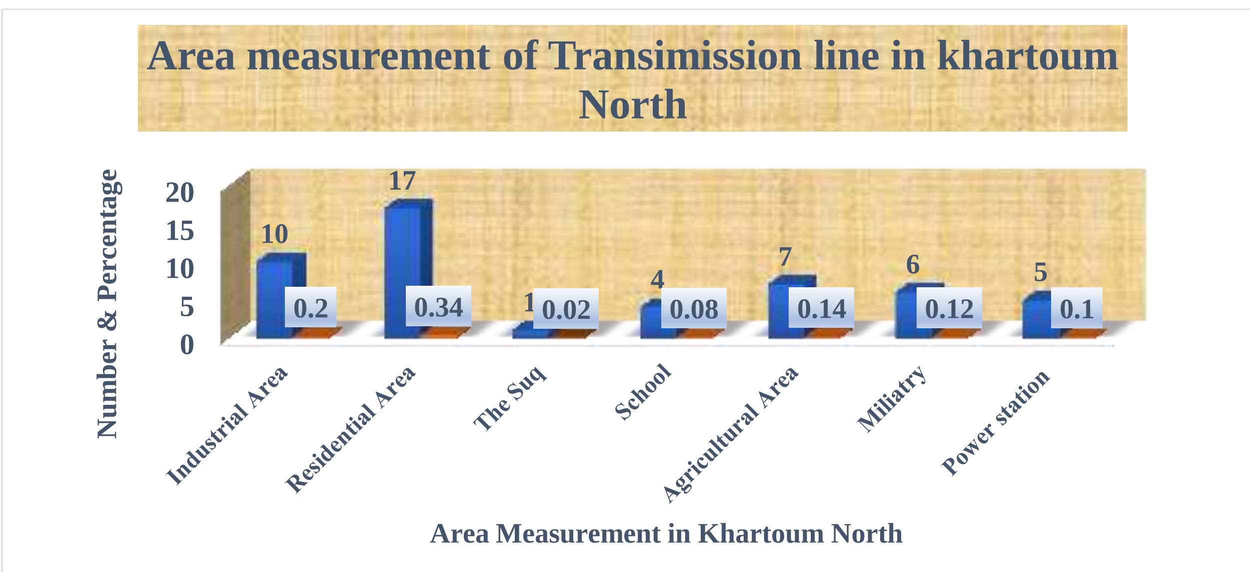

Figure (4.16) Summary of Measurement from Transmission Lin in Khartoum North at 50 locations

Table (4.13) Measurement from the Antennas in Khartoum North at 50 locations

No	Location	latitude	Longitude	Details
Residential Area				
1	Al-Maouna Street	15.40317332° **N**	32.33230784° **E**	100 m away from the mosque / located in a residential building
2	Shambat4	15.3924.5448° **N**	32.3149764° **E**	20 m from a residential area
3	AL-Eizba1	15.4023.9088° **N**	32.33505008° **E**	In the house
4	AL-Eizba2	15.4027.9088° **N**	32.3407932° **E**	20 m from residential buildings
5	Azzirab 3	15.4458488° **N**	32.33223632° **E**	In a residential area
6	Kafwry - 4	15.3739846° **N**	32.3428.9668° **E**	20 m from a residential area
7	Kafwry - 5	15.37420528° **N**	32.334986° **E**	20 m from a residential area
8	kubir 1 Industrial Area 1	15.38151692° **N**	32.33384912° **E**	20 m from a residential area
9	Kafwry- 6	15.3825.9296° **N**	32.3353586° **E**	20 m from a residential area
10	Azzirab 4	15.44195468° **N**	32.331032° **E**	In a residential area
11	AL-Hilfaya- 2	15.4146956° **N**	32.333544° **E**	In a residential area
12	AL-Hilfaya -3	15.41489372° **N**	32.325595° **E**	In a residential area
13	kafwry -Al Radwan Mosque	15.39147816° **N**	32.32292476° **E**	20m from -Al Radwan Mosque
14	Al-Maouna Stree 2	15.40356412° **N**	32.3225716° **E**	On the main street in a residential building
15	AL-Hilfaya	15.42159588° **N**	32.33230364° **E**	In an apartment building
16	kafwry 7	15.38259296° **N**	323353586° **E**	20 m from a residential area
17	Shambat 5	15.39180036° **N**	32.31024° **E**	20 m from a residential area
18	El-Shabeia / Al -Maouna street	15.38416868° **N**	32.3147.658° **E**	21 m from a residential area
19	Al-Sababi	15.3753914° **N**	32.31251904° **E**	On the main street in a residential building
20	AL-Shaebiat - Akhar Mahatah	15.38423492° **N**	32.3182412° **E**	20 m from a residential area and school of Osman prime
21	Shambat near the Maqabir of Shambat- 1	15.38504204° **N**	32.3125562° **E**	20 m from a residential area

22	Shambat near the Maqabir of Shambat- 2	15.3110548° **N**	32.31241896° **E**	21 m from a residential area
23	Shambat near the Maqabir of Shambat 3	15.3974016° **N**	32.32393° **E**	22 m from a residential area
24	Shambat South	15.39131256° **N**	32.31861552° **E**	23 m from a residential area
25	Kubir near kubir prison	15.3727008° **N**	32.3321616° **E**	On the main street in a residential building
26	Tuqatie Bridge kubir 1	15.37270192° **N**	32.33240192° **E**	20 m from a residential area
27	Tuqatie Bridge kubir 2	153729.9748° **N**	32.33248796° **E**	20 m from a residential area
28	kafwry 1	15.37203952° **N**	32.33315972° **E**	20 m from a residential area
29	kafwry 2- - Police Department kafwry	15.37140988° **N**	32.3354342° **E**	20 m from a Police Department
30	kafwry 3 - Smit Club	15.37144192° **N**	32.3481768° **E**	20 m from a residential area
31	University of Khartoum / Clutuical college	15.40373332° **N**	32.32216132° **E**	On an empty space
32	Industry stress	15.41185784° **N**	32.3321276° **E**	There is a mosque of major industries / located in a residential area
	Hospital			
33	Ahmed Qassem Hospital 1	15.38200724° **N**	32.3152.0752° **E**	100 m from hospital
34	Bahri Hospital	15.3728074° **N**	32.338548° **E°**	In the hospital
35	Bahri stress/ heath Care Center	15.4030774° **N**	32.32411216 ° **E**	Near Al Baraha Hospital
	Schools			
36	Shambat 2	15.39415188° **N**	32.3241676° **E**	About 150 m from Shambat School
37	North Droshab2	15.43525108° **N**	32.340426° **E**	Located 50 m from the school / located in an empty area
38	Azzirab -2	15.43531552° **N**	32.33223632° **E**	Located 100 m from the school / located in an empty area
39	Al-Maouna street 3	15.41571884° **N**	32.334914° **E**	On the main street in a residential building / 100 m from the pen school

Al-Souq				
40	Souq AL-Hulfaya	15.42479576° **N**	33.3370504° **E**	the Al-Souq- on a residential building
41	AL-Dlrushab Janub	15.43352596° **N**	32.33552996° **E**	Located in any empty land / near a mosque
42	North Droshab1	15.4341952° **N**	32.34106212° **E**	Near to Dali Mosque
43	Azzirab station - power station	15.4429256° **N**	32.33471276° **E**	located in an empty area
44	Old Azzirab Mosque	15.43489252° **N**	32.33162144° **E**	There is Quranic area / there is an empty area
45	Wad El Bashir Theater	15.4039° **N**	32.3366984° **E**	On a sports stadium / no residential building
46	Shambat 1	15.39592272° **N**	32.3253916° **E**	In a residential building
47	Shambat- 3	15.3921708° **N**	32.3151708° **E**	There is on Shambat Square
Industrial Zone				
48	kubir 1 Industrial Area 2	15.38151692° **N**	32.33384912° **E**	Industrial Zone
49	Kubir 1 Industrial Area 2	15.3835.2356° **N**	32.33432108° **E**	Industrial Zone
50	Kubir 1 Industrial Area -3	15.3922104° N	32.3490804° E	Industrial Zone

Table (4.14) Summary of Measurement from the Antennas in Khartoum North at 50 locations

No	Area measurement in Khartoum North	Number of Antennas	%
1	Residential Areas	32	0.64
2	Hospitals	3	0.06
3	Schools	4	0.08
4	Al-Souq	8	0.16
5	Industrial Zones	3	0.06
Total		50	1.00

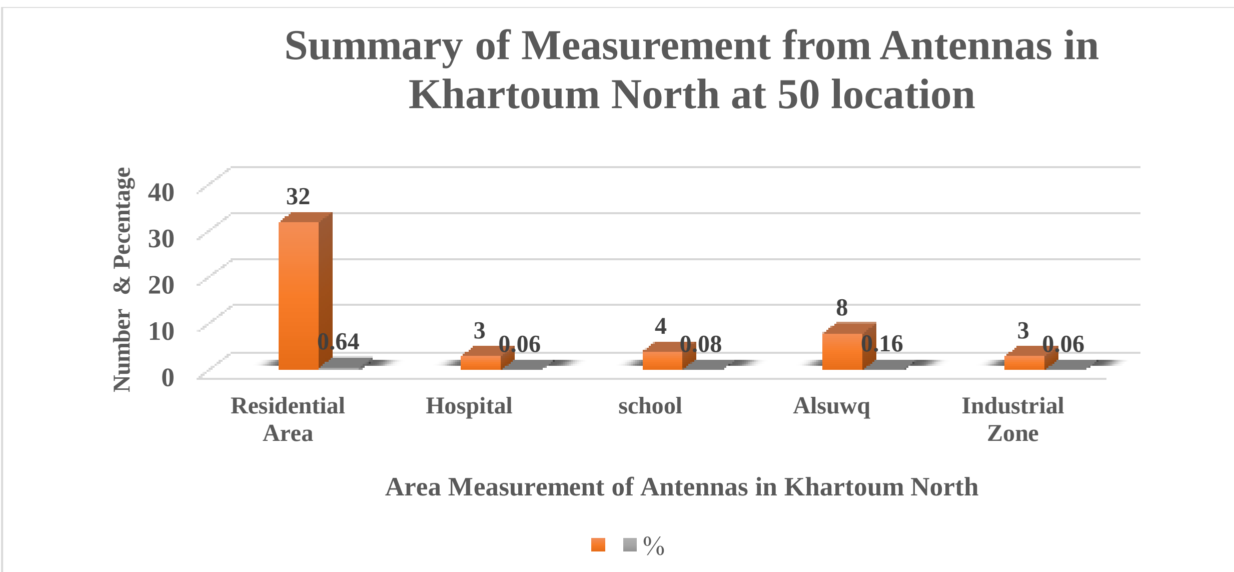

Fig (4.17) Summary of Measurement from Antennas in Khartoum North at 50 locations

Table (4.15) Measurement from the Transmission lines Omdurman at 50 locations

NO	Locations	Longitude	Latitude	Notice
Military				
1	Military Academy 1	15.36156636° **N**	32.2853284° **E**	Military zone on 10 m
Residential area				
2	Al-Mohaddessin 1	15.36375624° **N**	32.2814304° **E**	20 m from a residential area
3	Military Academy2	15.36182484° **N**	32.28467256° **E**	20 m from a residential area
4	On Sharie Al-Mohaddessin -1	15.36208836° **N**	32.28381432° **E**	20 m from a residential area
5	On Sharie Al-Mohaddessin -2	15.36208836° **N**	32.28381432° **E**	20 m from a residential area
6	Hadiqat Al-Nakhi 1	15.36235906° **N**	32.29295212° **E**	20 m from a residential area
7	Hadiqat Al-Nakhil 2	15.252972° **N**	32.28207912° **E**	20 m from a residential area
8	Tuqatie Al- Al-Mohaddessin	15.36317592° **N**	32.28158916° **E**	20 m from a residential area
9	Ashlaq Al-bulis	153.6479916° **N**	32.28168944° **E**	20 m from a residential area
10	Tuqatie Al-Mohaddessin with ashlaq	15.3748432° **N**	32.28179364° **E**	20 m from a residential area
11	Sharie Al-Eawdih with Al-Muhandisin	15.37138896° **N**	32.28178898° **E**	20 m from a residential area
12	Al-Mohaddessin -2	15.37202008° **N**	32.28163128° **E**	20 m from a residential area
13	Al-Mohaddessin-3	15.37199776° **N**	32.2889688° **E**	20 m from a residential area
14	Al-Mohaddessin-4	15.37198917° **N**	32.2811712° **E**	20 m from a residential area
15	Al-Mohaddessin-5	15.37193296° **N**	32.27538272° **E**	20 m from a residential area
16	Hamd Al-Nile	15.37195276° **N**	32.2747.272° **E**	20 m from a residential area

17	Umbadda1	15.37257412° **N**	3227407052° **E**	20 m from a residential area
18	Umbadda2	15.37356628° **N**	322740024° **E**	20 m from a residential area
19	Umbadda3	15.37424524° **N**	32.7407052° **E**	20 m from a residential area
20	Umbadda4	15.37480648° **N**	32.27405936° **E**	20 m from a residential area
21	Umbadda5	15.37519312° **N**	32.27404748° **E**	20 m from a residential area
22	Umbadda6	15.37575724° **N**	32.2741022° **E**	20 m from a residential area
23	Umbadda7	15.382868° **N**	32.2741022° **E**	20 m from a residential area
24	Omdurman - Al-Dawha 1	15.3891932° **N**	32.27402804° **E**	50 m from residential areas
25	Omdurman - Al-Dawha 2	15.38151188° **N**	32.27403096° **E**	50 m from residential areas
26	Omdurman - Al-Dawha 3	15.3821912° **N**	32.27403096° **E**	50 m from residential areas
27	Omdurman - Al-Dawha 4	15.3825512° **N**	32.27393444° **E**	50 m from residential areas
28	Omdurman - Al-Dawha 5	15.38323121° **N**	32.27402768° **E**	50 m from residential areas
29	Omdurman - Al-Dawha 6	15.3825512° **N**	32.27393444° **E**	50 m from residential areas
30	Omdurman - Al-Dawha 7	15.38323121° **N**	32.27402768° **E**	20 m from a residential area
31	AL-Wahat -East	15.41516552° **N**	32.30202356° **E**	20 m from a residential area
32	AL-Wahat -West	15.4153826° **N**	32.30117756° **E**	20 m from a residential area
33	Omdurman - AL-Galea 2	15.4565592° **N**	32.2936258° **E**	100 m from a residential area
34	Omdurman - AL-Galea 3- Satiation 1	15.425958° **N**	32.29337056° **E**	100 m from a residential area
35	Omdurman - AL-Galea 3- Satiation 2	15.425958° **N**	32.29337056° **E**	100 m from a residential area

36	Omdurman -AL-Harih 9 -2	15.42.8292° **N**	32.28552072° **E**	20 m from a residential area
37	AL-Thawrat 58	15.4256912° **N**	32.27552636° **E**	100 m from a residential area
38	AL-Thawrat 58 AL-Muthlath 2	15.42259704° **N**	32.2826724° **E**	50 m from residential areas
39	AL-Thawrat 58 AL-Muthlath 3	15.42259704° **N**	32.2826724° **E**	20 m from a residential area
40	AL-Thawrat 58 AL-Muthlath 4	15.4241328° **N**	32.28246° **E**	20 m from a residential area
41	Al-Thawrat 58	15.02584964° **N**	32.2752362° **E**	20 m from a residential area
AL-Souq				
42	Omdurman -AL-Harih 9 -3	15.42110268° **N**	32.4845° **E**	in an Al- Souq
43	Souq AL-Shnqytii 1	15.42159084° **N**	322.8405012° **E**	in an Al- Souq
44	Souq AL-Shnqyti 2	15.4219.0616° **N**	32.2838708° **E°**	in an Al- Souq
45	Souq AL-Shnqyti 3	15.42177048° **N**	32.28320772° **E**	in an Al- Souq
46	Souq q AL-Shnqyti 4	15.42223596° **N**	32.28252228° **E**	in an Al- Souq
Schools				
47	Al- Ebdaa Secondary Private School	15.42245412° **N**	32.28216804° **E**	Near 100m Al Ebdaa Secondary Private School
48	Al-Thawrat 58 AL-Muthlath 1	15.4225668° **N**	32.28117408° **E**	residential areas 150 meters - 100 m AL-Qarania schools
49	Al-Thawrat 60- Halayib	15.4293996° **N**	32.28519492° **E**	Residential buildings are 100 m away from Riad Ammar bin Yasser
50	Omdurman -AL-Harih 9 -1	15.42387° **N**	32.2933° **E**	Residential buildings are 100 m away from Riad Am Razan
51	Omdurman - AL-Galea 1	15.4202484° **N**	32.29546576° **E**	20 meters from residential areas - 10 meters high school

Table (4.16) Summary of Measurement from the Transmission Lines in Omdurman at 50 locations

NO	Locations	Number	%
1	Residential areas	40	0.78
2	Military	1	0.02
3	AL-Souq	5	0.10
4	Schools	5	0.10
Total		51	100%

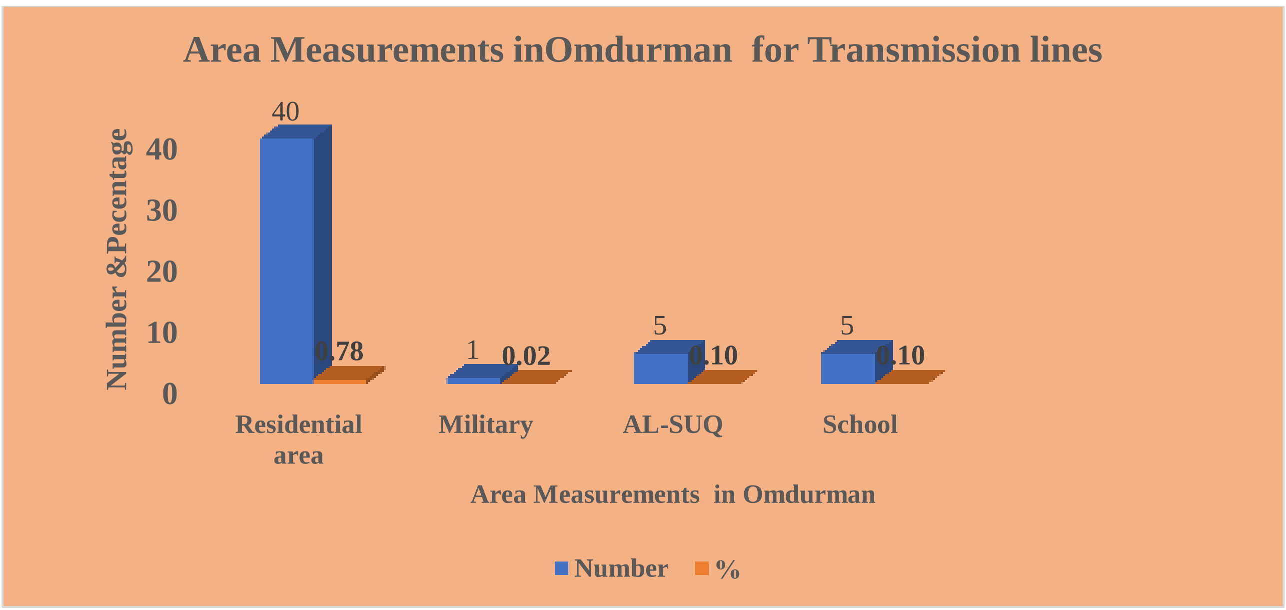

Figure (4.18) Summary of Measurement from Transmission Lines in Omdurman at 50 locations

Table (4.17) Measurement from the Antennas Omdurman at 50 locations

No	locations	latitude	Longitude	Details
Residential Building				
1	Al-Mohaddessin -1	15.3638286° **N**	32.28162516° **E**	On a residential building
2	On Wadi Street	15.3911592° **N**	32.29212604° **E**	On a residential building
3	On Wadi Street near Dodi Restaurant 1	15.3921096° **N**	32.29184056° **E**	On a residential building/ on the 10m near Restaurant
4	On Wadi Street near Dodi Restaurant 2	15.3921096° **N**	32.29505476° **E**	On a residential building
5	Street Al-Dawma	15.39398564° **N**	32.2925656° **E**	On a residential building
6	Sudatil AL-Qamayir	15.4046992° **N**	32.29561786° **E**	20 m there is a residential area
7	Al- Mohaddessin Sharie Hamd AL-Nay-l	15.37193476° **N**	32.27568152° **E**	On a residential building
8	sharie al'arbaein	15.370738° **N**	32.28446124° **E**	On a residential building
9	Al-Muhandisin Eali Sharie Hamd AL-Nnayl	15.3808664° **N**	32.2714296° **E**	On a residential building
10	AL-Ruwda	15.40430176° **N**	32.29517128° **E**	On a residential building
11	Hayi AL-Eeumda	15.3925488° **N**	32.297884° **E**	On a residential building
12	Mahdawi – AL-Thawrat AL-Harat AL-Ththaminat 2	15.41325536° **N**	32.30118476° **E**	On a residential building
13	AL-Thawruh 21- Halayib	15.42170712° **N**	32.2989124° **E**	On a residential building
14	AL-Wahat 2	15.423335844° **N**	32.30402912° **E**	On a residential building
15	AL-Wahat 3	15.4239754° **N**	32.30428328° **E**	On a residential building
16	Hayi AL-Ruwdat - shrq	15.40342048° **N**	32.3025528° **E**	On a normal building
17	AL-Haruh 9	15.42127296° **N**	32.28409008° **E**	On a residential building
18	AL-Thawrat AL-Harat 58- Sharie AL-Aimtidad	15.42450576° **N**	32.282118° **E**	On a residential building
19	Mahdawi – AL-Thawrat AL-Harat AL-Ththaminat 3	15.4134.3716° **N**	32.30125388° **E**	On a residential building
20	AL-Haruh 38	15.4432748° **N**	32.27521928° **E**	There is no residential building - 20 m from residential areas
21	AL-Haruh 37	15.4491608° **N**	32.28172508° **E**	There is no residential building - 20 m from residential areas

22	AL-Haruh 1 48	15.4471736° **N**	32.26420096° **E**	There is no residential building - 20 m from residential areas
23	AL-Haruh 2 48	15.442499° **N**	32.28329016° **E**	There is no residential building - 20 m from residential areas
24	Sabirin 39	15.43207804° **N**	32.285043° **E**	On a residential building
25	Omdurman-AL-Manarih	15.43236872° **N**	32.3132628° **E**	There is no residential building - 10 m from residential areas
26	Al-Hatanuh 1	15.42498168° **N**	32.3127552° **E**	There is no residential building - 3 m from residential areas
27	AL-Wahat-west 1	15.4116936° **N**	32.30118188° **E**	On a residential building
28	Stadium -Wada Nubawi 1	15.37489708° **N**	32.29226392° **E**	On the football field
29	Stadium 1-wada Nabawi 2	15.37489708° **N**	32.29226392° **E**	On the football field
30	Tuqatie Al-Thawruh Bialnas with Al-ththamina	15.4113416° **N**	32.2977532° **E**	On a residential building
31	AL-Wahat-on the Nile Street	15.41381336° **N**	32.3138244° **E**	On a normal building - on the Nile Street
32	Sharie AL-Eurda	15.3838076° **N**	32.286582° **E**	Transportation area / Housing for students
Hospitals				
33	Al-Busatuh	15.38339648° **N**	32.2849412° **E**	200 m away from Al Tijani El Mahi Hospital
34	Omdurman Youth Center	15.3822.5168° **N**	32.29283848° **E**	100 m away from Al-Daiyat Hospital
35	Mahdawi – Al-Thawrat Al-Harat AL-Ththaminat 1	15.4139.9164° **N**	32.304122° **E**	20 m from the Arab Center for Medical Treatment
36	AL -Dayat Hospital Omdurman	15.3813.1784° **N**	32.29258972° **E**	100 m away from Al-Daiyat Hospital
37	Taqi Specialist Hospital	15.3815666° **N**	32.2920796° **E**	on the hospital
Schools				
38	Al - Harah 9 Secondary School For Boys	15.4227396° **N**	32.28550092° **E**	Inside the school / 50 m away there are two residential buildings
39	Wada Nubawi near King Fahd Private Secondary School	15.39572076° **N**	32.29259188° **E**	150 m away from King Fahd Private Secondary School

40	Wada Nubawi	15.402352° **N**	32.402352° **E**	150 m from the Faculty of Education, University of Khartoum
41	Al-Wahat-West 2	15.41558132° **N**	32.31171036° **E**	On a residential building - 20 m from Riyadh Schools of Al-Tamayuz International
42	AL-Thawrat 21-Mostafa Bashir School	15.42132192° **N**	32.2926441° **E**	Inside the school Mustafa Bashir
43	AL-Thawrat 58	15.42392056° **N**	32.28131772° **E**	School 100 meters away
44	AL-Hatanuh 2	15.42476568° **N**	32.3112316° **E**	There is no residential building - there is a school after 30 m Baba Ali private school
45	AL-Qamayir-Water Station	15.4044544° **N**	32.3015174° **E**	On a normal building-20 meters there is a private secondary school girl
46	Al-Qamayir	15.4074244° **N**	32.3020448° **E**	AL-Nasr College is 100 meters away
47	AL-Thawrat Bialna-Cooper Secondary School for Boys	15.40185628° **N**	32.291092° **E**	Inside the school - 20 m University of Science and Technology
48	Al-Thawrat Bialnas-Al - Khwarizmi School-	15.40396075° **N**	32.298664° **E**	Above the school - 20 m residential area
AL- Souq				
49	Souq Al-Shuhada'	15.3842288° **N**	32.29199212° **E**	Transportation Area
50	Souq Al-Shuhada'	15.3842288° **N**	32.29199212° **E**	Transportation Area

Table (4.18) Summary of Measurement from the Antennas in Omdurman at 50 locations

No	Area of measurement	Number	%
1	Residential Building	32	0.65
2	Schools	11	0.22
3	Hospitals	5	0.10
4	Al-Souq	2	0.04
Total		50	1

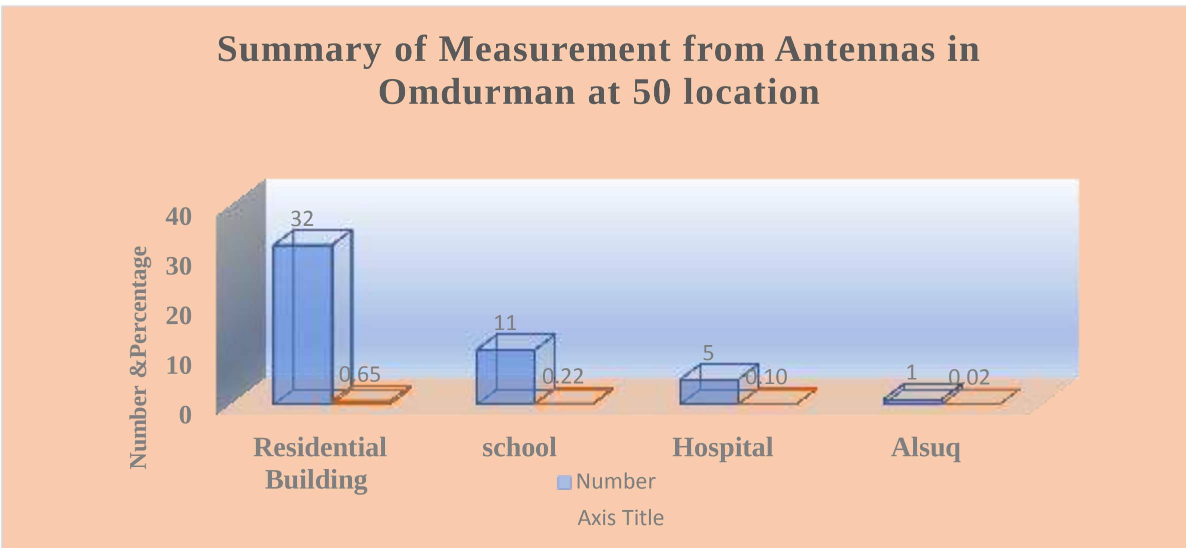

Fig (4.19) Summary of Measurement from Antennas in Omdurman at 50 locations

Cancer and the electromagnetic Radiation

Recently, it was argued that electromagnetic waves caused some diseases, such as frequent headaches and cancer, but this argument in order to be proven must be taken into account some factors, including those near communications towers from residential areas the amount of dose of these antennas at the time of exposure to this dose and age and genetic Based on this concept, all patients with Khartoum state were taken for the years 2018 and 2019 for Khartoum Oncology Hospital according to the table below.

Table (4.19) to show the number of cancer patients in Khartoum state for the year 2019 according to statistics of Radiation & Istopes Central-Khartoum (RICK)Hospital

The number of cancer patients in Khartoum state for the year 2019 according to statistics of Radiation & Istopes Central-Khartoum (RICK)Hospital

2019			Age Of Male							Age of Female						
Months	Female	Male	0-29	%	30-59	%	60-90	%	Total	0-29	%	30-59	%	60-90	%	Total
1	78	55	11	0.20	17	0.31	27	0.49	55	12	0.15	38	0.49	28	0.36	78
2	139	108	16	0.15	29	0.27	63	0.58	108	14	0.10	82	0.59	43	0.31	139
3	111	107	17	0.16	30	0.28	60	0.56	107	6	0.05	61	0.55	44	0.40	111
4	118	62	13	0.21	22	0.35	27	0.44	62	14	0.12	61	0.52	43	0.36	118
5	97	75	8	0.11	26	0.35	41	0.55	75	11	0.11	53	0.55	33	0.34	97
6	87	63	15	0.24	18	0.29	30	0.48	63	12	0.14	48	0.55	27	0.31	87
7	117	80	13	0.16	26	0.33	41	0.51	80	5	0.04	69	0.59	43	0.37	117
8	66	50	3	0.06	19	0.38	28	0.56	50	5	0.08	34	0.52	27	0.41	66
TOTAL	813	600	85	1.28	187	2.55	317	4.17	600	79	0.80	446	4.35	288	2.86	813

The table (4.19) shows the number of cancer patients in 2019 to the month of August in general view we find that the number of infected in women the largest 800 patients compared to 600 patients for men.
On the other hand, we find that the number of people with cancer between the ages of 30 to 59 in women is the largest value by 466 infected with 43.5% compared to 187 men with 22.5%. These results can be considered that the probability of causing electromagnetic waves in cancer for women or men considering the time of exposure and the proximity of antennas to each patient

Table (4.20) to show the number of cancer patients in Khartoum state for the year 2018 according to statistics of Radiation & Istopes Central-Khartoum (RICK)Hospital

The number of cancer patients in Khartoum state for the year 2018 according to statistics of Radiation & Istopes Central-Khartoum (RICK)Hospital																
2018		Age of Male								Age of Female						
Months	Female	Male	0-29	%	30-59	%	60-90	%	Total	0-29	%	30-59	%	60-90	%	Total
1	74	50	5	0.1	17	0.3	28	0.6	50	5	0.07	46	0.62	23	0.31	74
2	46	48	16	0.32	10	0.2	22	0.5	48	5	0.11	26	0.57	15	0.33	46
3	101	80	10	0.2	37	0.5	33	0.4	80	8	0.08	56	0.55	37	0.37	101
4	128	94	10	0.2	33	0.4	51	0.5	94	20	0.16	66	0.52	42	0.33	128
5	72	59	4	0.08	28	0.5	27	0.5	59	9	0.13	35	0.49	28	0.39	72
6	47	43	15	0.3	13	0.3	15	0.3	43	10	0.21	25	0.53	12	0.26	47
7	84	69	13	0.26	21	0.3	35	0.5	69	11	0.13	47	0.56	26	0.31	84
8	80	41	6	0.12	9	0.2	26	0.6	41	10	0.13	46	0.58	24	0.30	80
9	90	82	11	0.22	28	0.3	43	0.5	82	5	0.06	53	0.59	32	0.36	90
10	75	41	8	0.16	17	0.4	16	0.4	41	15	0.20	41	0.55	19	0.25	75
11	64	50	11	0.22	20	0.4	19	0.4	50	10	0.16	30	0.47	24	0.38	64
12	72	64	12	0.24	23	0.4	29	0.5	64	14	0.19	31	0.43	27	0.38	72
ToTal	933	671	121	2.42	256	4.178	344	5.67	721	122	1.612	502	6.444	309	3.944	933

In general, for table (4.20), view of previous years we find that the number of cancer patients in Khartoum state was taken from the corn hospital for tumors. It was found that the percentage of the disease in women is greater than the number of men, especially the elderly.

For the presence of women in homes for the first time, this leads to sitting for greater exposure. Electromagnetic radiation has the potential to get cancer.

In general, for women, between the ages of 30 to 59 and 60 to 90, the percentage of patients with cancer is between 41% and 56% respectively. The comparison for the same period for men is 64% and 39% respectively In 2018, the number of women aged 30 to 90 is higher than the number of men.

Section C

Study the People living around the BTS Cancer field study at Khartoum State

Field Study of the cancer distribution and percentage among people living around towers was made for 180 volunteers. The study divided the state into six categories. Three of them are at urban areas in Khartoum, Omdurman, and Khartoum North. The other three are at rural areas in the same cities.

A. Gender

Table No. (4.21) The cancer distribution and percentage at Khartoum state

Gender	Frequency	%
Male	108	60.0
Female	72	40.0
Total	180	100%

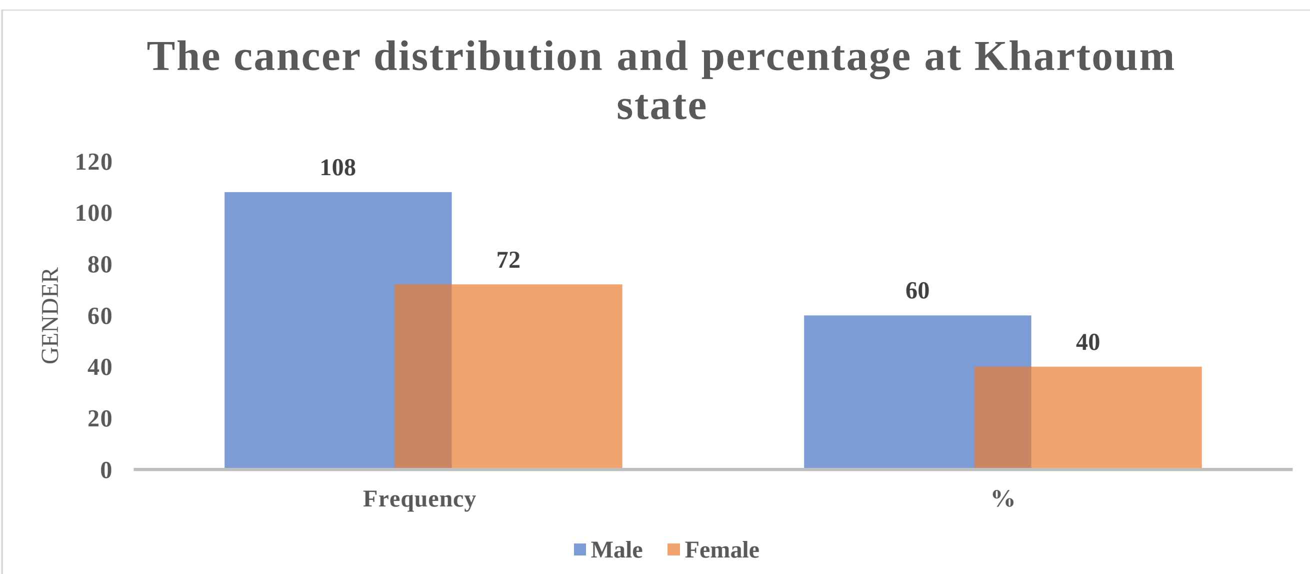

Figure (4.20) Frequency distribution of the study sample according to type

It is evident from Table No. (4.21) and Fig. No. (4.20) that the study individuals in the gender variable numbered (108) individuals, at a rate of (60.0%), and among females the number reached (72) individuals, at a rate of (40.0%).

B. Age

Table No. (4.22) Cancer distribution and percentage among women and older men compared to workers and students at urban areas

Age/Years	Frequency	%
Less than 30 years	35	19.4
30−40	45	25.0
41−50	33	18.3
51−60	26	14.4
61−70	32	17.8
71 more	9	5.0
Total	180	100

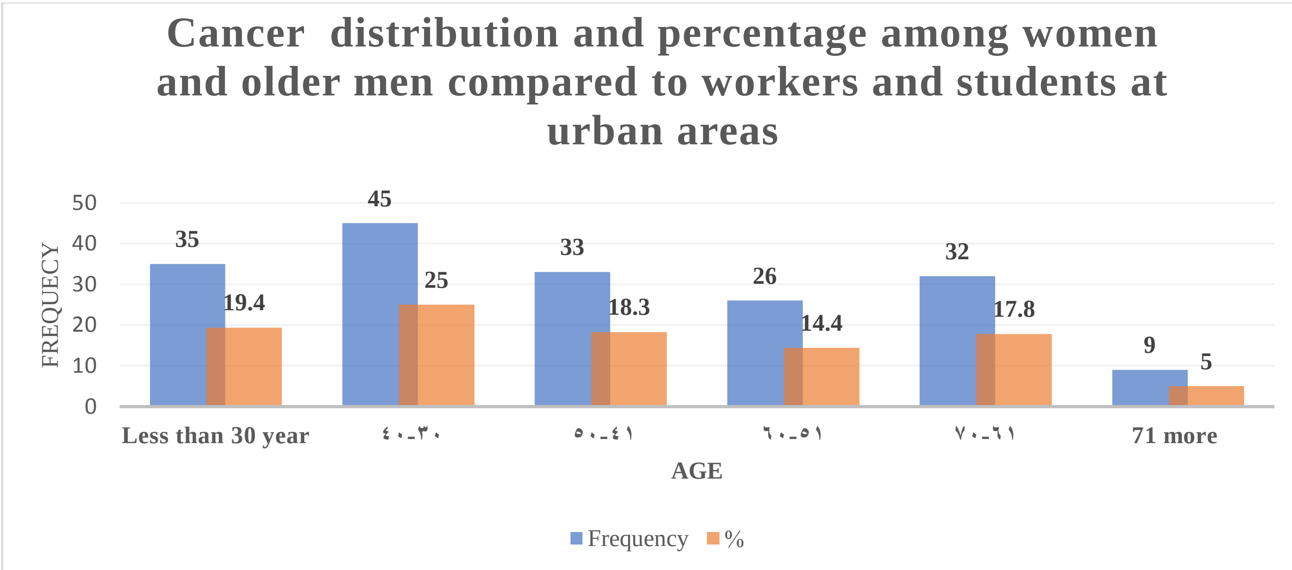

Figure (4.21) Cancer distribution and percentage among women and older men compared to workers and students at urban areas

It is evident from Table No. (4.22) and Fig. No. (4.21) that the study individuals in the variable age, less than 30 years old, numbered (35) individuals, at a rate of (19.4%), and among those aged between 30-40 years, their number reached (45) individuals with a percentage of (25.0%) and among those aged 41-50 years, their number reached (33) individuals, at a rate of (18.3%). As for those aged 51-60 years, there were (26) individuals with a rate of (14.4%). As for those aged 61-70 years, their number was (32 individuals, at a rate of (17.8%), and among those 71 years of age or over, their number reached (9) individuals, at a rate of (5.0%).

C. Occupation

Table No. (4.23) show the frequency distribution of the study sample according to Occupation

Occupation	Frequency	%
Student	35	18.4
Employee	44	25.4
Free workers	64	35.6
Housewife	37	20.6
Total	180	100

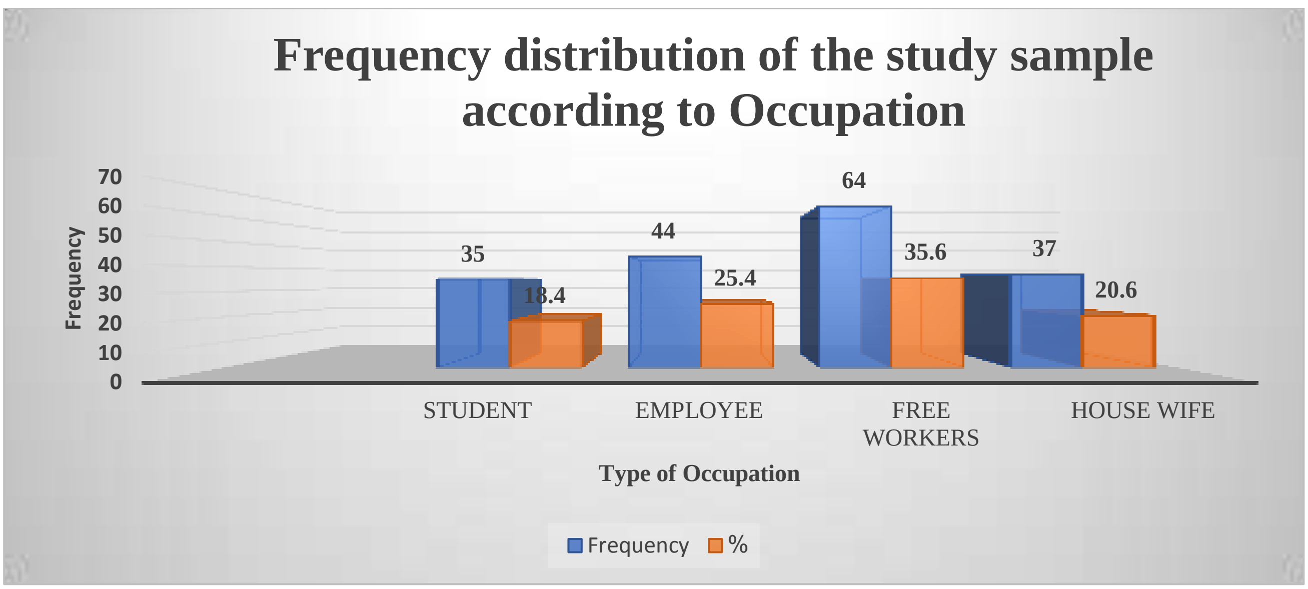

Figure (4.22) Frequency distribution of the study sample according to Occupation

It is evident from table No. (4.23) and figure No. (4.22) that the study members according to the profession, the number of students reached (35) individuals and the percentage of (18.4%) and among those whose profession is an employee their number reached (44) individuals and the percentage of (25.4%). (64) individuals, at a rate of (35.6%), and of those whose profession is a housewife, their number reached (37) individuals, at a rate of (20.6%).

D. Social status

E. Table No. (4.24) show the frequency distribution of the study sample according to social status

Status	Frequency	%
Married	134	74.4
Unmarried	42	23.3
widow	4	2.2
Total	180	100

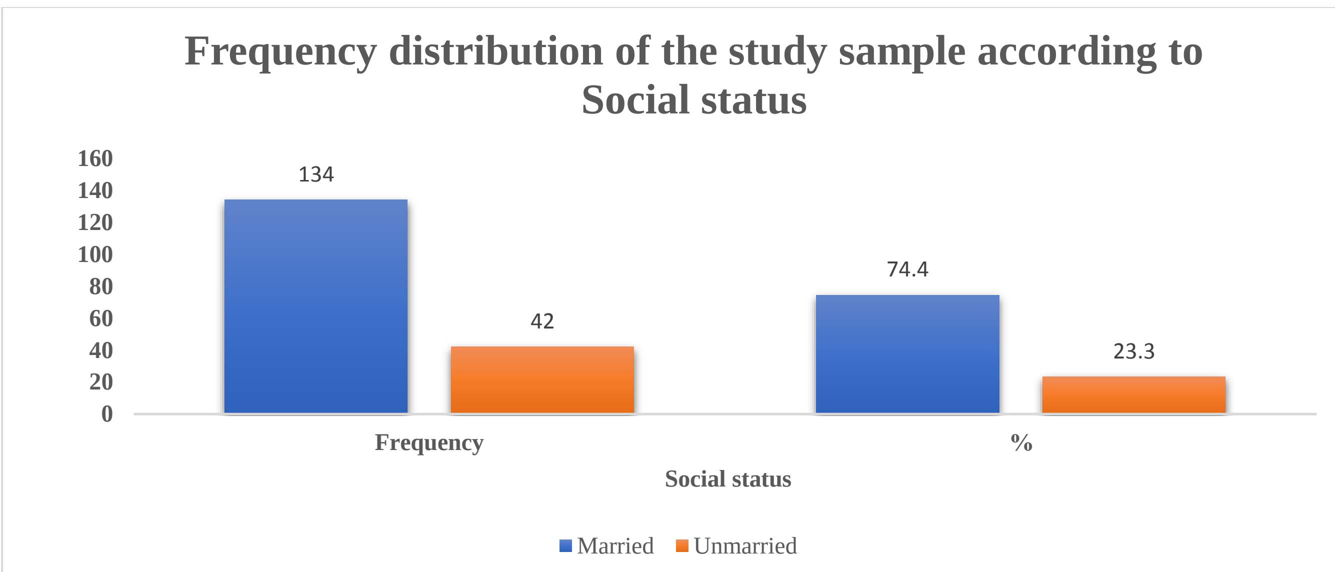

Figure (4.23) Frequency distribution of the study sample according to social status

it is evident from Table No. (4.24) and Fig. No. (4.23) that the study individuals, according to marital status, are married, their number is (134) individuals, at a rate of (74.4%), and of those whose marital status is unmarried, their number is (42) individuals and by (23.3%) and of those whose marital status Widows, their number reached (4) individuals, at a rate of (2.2%).

F. The type of Cancer s disease

Table No. (4.25) The cancer distribution and percentage at Khartoum State

Cancer disease	Frequency	%
Cancer Disease	44	24.4
No Cancer Disease	136	75.6
Total	180	100

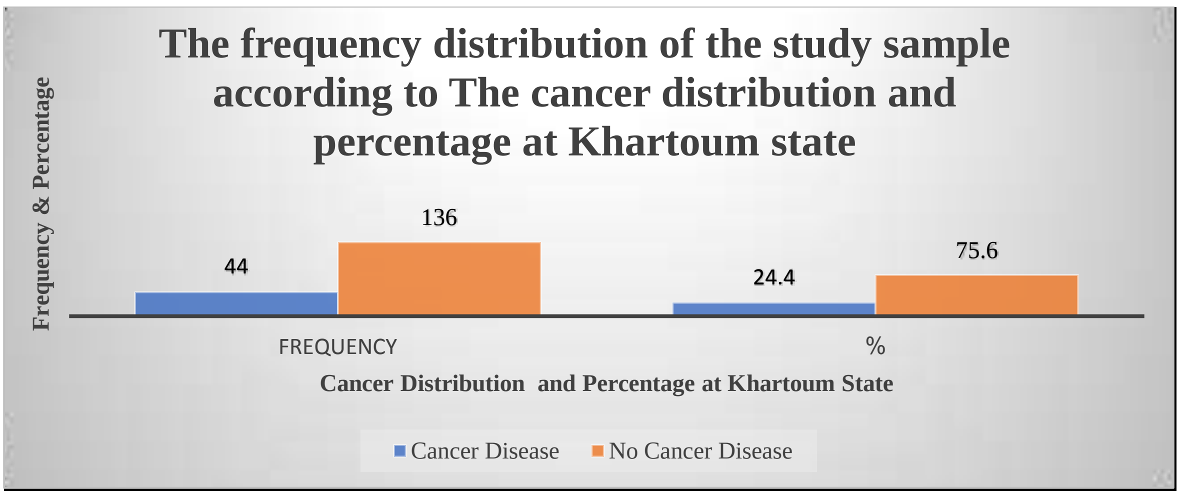

Figure (4.24) The cancer distribution and percentage at Khartoum state

It is evident from Table No. (4.25) and Fig. No. (4.24) that the study individuals, according to the type of cancerous disease, have a cancerous disease, their number reached (44) individuals and the percentage of (24.4%) and those who see no cancerous disease number (136) individuals and the percentage of (75.6) %).

G. Cancer rate among women, older men, male workers, and students in urban areas

Table No. (4.26) Cancer distribution and percentage among women and older men compared to workers and students at urban areas

Status	Frequency	%
Women and the Older men	14	48.3
Workers and students	15	51.7
Total	29	100

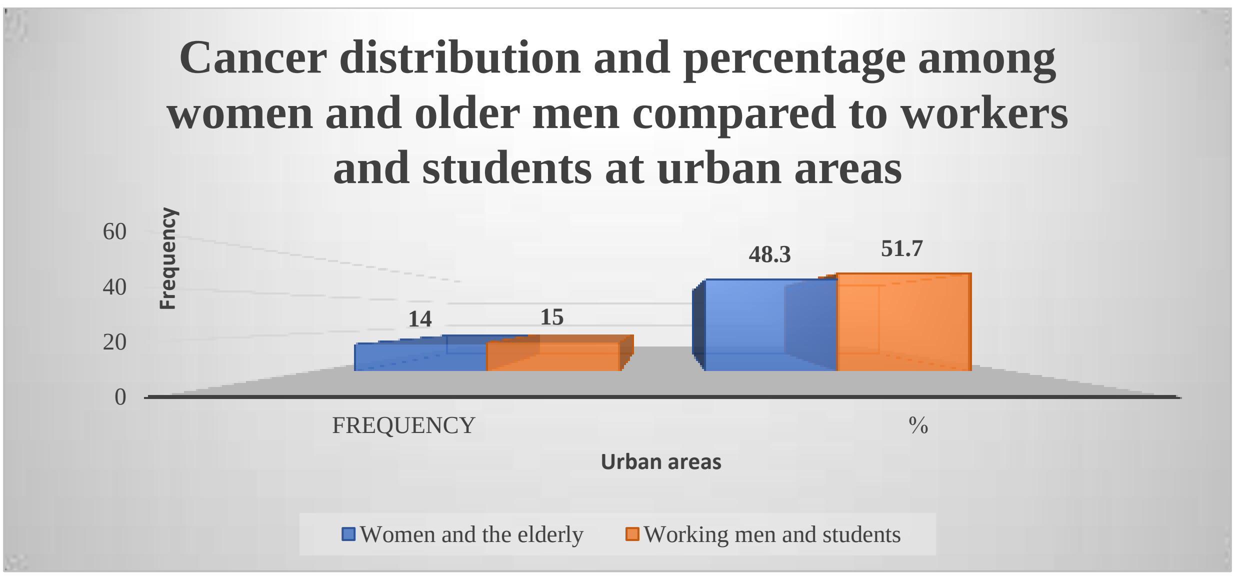

Figure (4.25) Cancer distribution and percentage among women and older men compared to workers and students at urban areas

It is evident from Table No. (4.26) and Fig. No. (4.25) that the study individuals according to the percentage of cancer among women and the older men, male workers and students in urban areas, who are women and the elderly, their number reached (14) individuals with a percentage of (48.3%), while we find those who They are working men and students, their number reached (15) individuals, at a rate of (51.7%).

H. According to the percentage of cancer among women, the elderly, male workers, and students in rural areas

Table No. (4.27) Cancer distribution and percentage of cancer among women, the elderly, male workers, and students in rural areas

Status	Frequency	%
Women and the older men	13	86.7
Workers and students	2	13.3
Total	15	100

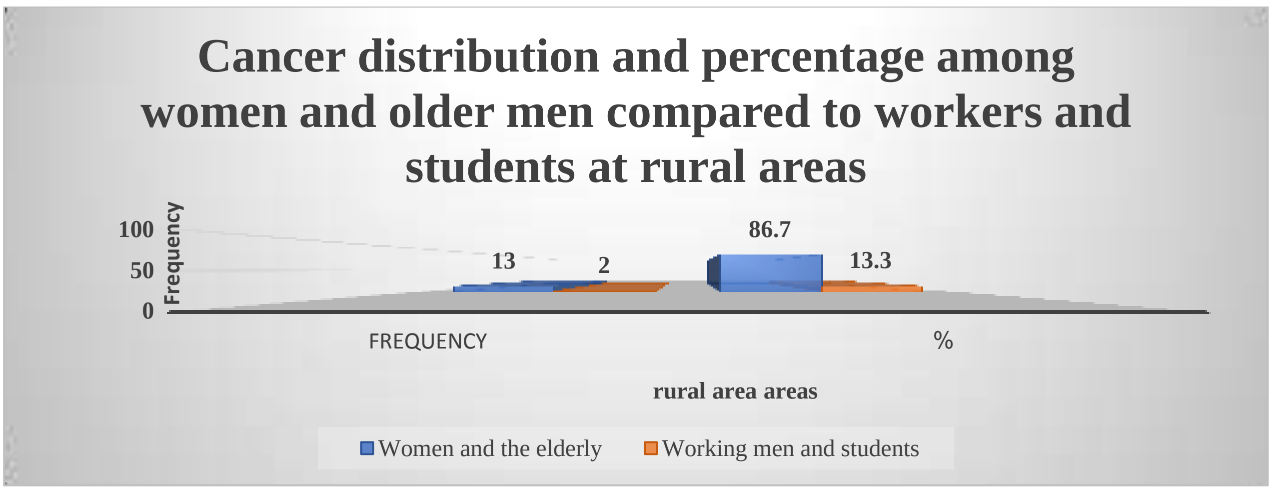

Figure (4.26**)** Cancer distribution and percentage among women and older men compared to workers and students at rural areas

It is clear from Table No. (4.27) and Fig. No. (4.26) that the study individuals according to the percentage of cancer among women and the older men , male workers and students in rural areas, who are women and the elderly, totaled (13) individuals and a percentage of (86.3%), while we find those who They are working men and students, their number reached (2) individuals, and the percentage of (13.3%).

I. Details of the presence of the cancer disease

Table No. (4.28) show the frequency distribution of the study sample according to the type of the presence of the cancer disease

Type of Cancer disease	Frequency	%
Prostate	5	11.4
liver	5	11.4
leather	9	20.5
cervix	8	18.2
Bone Marrow	4	9.1
gum	4	9.1
Thyroid glands	3	6.8
The breast	6	13.6
Total	44	100

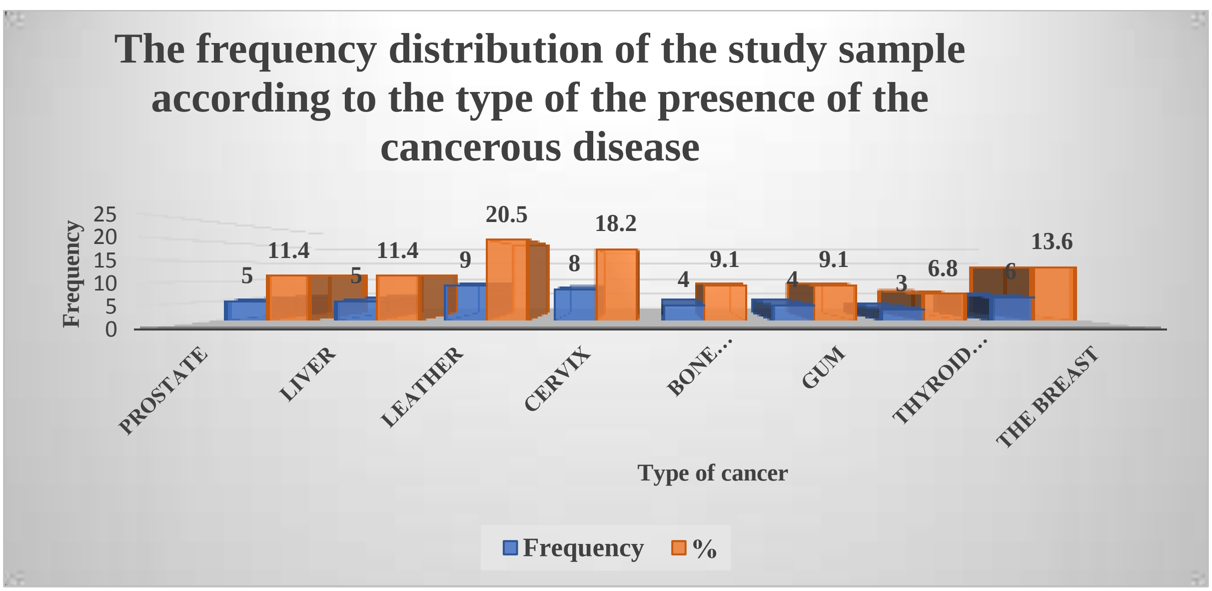

Figure (4.27) Frequency distribution of the study sample according to **the presence of the cancerous disease**

It is clear from Table No. (4.28) and Fig. No. (4.27) that the study individuals according to the details of the presence of cancerous disease, prostate number (5) individuals and a percentage (11.4%) and among those who type of cancerous liver disease, their number reached (5) individuals and a percentage (11.4%). The type of cancerous disease was skin, their number was (9) individuals, at a rate of (20.5%), and among those who had the type of cancerous cervical disease, the number was (8) individuals, at a rate of (18.2%), and among those with the type of cancerous disease, bone marrow numbered (4) individuals, at a rate (9.1%). Of those who had the type of cancerous disease in the gums, their number was (4) individuals, at a rate of (9.1%), and among those who had the type of cancerous disease of the thyroid glands, the number was (3) individuals, at a rate of (6.8%), and among those who had the type of cancerous disease breast, the number was (6) individuals, with a percentage of (13.6%).

J. Resident

Table No. (4.29) show the frequency distribution of the study sample according to the type of the presence of Resident

Status	Frequency	%
Khartoum	60	33.3
Khartoum Bahari	60	33.3
Omdurman	60	33.3
Total	180	100

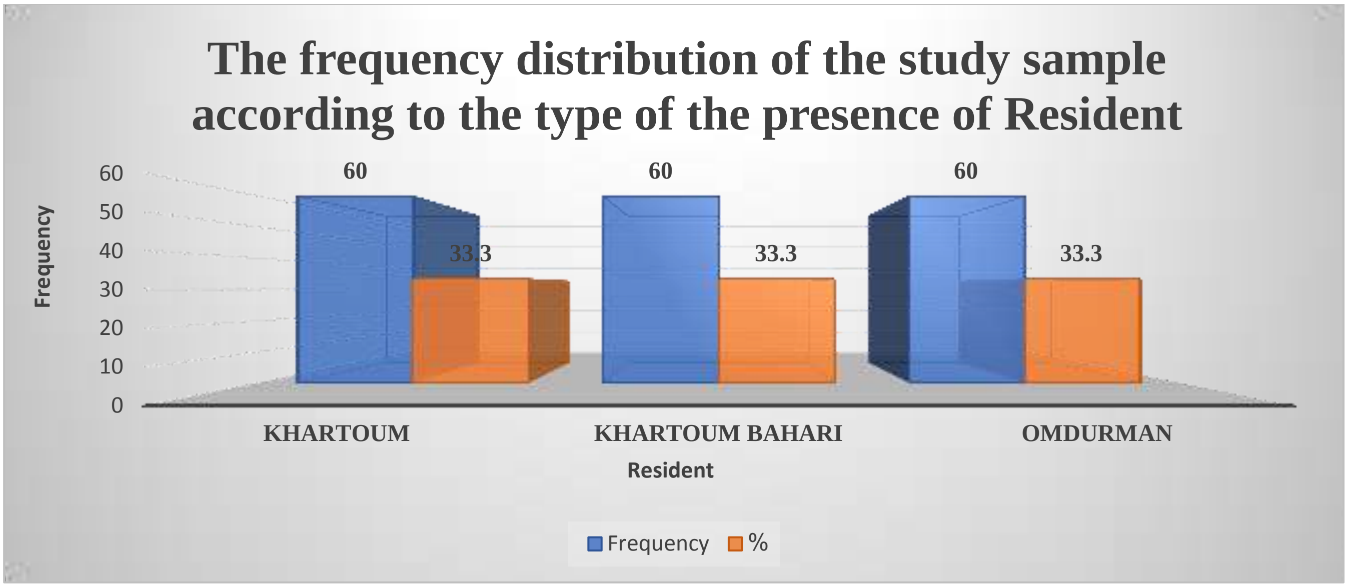

Figure (4.28) Frequency distribution of the study sample according to **the presence of Resident**

it is clear from Table No. (4.29) and Fig. No. (4.28) that the study individuals according to the place of residence, Khartoum numbered (60) individuals, at a rate of (33.3%), and among those whose place of residence was nautical, their number reached (60) individuals and a percentage of (33.3%). Their number reached (60) individuals, at a rate of (33.3%).

K. How long have you lived in this place?

Table No. (4.30) show the frequency distribution of the study sample according to the type of How long have you lived in this place

Living in the Place	Frequency	%
Less than 20 years	92	51.1
20-40 year	48	26.7
40-60 year	23	12.8
60-80 year	17	9.4
Total	180	100

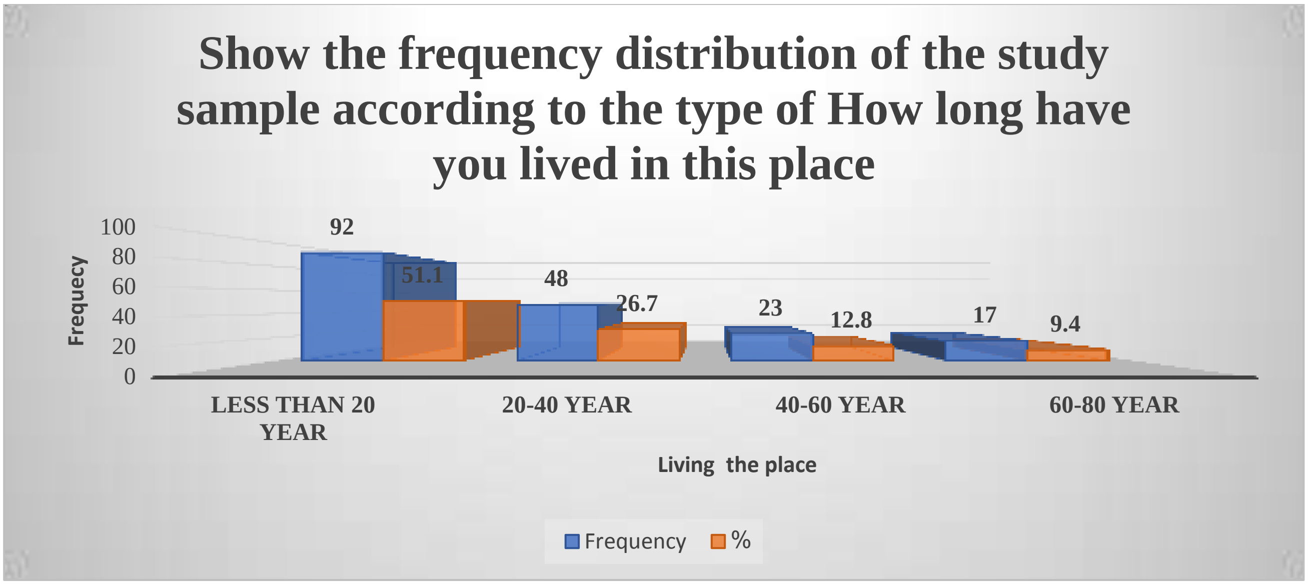

Figure (4.29) Frequency distribution of the study sample according to **How long have you lived in this place**

Table No (4.30) Fig (4.29) Since when you lived in this place, the number of those who live in the place for less than 20 years has reached (92) individuals, at a percentage (51.1%). As for those who live in this place between 20-40 years, their number (48) individuals, at a rate of (26.7%). They live in this place between 40-60 years, their number is (23) individuals, at a rate of (12.8%), and of those who live in this place between 60-80 years old, their number is (17) individuals, at a rate of (9.4%).

L. How many hours do you spend at home?

Table No. (4.31) show the frequency distribution of the study sample according to the type of How many hours do you spend at home?

Status	Frequency	%
Less than 20 Hours	9	5.0
8-10 Hours	53	29.4
11-13 Hours	77	42.8
14-16 Hours	15	8.3
17-19 Hours	26	14.4
Total	180	100

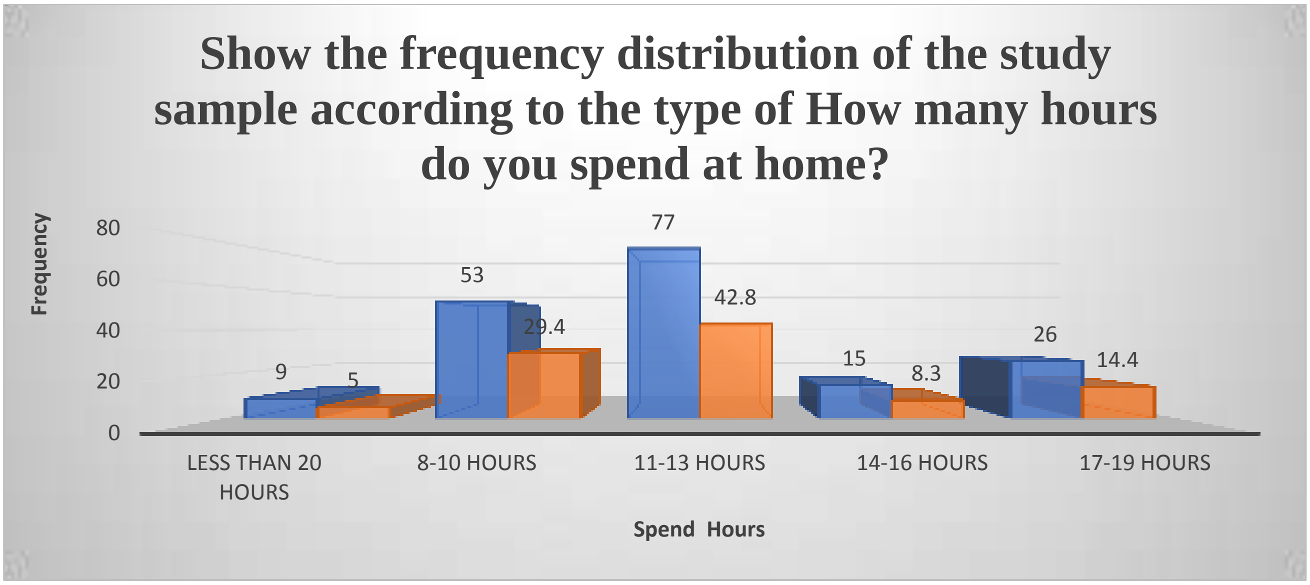

Figure (4.30) Frequency distribution of the study sample according to **the type of How many hours do you spend at home?**

Table No (4.31) and Fig(4.30)The number of hours you spend at home, who spend 8-10 hours, numbered (9) individuals, at a rate of (5.0%). As for those who spend between 11-13 hours, their number reached (53) individuals, at a rate of (29.4%), and among those who spend between 11- 13 hours, their number reached (77) individuals, at a rate of (42.8%), and of those who spent between 14-16 hours at home, their number was (15) individuals, at a rate of (8.3%), and among those who spend between 17-19 hours, their number was (26) By (14.4%).

L. The proportion of people with cancer in urban and rural areas

Table No. (4.32) show the frequency distribution of the proportion of people with cancer in urban and rural areas

Areas	Frequency	%
Urban	29	65.9
Rural	15	34.1
Total	44	100

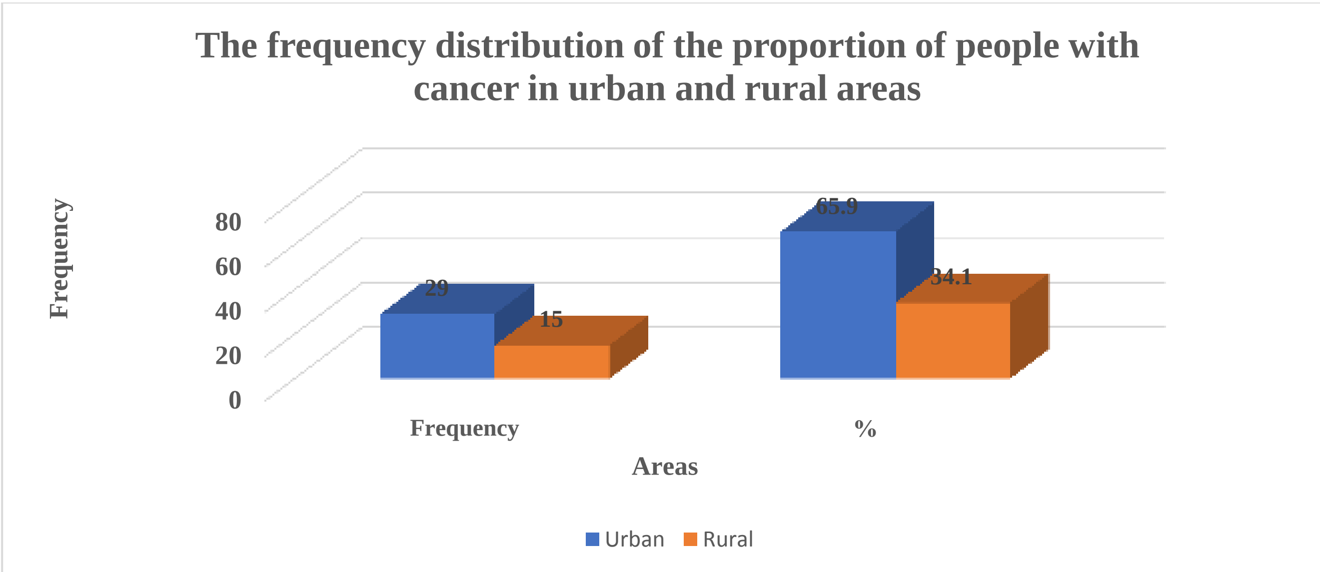

Figure (4.31) frequency distribution of the proportion of people with cancer in urban and rural areas

In view of tables (4.32) and figure (4.31) the percentage of cancer disease in urban areas is 65.9%, about two times that in the rural areas which is 34.1%. This is related to the fact that in urban areas the number of towers is considerably larger than the rural areas. Thus, the radiation is more intensive in urban areas. In rural areas, table (4.32) and figure (4.31) show that the cancer percentage of women and older men is86. 7% which is considerably larger than that of workers and students. This may be attributed to the fact that the number of towers near houses are larger than near farms and schools where workers and students exist.

Discussion

4.6 Communication Towers

Modern tools of communication are electronic devices, so the user is always exposed to radiation which, to some extent, has a negative impact on the user of the device. According to different researchers it could cause different health problems, from sleep disturbance up to tumurs. Researchers are trying to minimize this negative impact and recommend the safe frequency and distance. Figures (4.2,3,5,6) for Khartoum, Omdurman and Khartoum North and (4.8,9) for Omdurman show that the measurements taken from 300 sites in Khartoum State indicate that the radiation decreases considerably at 100 m from the tower. However, till now, the density of towers in Khartoum is relatively small compared to other countries. In Tanzania, the authorities recommended that people should reside far from the tower by 120 m or more [138,139]. In France, 300 m from the tower is considered as a safe distance [140]. A study in Germany shows that the risk of newly developing cancer was three times higher among those who had lived during the past 10 years within a distance 400 m from the tower in comparison to those who had lived further away [141]. In Brazil, it is considered that there is a risk of cancer mortality at residential distances of 500 m or less from the transmission tower [142].

The data collected from Radiation & Istopes Central-Khartoum (RICK)hospital in 2018 and 2019 shows that the percentage of cancer disease is clearly related to the radiation intensity which increases upon increasing the number of towers. Figure (4.15) shows that for Khartoum city the number of towers at residential areas are 26, at schools are 12, at (Al-Souq) are 4. Thus, for the number of towers at residential areas is more than twice than that of schools and markets (AL-Souq) separately. For Omdurman, figure (4.19), shows that the number of towers at residential areas are 40, at schools are 5, at (AL-Souq) are 5. Thus, the number of towers at residential areas is about 8 times than that of the schools and markets. According to the cancer data collection of Radiation & Istopes Central-Khartoum (RICK)hospital in table (4.20), It has been found that the cancer percentage is higher for older men (60-90), and younger women (30-59) who stay for a long time in residential areas where the concentration of tower's are considerably higher than the other areas like markets and schools and rural areas. Moreover, younger women use cosmetics which also increases cancer percentage. Unlike older men older women spend more time in the social activities spending more time along the road and rural areas where the concentration of towers and radiation doses are considerably lower.

The result of Radiation & Istopes Central-Khartoum (RICK)hospital data has been confirmed by the field work done for 180 volunteers at Khartoum state. Figure (4.21) concerning comparison of cancer percentage the women and older men who stay for a long time at residential areas is 48. 3%, which is slightly lower than the workers and student’s cancer percentage 51.7%. This may be attributed to the fact that the role of radiation in causing cancer at residential areas is counter balanced by the role of high air pollution in causing cancer disease. However, for rural areas the result is different due to the considerably low air population. Figure (4.26) for rural areas indicated that the cancer percentage of women and older men which stay for a long time at residential areas is 86.7 %,whereas the percentage for workers and students is 13.3%.Since figures (4.11, 12,14) indicates that the number of towers at residential areas is considerably higher than at schools and markets, it thus quite natural to expect the cancer percentage of women and older men to be considerably higher than that of workers and students.

The geometry of radiation source affects considerably the radiation power. The towers in Omdurman (figures 4.5,6) which is in the form of complete circle in the form of a cylinder radiates more power than the ones that are in the Khartoum (figures 4.2,3,8,9) which are in the form of 1/6 circle except for the maximum power. The maximum power is affected by the tower’s intensity. This is since the maximum power is related to the cylindrical structure of the source which distribute itself parallel to the earth surface thus travels for a long distance without being diminished considerably. Thus, it is affected by the intensity of the nearby towers. Therefore, the maximum power in Khartoum where the intensity of the towers is high is higher than that of Omdurman

4.7 High Voltage Lines

Figures (4.11,12,12) show that the electric fields from high voltage transmission lines can be very strong outside near the wires. However, inside the home, the building structure usually provides some shielding. Magnetic fields can pass through most objects and can't be blocked as easily as electric fields.

The field strength decreases quite rapidly with increasing distance from the lines. The measurements taken at Khartoum State show that the field strength becomes very small at about 100 m from the high voltage lines.

4.8 Percentage of Cancer Rural and urban area

According to the table the (4.32) cancer percentage is higher where the number of towers is considerably larger. Therefore, the cancer percentage in urban areas is larger compared to rural areas and is also higher in rural areas for women and older men which stay in houses for a longer time, where the number of towers is considerably larger compared to the workers and students which take relatively short times in hous

Chapter Five

Conclusion and Recommendations

5.1 Conclusion

We find that the percentage of women in the corn hospital is greater than the number of men, this means that most women will be around for long periods of time (Long Exposure). The cancer percentage is higher where the number of towers are considerably larger. Therefore, the cancer percentage in urban areas is larger compared to rural areas and is also higher in rural areas for women and older men which stay in houses for a longer time, where the number of towers is considerably larger at residential areas compared to markets and schools where the workers and students stay and take relatively short times in houses. The appearance of the tower's radiation effect in rural areas rather than urban areas comes from the fact that in rural areas the main cause of cancer is radiation, while in urban areas air pollution and use of cosmetic by women contribute also to causing cancer. The geometry of radiation source affects considerably the radiation power of the towers. Large area sources emit intensive power near the towers. The power at large distance from the tower is affected by the number of towers in surrounding areas.

5.2 Recommendations

1. There must be policies on the presence of communication towers and high voltage lines in residential areas. The radiation from these sources might affect human health. The authorities must not give permission for the installation of communication towers or high voltage lines at a distance less than 100 m from residential areas.
2. There must be routine medical checkup for those who live at a distance less than 500 m from communication towers or high voltage lines. The radiation from these sources could take several years of exposure to cause serious health damage. It is noticed that there are buildings at a distance less than 100 m from the high voltage lines. A special attention must be given to the occupant of these buildings.
3. Families are recommended to live in rural areas or at least take their weak ends at rural areas.
4.The long-time exposure which is assumed to be related to the cancer disease can also be minimized by providing a sort of shielding using minerals. One also can give some advice to use mobiles and computers only for urgent purposes.
5. It is necessary to pay attention to the field of non-ionizing radiation among all government institutions and to make rules and regulations for communication towers, with the participation of all universities and research institutions that are interested in the field, and to make periodic measurements of the towers, especially those close to schools, residential areas, and markets, and start observations.
6. High transmission lines must be observed in residential areas, schools, and hospitals, as they must be in long distances to reduce exposure.
7.It is necessary to make a map of the Republic of Sudan for non-ionizing radiation, determine the number of towers and distances from regions, schools, hospitals, and determine the rates of cancer and the people who live near it.
8. Do not use devices that contain radio rays for a long time, as exposure to them can be one of the probability factors for cancer and modern viruses.

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LIST OF PAPERS

The thesis depends on some papers, which will be the included in the text

Paper One:

Investigation of electromagnetic radiation emitted from mobile base stations in Khartoum state

Department of Physics, faculty of science, Sudan University of science and Technology, Khartoum-Sudan. Sudan Atomic Energy Commission (SAEC), Khartoum –Sudan, Mohammed Idriss. Ahmed, Mohammed Osman Sid Ahmed, Hafiz F.AL Rahman, Isam Salih M. Mousa and Hajo Idriss

(International Journal of Scientific and Research Publications, Volume 6, Issue 4, April 2016 99 ISSN 2250-315).

Paper Two:

Assessment Magnetic field emitted from transmission lines in Khartoum state

Mohammed Idriss. Ahmed[1], Mohammed Osman Sid Ahmed[2] 1Department of Physics, faculty of science, Sudan University of science and Technology, Khartoum-Sudan 2 Sudan Atomic Energy Commission (SAEC), Khartoum – Sudan

IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 12, Issue 6, Ver. I (Nov.- Dec. 2017), PP 01-06 www.iosrjournals.org.

Paper Three:

Assessment of Possible Biological Risk of the Share and Non- Share Locations at the Base Transceiver Station (BTS) for Companies Operation in Khartoum State, Sudan

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Paper Four:

Non-Ionizing Radiation in Africa

Mohammed Idriss Ahmed Mohammed [1], IOSR Journal of Applied Physics (IOSR-JAP) e-ISSN: 2278-4861.Volume 13, Issue 1 Ser. I (Jan. – Feb. 2021), PP 01-04 www.Iosrjournals.OrgIOSR Journal of Applied Physics (IOSR-JAP.

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Tables of Measurements of companies Operations

Table show the Number of BTs in Khartoum until 2019 for Company A

Company	Name	Number Sites	Longitude	latitude	Technology	Number	Share Opti	Number	Power dB
A	Khartoum	231	32.487917 ° E 32.655205° E	15.516528° N 15.502845° N	3G Only	2	Not share	227	31-41.76
					2G\3G	225	Share	4	
					2G Only	4			
A	Jabl Awlia	113	32.503056 ° E 32.587111° E	15.241111 ° N 15.523694° N	2G\3G	113	Share	2	36.99-41.76
							Not share	111	
A	Karari	82	32.505528 ° E 32.520309° E	15.687806 ° N 15.700458° N	2G Only	1	Share	1	41.76
					2G\3G	2	Not share	80	
A	Khartoum North	113	32.5181 ° E 32.747085 ° E	15.6447° N 16.25216° N	2G	3	Share	1	41.76
					2G\3G	110	Not share	112	
A	Ombda	97	32.419889° E 32.370389° E	15.6469° N 15.663639° N	2G Only	3	Not share	97	36.99-41.76
					2G\3G	94			
A	Omdurman	95	32.468° E	15.658472° N	2G Only	1	Share	2	36.99-

			32.482667° E	**15.648644° N**	**2G\3G**	**94**	**Not share**	**93**	**41.76**
A	**Sharg Al-Nile**	**96**	**32.592722° E**	**15.6183° N**	**2G Only**	**3**	**Not share**	**96**	**36.99-41.76**
			32.600715° E	**15.581391° N**	2G\3G	93			

Table show the Number of BTs in Khartoum until 2019 for Company B

Company	Name	Number Sites	Longitude	latitude	Technology	Number	Share Opti	Number	Power dB
B	Khartoum	151	32.54941° E 32.4979° E	15.59572° N 15.5474° N	2G	8	Share	10	40-47.8
					2G,3G	50			
					2G,3G,4G	60			
					3G	3	Not share	141	
					3G,4G	27			
					3G, LTE	1			
					4G	2			
B	Jabl Awlia	62	32.4703° E 32.5443° E	15.4587° N 15.4857° N	2G	19	Share	28	41.139434-47.8
					2G,3G	43	Not share	34	
B	Karari	48	32.4467° E 32.4992° E	15.764° N 15.6865° N	2G	9	Share	33	41.760913-47.8
					2G,3G	35			
					2G,3G,4G	2	Not share	15	
					4G	2			

B	**Khartoum North**	**71**	**32.5233° E 32.5639° E**	**15.6528° N 15.6286° N**	**2G**	**11**	**Share**	**38**	**41.139434-47.8**
					2G,3G	**42**			
					2G,3G,4G	**14**	**Not share**	**33**	
					3G,4G	**4**			
B	**Ombda**	**54**	**32.4399° E 15.6428° E**	**15.6491 ° N 32.41802° N**	**2G**	**4**	**Share**	**50**	**41.139434-47.8**
					2G,3G	**50**	**Not share**	**4**	
B	**Omdurman**	**55**	**32.4664° E 32.4644° E**	**15.6307° N 15.6132° N**	**2G**	**1**	**Share**	**25**	**41.139434-47.8**
					2G,3G	**40**			
					2G,3G,4G	**10**			
					3G,4G	**1**	**Not share**	**30**	
					3G, LTE	**2**			
					4G	**1**			
B	**Sharg Al-Nile**	**51**	**32.63285° E 32.61041° E**	**15.62814° N 15.64805° N**	**2G**	**16**	**Share**	**27**	**41.139434-47.8**
					2G,3G	**35**	**Not share**	**28**	

Table show the Number of BTs in Khartoum until 2019 for Company C

Company	Name	Number Sites	Longitude	latitude	Technology	Number	Share Opti	Number	Power dB
C	Khartoum	284	32.506425 ° E 32.57592° E	15.564883° N 15.55235° N	2G	3	Share	212	41.139434-47.8
					2G/3G	84			
					2G/3G/4G	151			
					3G	44	Not share	72	
					3G/4G	2			
C	Jabl Awlia	106	32.5665° E 32.46732 ° E	15.5135 ° N 15.47302 ° N	2G	4	Share	72	33-44
					2G/3G	54			
					2G/3G/4G	26	Not share	34	
					3G	22			
C	Karari	76	32.504548° E 32.51266 ° E	15.688269° E 15.698611° N	2G/3G	44	Share	61	38-43
					2G/3G/4G	18			
					3G	12	Not share	15	
					3G/4G	2			
C	Ombda	85	32.4218° E 32.36121° E	15.6201° N 15.66218° N	2G	6	Share	67	33-47
					2G/3G	62			
					2G/3G/4G	5			
					3G	11	Not share	18	
					3G/4G	1			

C	**Omdurman**	**104**	**32.4658° E 32.48459 ° E**	**15.6216° N 15.64139° N**	**2G**	**5**	**Share**	**84**	**33-45**
					2G/3G	**33**			
					2G/3G/4G	**39**			
					3G	**25**	**Not share**	**20**	
					3G/4G	**2**			
C	**Sharg Al-Nile**	**109**	**33.8096° E 32.62396° E**	**15.9001° N 15.64181° N**	**2G**	**13**	**Share**	**75**	**33-45**
					2G/3G	**60**			
					2G/3G/4G	**9**	**Not share**	**34**	
					3G	**27**			
C	**Khartoum North**	**131**	**32.5181 ° E 32.747085° E**	**15.6528° N 15.6286° N**	**2G**	**13**	**Share**	**108**	**33-45**
					2G/3G	**60**			
					2G/3G/4G	**31**	**Not share**	**23**	
					3G	**27**			