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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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Telecommunication technology has become a very crucial method of communication nowadays in all countries. However, there many concerns regarding the safety and biological risk from telecommunications towers. This study aims to analyze the number and distribution of the base transceiver station (BTS) in Khartoum state and assess the possible biological risk. Khartoum State was divided into seven districts are calculated and compared with the Ministry of Communications. This study's results were obtained from the Telecommunication companies (A, B, and C) operating in the Khartoum State (. Khartoum state has 2214 BTs distributed in its seven districts (area =22,142 km2). The largest number of antennas was found in Khartoum, with 515 antennas, at 23 %, and the lowest in the district is Karari districts, with only 206(9%). The number of BTS in company A has 10 locations, 0.1% and None share 817 , 99% ,In Company B =492 location ,share lactation 233,47.35% ,Non Share 259(52.6%) and the Company C has 791 Locations, Share location= 695 (87.8%) , Non share has 200 (25.28%). According to the companies operation, the mean share locations in Khartoum state 45.3%, and Non-share locations are 59%. The study revealed that the number of non-shared antennas in the state of Khartoum is greater than the common antennas, and therefore, the resulting emitted power is less than the Share antennas. The current number of BTs comply with international guidelines. Based on the distribution of BTs, the risk is minimal to the general population.

Keywords: BTs. Share, Non- Share- Non-ionizing Radiation, Khartoum State

INTRODUCTION

Electromagnetic Radiation

The development of science and technology has a significant influence on lives because it modifies people's lifestyles, connections, communications, and transactions. Moreover, it affects the world's economic development. The effects of these developments are both positive and negative. All forms of EM energy share three fundamental characteristics: they all travel at high velocity, they have the same properties of waves, and the radiation is outward (originates) from a source. The wave spreads over a wide range. In unbounded media, wave propagation is utilized as a part of radio or television broadcasting, where the waves in transmission are accessible for everybody who might be intrigued. Such means of wave propagation do not help in a situation like a telephone conversation. The information is received privately by one person, commonly referred to as the end-to-end connection. EMR has electric and magnetic field components and passes through space at an estimated speed of 186,000m/s (miles per second); it can also be defined as the energy NOT complete to ionizing biological material including gamma and x radiations (Saeid, 2013, Chaitra et al., 2017). It refers to any particular electromagnetic radiation that does not carry enough energy per quantum (photon energy) to ionize atoms or molecules].

Non-ionizing radiation is associated with two significant potential hazards: electrical fields (current & voltage) and biological factors (Saeid, 2013, Chaitra et al., 2017, Aris et al., 2020). Some scientists have investigated the effects of non-ionizing radiation, and they have written recommendations based on their hypothesis. They depend on transparent and described criteria for evaluating scientific data, such as paying close attention to the number of participants/animals/cells considered in the studies. Consequently, they also look into the potential biases and confounding factors (NCI, 2018, Martin et al., 2015; Moulder, 2014)

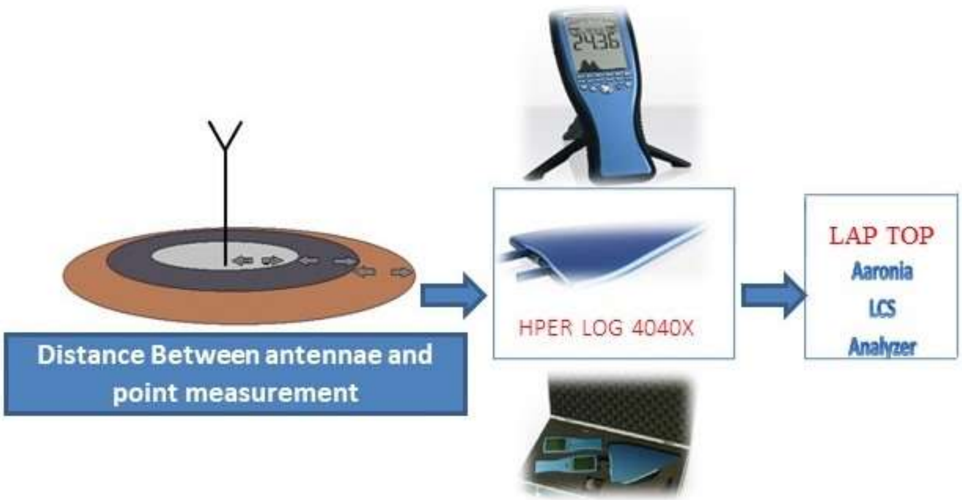
Types of non-ionizing electromagnetic radiation (NIR)

Non-ionizing electromagnetic radiation (NIR) can be divided into non-ionizing radiation according to the Frequency, wavelength, sources, types, and biological effect, according to the table below (Moulder, 2014)

Table 1: to show the Types of non-ionizing electromagnetic radiation (NIR)(IARC,2013, Luc, 2012

Types of non-ionizing	Wave Length (m)	Frequency	Types-Biological effects- Sources
Near ultraviolet radiation Ultraviolet light can cause burns to skin	318–400 nm	750–950 THz	Eye: photochemical cataract; skin : erythema, including pigmentation
Microwave	1 mm – 33 cm	1–300 GHz	Biological effects Heating of body tissue Source Mobile/cell phones, microwave ovens, telecommunications, radar, Wi-Fi
Radio-frequency radiation	33 cm – 3 km	100 kHz – 1 GHz	Biological effects : Heating of body tissue, raised body temperature Source: Mobile/cell phones, television, FM, AM, shortwave, CB, cordless phones
Low-frequency RF	>3 km	<100 kHz	Accumulation of charge on body surface; disturbance of nerve & muscle responses Source: Power lines
Thermal radiation	700-1050 nm	430 THz	Infrared radiation,

Fig. 1. The setup of measurement from antennas



.MATERIALS AND METHODS

Distribution BTs in Khartoum

Khartoum State is the capital of Sudan and the largest in the country, with a population of approximately 7,687,500 people. It lies between longitude and latitude 32.53333, 15.63333. It covers an area of 22,142 km^2 and contains seven districts, which include: Khartoum (KH), Khartoum North (KN), Shrq AL-Nile (SN), Jabal Awlia (JA), Karari (KR), Ombada (OB), and Omdurman (OM). Four companies are operating A, B, C, and D as telecom operators distributed in the cities and regions, but the last company work in internet services. The data were collected from all these locations and compared with the data from the ministry of communications.

Study area

The study area is divided according to the operating companies to the four A, B, C, and D, calculating the number of towers for each operating company in all regions in the seven governorates of Khartoum. Table 2 shows the necessary data of telecommunications companies in Sudan with relevant frequencies.

Measurements

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, making it applicable in field-strength and EMC measurements. Also, its high precision enables researchers to use it in laboratories or open-field applications.

Table 2: Tele communication companies in Sudan

Company	License Date	Technology
Zain	1996	3.5G (GSM and WCDMA)+ 4G
MTN	2003	3G+ (GSM)
Sudani	2006	3.75G (CDMA)
Canar	2005	3G (CDMA)

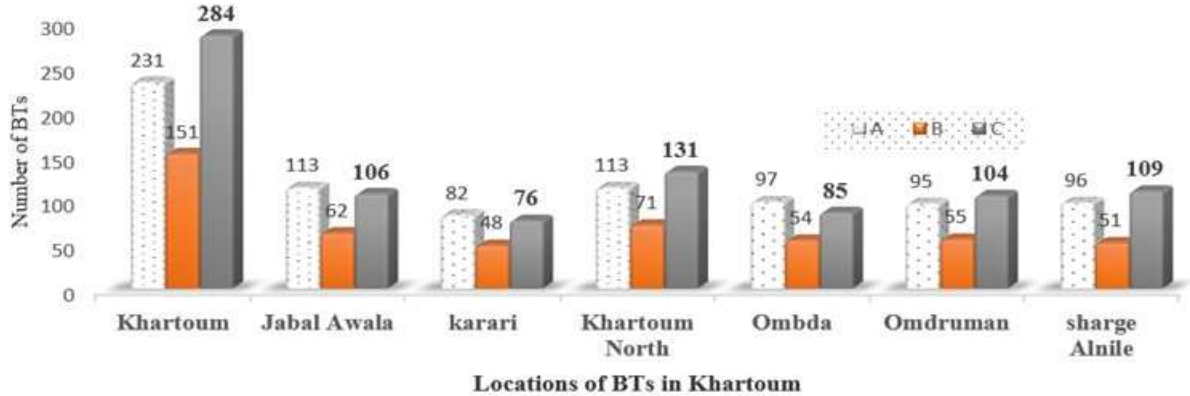
CDMA: Code-division multiple access , GSM : Global System for Mobile Communications

The present study's selected area 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 transmission lines were determined using accompanied software (Aaronia LCS analyzer). The devices (Hyper LOG 4040 X) used in the measurements were connected to a laptop to calibrate and analyze the spectra. The data were analyzed according to the ICNIRP 2010 safety limits guidelines.
Measurements performed at distances from 10m to 100 m far from the antennas, while a GPS device

was used to locate the antennas' coordinates. The setup of the instruments used is shown in Fig. 1.

Figure 2. The number of antennas in Khartoum State for operators companies



RESULT AND DISCUSSION

Table 3 shows the number of BTs in Khartoum State for operators companies. According to company A, B, or C., the number of Share antenna and non-share antennas is utmost in Khartoum and 40% and 28% higher, respectively. As, the non-shared antennas, we find that in Jabal Awlia and Khartoum North, they are egalitarian to 14%, and also Charge Al Nile and Ombda are equal to 12%. There is no standard Share antenna in the Charge Al Nile and Ombda regions due to the lack of modern buildings that limit the signal strength. It was noted that the more significant number of common antennas in Jabal Awala and Charge Al-Nile by 19% and 18%, respectively. The minimum was in Khartoum, at 4%. The number of non-shared antennas is the most massive (31%) and the lowest in Karari and Sharqe Al-Nile (10%).

The number of antennas does not share with company B is 53% greater than the number of common antennas, 47% at the top view.

From the observation from Company C, the maximum number of Antennas locations for share and non-shared antennas in Khartoum ranged between 31% and 36%. We find that Jabal Awliya and Karari are equal in the shared antennas by 11%. However, in the Karari region, there are no non-shared antennas, while there are 17% in Jabal Avila and Sharg Al-Nile Nile regions. Figure: 2 the number of antennas in Khartoum State for operators companies Table 4 showing the number Share and Non-Share Locations of BTs for Company A in Khartoum State (Fig.3) shows the total showing the number of Shares and None -share antennas for Company A for localities of Khartoum State. Tables 4,5 and 6 shows the number of Share and None -Share antennas for companies A,B and C for locations of Khartoum State

Table 3 shows the number of BTs in Khartoum State for operators companies

No	BTs	A	B	C	Total	%
1	Khartoum	231	151	284	515	0.23
2	Jabal Awalia	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	Omdruman	95	55	104	254	0.11
7	sharge Alnile	96	51	109	256	0.12
	Total	827	492	895	2214	

Table 4. show the number Share and Non-Share Locations of BTs for company A in Khartoum State						
No	**Locations**	**Share Locations**	**Percentage of share locations %**	**Non- Share locations**	**Percentage of Non-share locations %**	**Total**
1	Khartoum	4	40%	227	28%	231
2	Jabl Awlia	2	20%	111	14%	113
3	Karari	1	10%	81	10%	82
4	Khartoum North	1	10%	112	14%	113
5	Ombda	0	0%	97	12%	97
6	Omdurman	2	20%	93	11%	95
7	Sharge Al Nile	0	0%	96	12%	96
Total		10	1.00	817	2.03	827
%		1.2%		98.7%		

Table 5. Shows the number of Share and Non -Share antennas for Company B for locations of Khartoum State						
No	**Locations**	**Share Locations**	**Percentage of share locations %**	**Non- Share locations**	**Percentage of Non-share locations %**	**Total**
1	Khartoum	10	4%	141	31%	151
2	Jabal Awala	44	19%	18	13%	62
3	Karari	33	14%	15	10%	48
4	Khartoum North	38	16%	33	14%	71
5	Ombda	42	18%	12	11%	54
6	Omdurman	25	11%	30	11%	55
7	Sharge Al-Nile	41	18%	10	10%	51
Total		233	100%	259	100%	492
%		47%		53%		

Table 6 shows the number of Share and None -Share antennas for Company C for locations of Khartoum State						
No	**Locations**	**Share Locations**	**Percentage of Share Location %%**	**Non-Share Locations**	**Percentage of Non-Share Location %%**	**Total**
1	Khartoum	212	31%	72	36%	284
2	Jabal Awila	73	11%	33	17%	106
3	Kararai	76	11%	0	0%	76
4	Khartoum North	108	16%	23	12%	131
5	Omdurman	84	12%	20	10%	104
6	Ombda	67	10%	18	9%	85
7	Sharg Al-Nile	75	11%	34	17%	109
Total		695	100%	200	1.00	791

%	87.8%		25.3%		

The Relation between locations Share or Not share in Company A

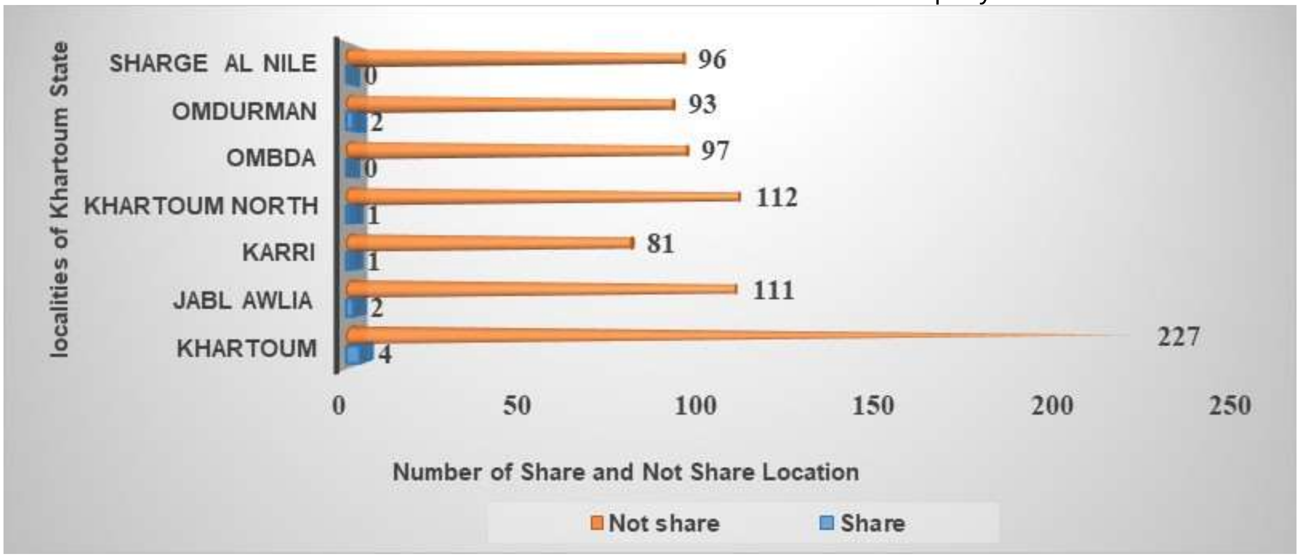


Figure: 3 showing the number of Share and Not -share antennas for company A for localities of Khartoum State

Number of Share and Not -share antennas for Company B for localities of Khartoum State

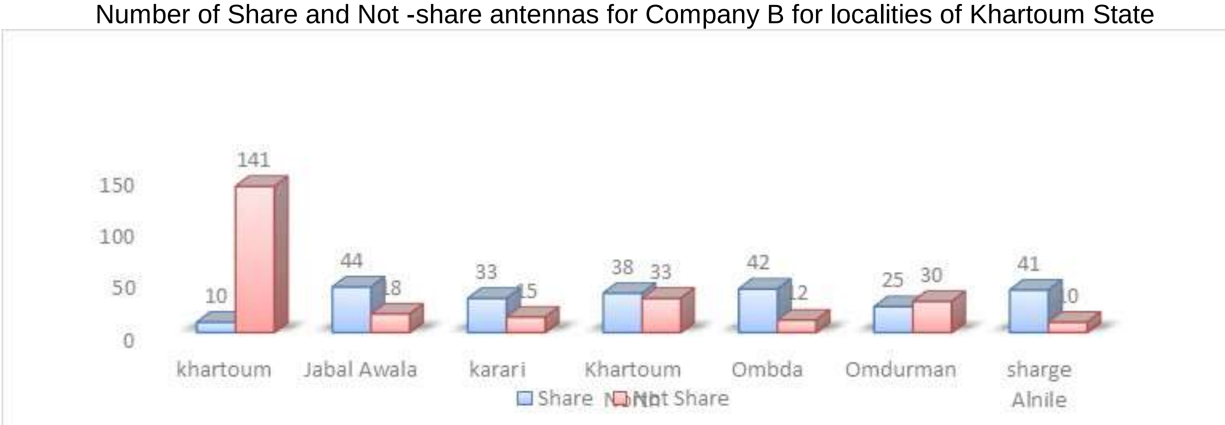


Figure 3 shows the number of Share and None -share antennas for Company B for localities of Khartoum State

Number of Share and Not -share antennas for Company Cfor localities of Khartoum State

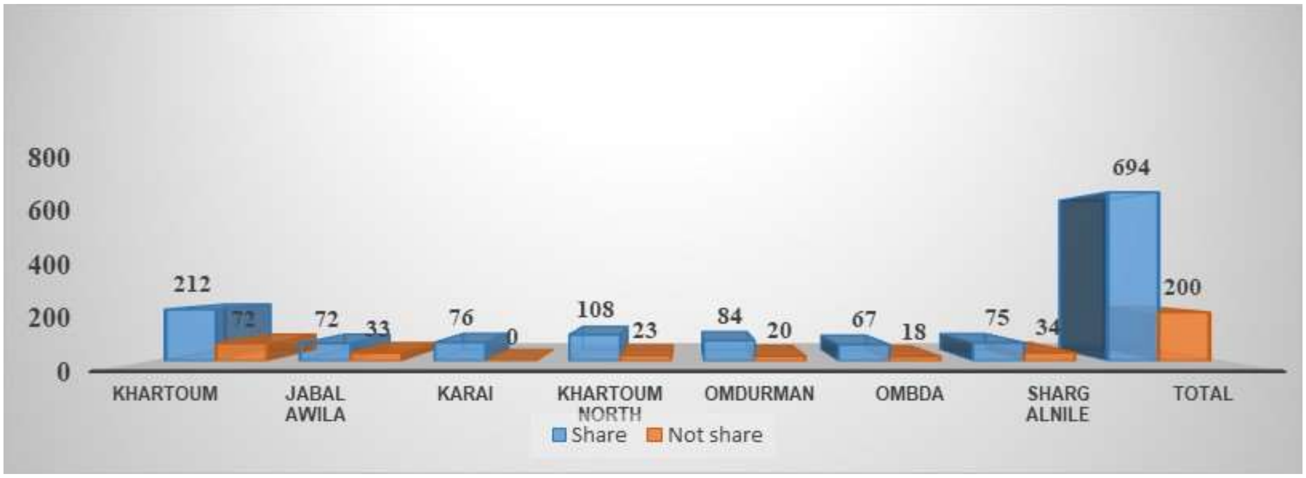


Figure 4 to show the number of antennas for Company C for Khartoum State districts

The majority of the buildings of Khartoum State are in the horizontal position. However, some areas have been entered modern buildings, which led to buildings' participation to increase the signal strength and the power resulting from those antennas. Miller et al. 2011 reported that cell towers emit Radiofrequency radiation. This study concluded that "Based on the evidence reviewed, it is our opinion that IARC's current categorization of RFR as a possible human carcinogen. Furthermore, Zothansiama et al. 2017 reported that the effects in the human blood of individuals living near mobile phone base stations (within 80 meters) compared with healthy controls (over 300 meters). The study found higher radiofrequency radiation exposures and statistically significant differences in the blood of people living closer to the cellular antennas. The ICNIRP (1998) set a limit for radiofrequency electromagnetic fields (EMFs) exposure should be below 10.0 GHz to prevent excessive heat in body temperature. The results of this study are within the international guidelines. Meo et al., 2018 concluded that High exposure to RF-EMF produced by mobile phone base station towers affects motor skills, spatial working memory, and attention in school adolescents compared to students who were exposed to low RF-EMF. The authors also revealed that Elementary school students exposed to high RF-EMFR generated by MPBS had a significantly higher risk of type 2 diabetes mellitus relative to their counterparts exposed to lower RF-EMFR. The group living closer to the antennas had, for example, statistically significantly higher biological risk. These changes are considered biomarkers predictive of cancer. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) and world health organization (WHO) provided a recommendation to protect the general public from avoidable risk from non-ionizing radiation(WHO, 2014, ICNIRP,1998; ICNIRP,2020). The recommendations intended to prevent the occurrence of severe biological risk while maximization of the benefits. These recommendations were formulated according to the highest radiation levels, above which the proven thermal effects of non-ionizing radiation are observed. However, there is general agreement that there may be additional health effects unrelated to the heating of tissues (non-thermal effects). Such effects may occur even if the radiation source has a lower power density than that recommended by the safety limits. Due to the massive benefit of non-ionizing radiation, prevention usage is not an option. They were thus decreasing the exposure to non-ionizing radiation while striking a balance between the needs of evolving technology and protecting human health from thermal and non-thermal effects. The data showed that the current BTs provide limited or no detectable risk for the general population. With the introduction of 5G technology, which emits ultra-high frequencies non-ionizing radiation with higher the frequency, the shorter the length of each wave. This means more waves hit our bodies in the same amount of time. Previous cellular generations emitted from 1 to 6 GHz frequencies. 5G cell towers may emit frequencies as high as 300 GHz. because 5G technology requires ultra-high intensity. Since the shorter length millimeter waves (MMV) used in 5G do not travel as far (and get obstructed easier), the cell signal will not be reliable with our current number of cell towers. 5G cell towers will have to emit the lower 3G & 4G waves as well, and many more will have to be installed. It is estimated that they will need a mini cell tower every 2 to 8 houses. All of this combined will significantly increase our RF radiation exposure and expected biological risk.

CONCLUSION

The increase in the installation of antennas and the rapid use must be taken into account with the population's distribution compared to the antennas to avoid the effects of the antennas and place them within the safe distance Global agreed Terms. We recommend that any new business near the common antennas be subject to monitoring, especially in nearby residential places, schools, and hospitals. Moreover, the safe distance is present because the energy from them is higher than the non-shared antennas. In general, views the date, the number of non-shared BTs compared share BTs is not large, indicating that the resulting power compared to antennas was as low as possible.

CONFLICT OF INTEREST

The authors declared that the present study was performed in the absence of any conflict of interest.

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AUTHOR'S CONTRIBUTION

MI, MD, MO, AA, and AS designed and performed the experiments, supervision validation, visualization, also wrote the first draft of the manuscript. All authors read and approved the final version.

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