Journal of Fundamental and Applied Sciences

Research Article

ISSN 1112-9867

Special Issue

Available online at http://www.jfas.info

EXPOSURE LEVEL FROM SELECTED BASE STATION TOWER AROUND KUALA NERUS: A PRELIMINARY ANALYSIS

A. R. S. N. Dianah[1], R. Umar[2], M. K. A. Kamarudin[2], A. N. Dagang[3] and S. N. Hazmin[1,*]

[1]School of Fundamental Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

[2]East Coast Environmental Research Institute (ESERI), Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300 Kuala Nerus, Terengganu, Malaysia

[3]School of Ocean Engineering, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

Published online: 17 October 2017

ABSTRACT

Health risk due to RF radiation exposure from base station tower (BST) has been debated for years leading to public concerns. Thus, this preliminary study aims to measure, evaluate and analyze the exposure level on three selected BST around Kuala Nerus. The measurement of exposure level in terms of voltage amplitude (dBmV) data were recorded using spectrum analyzer. The trend of exposure level shows that the characteristics of environment around the BST sites contribute to the variation of voltage amplitude for all study sites. Besides, the radiation exposure level of BST depends on several factors such as: the distance from the radiation sources, the height of the tower, tilt and direction of the antennas fixed on the top of the tower, the number of antennas on single tower, the type of radiation pattern, the direction of main beam of radiation, the feeding power and the operating frequency.

Keywords: base station tower; exposure level; radiofrequency; electromagnetic radiation.

Author Correspondence, e-mail: norhazmin@umt.edu.my

doi: http://dx.doi.org/10.4314/jfas.v9i5s.26

1. INTRODUCTION

Nowadays, worldwide communication system shown more advanced and sophisticated with various technologies. Furthermore, with this borderless world situations make people nowadays feel that the communication system is a very important asset to enable them to communicate with each other without the constraints of time and place.

Therefore, the rapid development of telecommunication systems have occurred around the world in line with the advancement of the world especially in developing countries [1]. The development of the telecommunications system has led to an increase of the use of mobile phones and also the installation of mobile phone base station everywhere that act as a communication medium for people to communicate with each other around the world [2-3]. With the mobile phone base station tower mounted closer to each other with high transmitting power, mobile phone be able to transmit and receive enough signal for the high quality coverage of communication up to several kilometers [2-4].

The exposure level from BST reaches its maximum when the number of users increasing and causing the full capacity of the base station is reached [2, 5]. When someone starts to make a call, the Radiofrequency (RF) signals to be transmitted to the nearest base station then routed to another base station which is nearest to the call receiver. Enough power will be transmitted so that the signal can be delivered and accepted by another base station [2].

Radiofrequency (RF) which is defined as the part of electromagnetic spectrum occupy the frequency range 3 kHz to 300 GHz [6-8]. Electromagnetic Field (EMF) is an important medium for carrying signals that can be voice, data or image form which propagate at the speed of light is emitted from a specific source to the desired recipients [9].

However, there are rumours that the construction of base station tower has caused public concern about the possibility of negative effects because of electromagnetic radiation (EMR)emitted from the base station antenna. In many countries, the high exposure levels were found in the vicinity of base stations [10] and the people living within the radius up to 10 m from the tower will receive 10,000 to 10,000,000 times stronger signal than required for mobile communication [11].

For example in Nigeria, there is a public concern on this issue when there are thousands of BST have been erected in the vicinity of residential areas [12].

Therefore, as a step to prevent negative effects on human health, International Commission on Non-Ionizing Radiation Protection (ICNIRP) as an international organization provides guidance on the health and environmental effects of (non-ionizing radiation) NIR to protect people and the environment from detrimental NIR exposure besides established responsible for the development guidelines of NIR exposure limits for the general public and workers [13].

Many researchers have conducted studies to determine the level of EM field around BST to ensure does not exceed the limit guidelines. There are also researchers who conducted this study to determine the safety distance should be recommended as a guide for the development of residential areas and suitable for human activities. Such research is also supported by [10] who thought that a study on electromagnetic fields radiated from cellular phone base station antennas is very crucial to take precautions for human health. Hence, there is a study was conducted in Nigeria as a step to determine whether the level of EMF meet the standards have been established by ICNIRP [12]. Furthermore, many recent studies have focused on measurement and assessment of electric field strength (E) levels and there is a study carried out the measurements at various places near the cell towers inside residential areas in Kirkuk, Iraq and found that the radiation levels were above the recommended values [1, 14-19].

The main aim of the project is to measure and evaluate the RF EMF exposure in voltage amplitude reading from selected base station tower (BST) besides to identify the sources exists around the area study.

2. METHODOLOGY

In this study, the measurements of electric field strength has been conducted at three different base station tower sites around Kuala Nerus, Terengganu. One of the base station tower selected is near to the Universiti Sultan ZainalAbidin named BST1, which represents as sub-urban environment and another two base station tower are located in villages and nearer to the BatuRakit beach named BST2 and BST3 respectively which represent as rural environment. Furthermore, there are another five BST are located near to the beach of BatuRakit.

The measurements were performed at distances 50 m to about 500 m in the vicinity of the

BST by standardize the data retrieval time from 10 am until 2 pm but on the different day. The measurement equipment consist of spectral analyser (model) connected to a directional receiving antenna was setup on the ground at every distance during 10 minutes at 1 second intervals and repeated for each site.

The exposure level in readings of voltage amplitude detected by spectrum analyser was recorded in decibel-millivolts (dBmV).

3. RESULTS AND DISCUSSION

In this study, there are two types of analysis that will be discussed. First, to determine the frequency sourced from BST for study sites named BST 1, BST 2 and BST 3. Second, to study the trend of exposure level in the measured of voltage amplitude related to the separation distance between BST and observation site. Besides, the factors that influenced the trend of the exposure level also taken into account.

First analysis was conducted to identify the frequency exist on spectrum readings and determine the sources available around the study area. Since focus of this research is to study the radiation pattern of source from the BST at various distances, so this analysis is to identify in advance the transmitted frequency source.

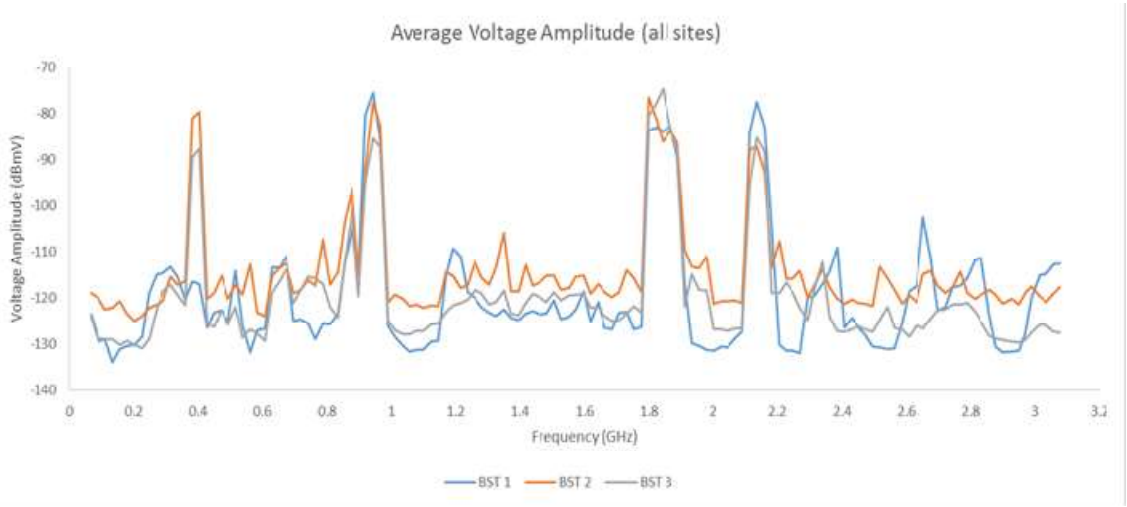

Fig.1. Measured voltage amplitude

The measured voltage amplitude for the three study sites between frequency range 0.0675 GHz up to 3.08 GHz are shown in Fig.1. Based on the Fig.1, the frequency peaks that exist shows that there are many sources of radiation around the study area. Table 1 indicates the

source of the highest frequency peaks for each study area that have been identify by referring to the Malaysian Communications and Multimedia Commission (MCMC) Allocation Spectrum Plan 2014 [20].

Table 1. The highest frequency sourced from each BST sites

Sites	Frequency	Sources
BST 1	945 MHz	Mobile (GSM and IMT) and broadcasting
	1800 MHz	Mobile (GSM and IMT)
	1867.5	Mobile (GSM and IMT)
	2137.5	Mobile (IMT)
BST 2	405 MHz	Mobile
	877.5 MHz	Mobile (IMT) and broadcasting
	945 MHz	Mobile and broadcasting
	1800 MHz	Mobile (GSM and IMT)
	2160 MHz	Mobile (IMT)
	2340 MHz	Mobile
BST 3	405 MHz	Mobile
	877.5 MHz	Mobile (IMT) and broadcasting
	945 MHz	Mobile and broadcasting
	1845 MHz	Mobile (GSM and IMT)
	2137.5 MHz	Mobile (IMT)

It was found that all the highest frequency peaks are sourced from BST that have been studied. The frequency was chosen not only because they have the highest high VA readings among others but also they are sourced from telecommunication BST.

Table 2. The highest frequency sourced from each BST sites

Sites	Frequency (MHz)	Voltage Amplitude (dBmV)		Difference Value	Average Difference
		Maximum	Minimum		
BST 1	945	-63.89	-133.61	69.73	63.27
	1800	-68.92	-131.05	62.13	
	1867.5	-73.44	-131.21	57.77	
	2137.5	-67.26	-130.72	63.46	
BST 2	405	-66.00	-86.41	20.41	20.39
	877.5	-84.75	-107.55	22.80	
	945	-64.95	-95.11	30.15	
	1800	-64.36	-89.81	25.45	
	2160	-84.52	-100.76	16.24	
	2340	-110.28	-117.54	7.27	
BST 3	405	-81.68	-102.43	20.75	23.97
	877.5	-95.18	-121.55	26.38	
	945	-77.02	-105.34	28.32	
	1845	-66.91	-92.05	25.14	
	2137.5	-78.46	-97.70	19.24	

Table above summarizes the difference value between maximum and minimum voltage amplitude measured for the highest frequencies selected from the three sites.

Based on the table above, the average difference BST 1 is higher at 63.27 and followed by BST 2 and BST 3 which 23.97 and 20.39 respectively. This due to the area BST 1 is denser compared to the area BST 2 and BST 3. This is because BST 1 is close to the two universities, busy roads, residential areas and shops while the BST 2 and BST 3 are located in rural areas and less of human activities. In addition, other factors that affect the value of voltage amplitude of high frequency peaks measured is either the number of users that access from the source or that source is close to the position of measurement instrument that have been set up.

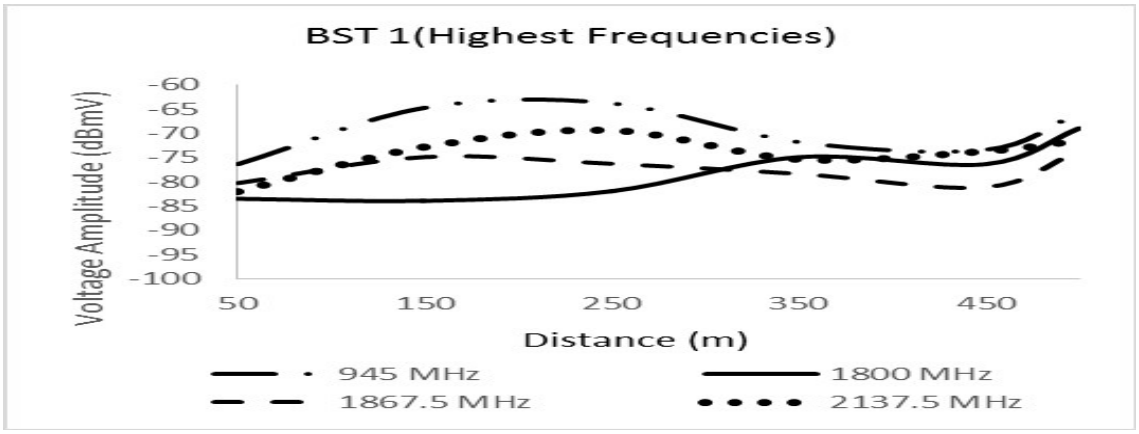

Fig.2. Exposure value of different highest frequencies of BST 1 in various distances

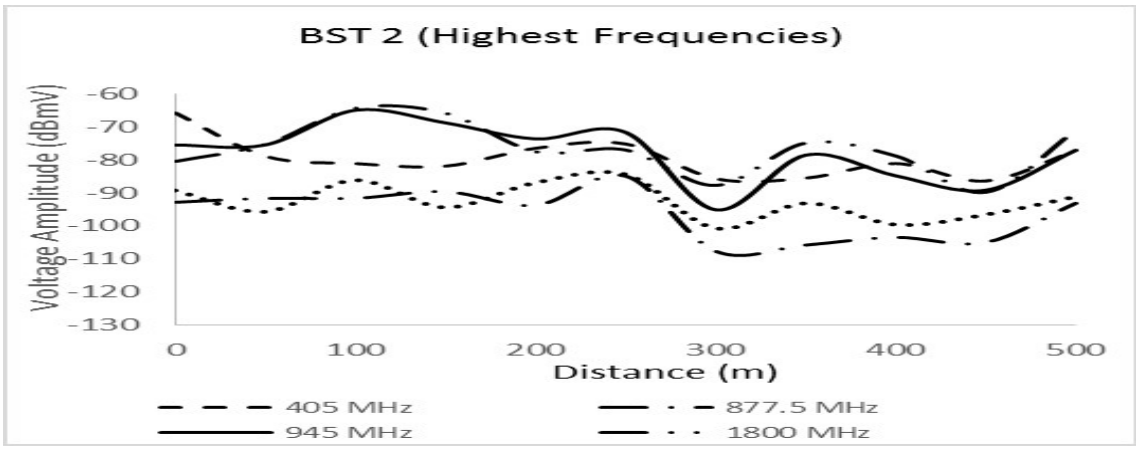

Fig.3. Exposure value of different highest frequencies of BST 2 in various distances

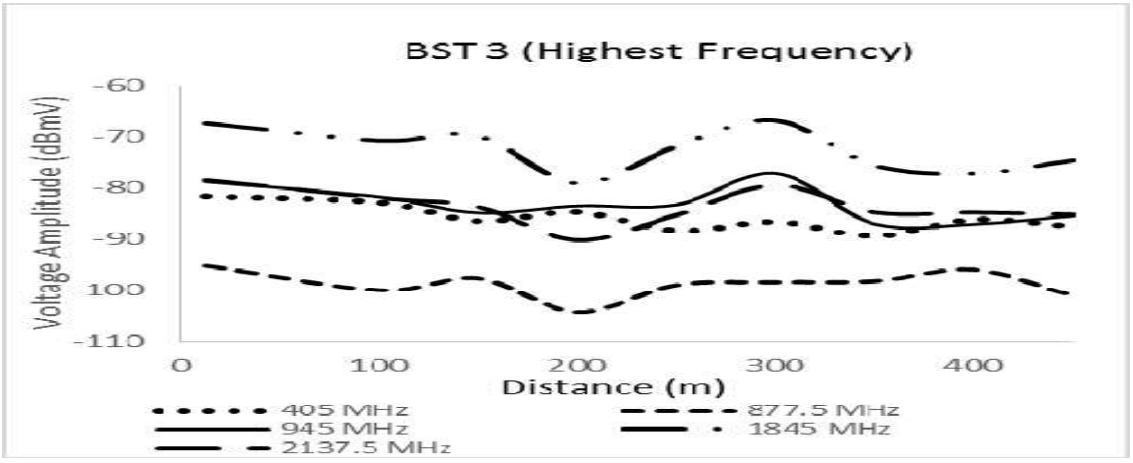

Fig.4. Exposure value of different highest frequencies of BST 3 in various distances

Fig. 2, Fig. 3 and Fig. 4 show various trend of exposure value of different highest frequencies for the three study sites. From the figures, it can be said that all the three sites have the same highest frequency of 945 MHz. BST 1 and BST 2 also BST 1 and BST 3 have the same

frequency of 2137.5 MHz and 1800 MHz respectively. Whereas, BST 2 and BST 3 share two frequencies 877.5 MHz and 945 MHz.

Obviously, in overall frequency of 945 MHz has the highest voltage amplitude value among of the highest for all sites. This may be the radiofrequency signal for the frequency to be transmitted at very high power.

Meanwhile, if a frequency peak has the highest exposure value for all distance as happens at the site BST 1, it means that power is transmitted from the source frequency is high compared to other sources. This is because, the higher the transmitted power causes the further the distance is taken for the attenuation to occur. The feeding power and the operating frequency. The higher the power transmitted from BST resulted the higher the exposure level [21-23].

According to the figure shown, the reading of VA are fluctuated at the various distance as a result according to the number of calls. Moreover, there are so many factors that probably influence the level of voltage amplitude such as: the distance from the radiation sources, main beam direction which is depends on the tilt and the direction of antennas on top of the BST, height of the BST and antenna installation, LOS path, feeding power and the operating frequency [21-23].

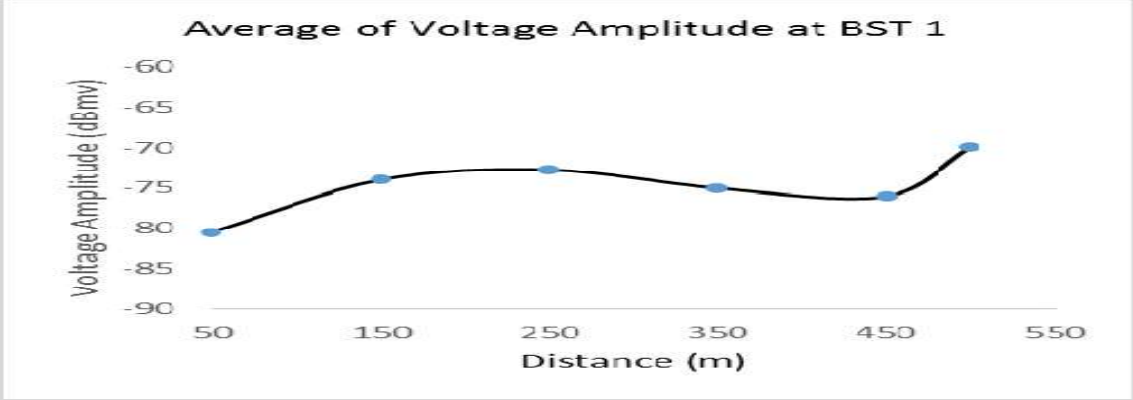

Fig.5. Average of the highest frequencies exposure value of BST 1

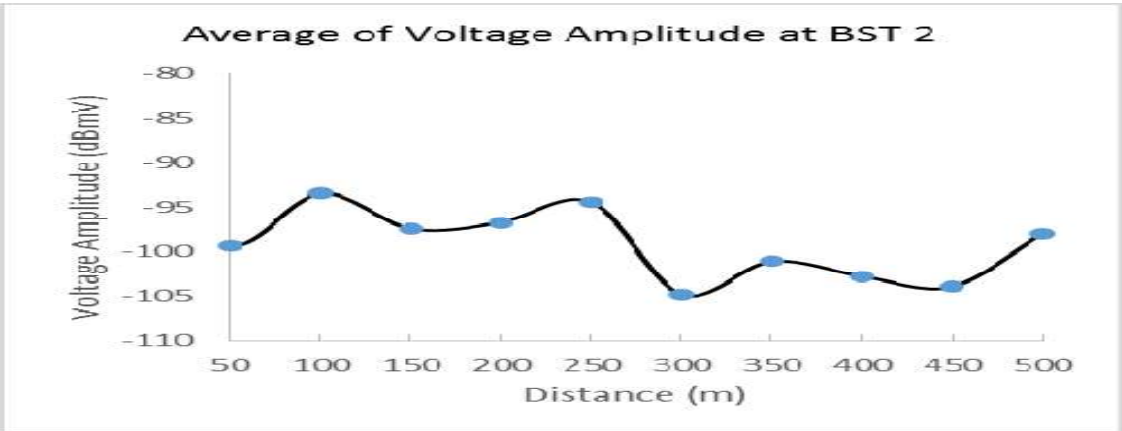

Fig.6. Average of the highest frequencies exposure value of BST 2

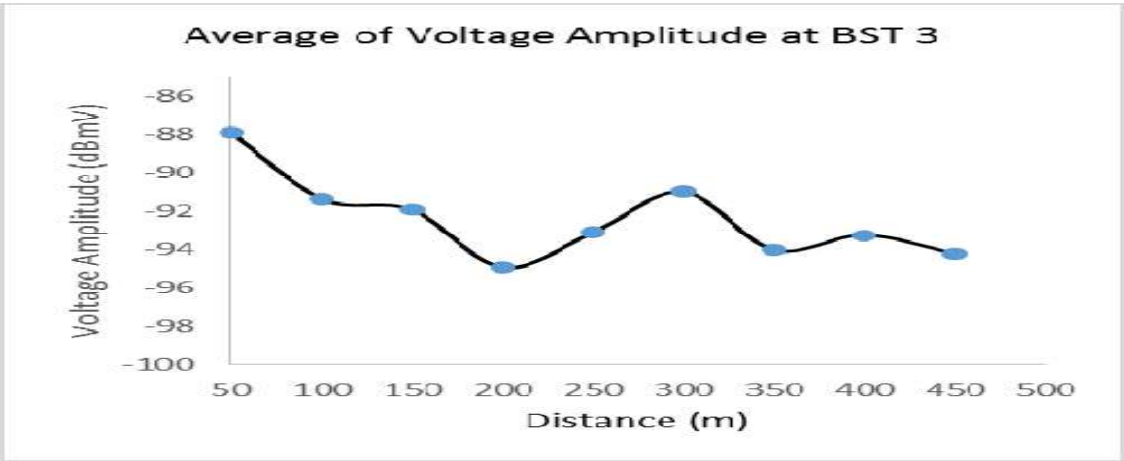

Fig.7. Average of the highest frequencies exposure value of BST 3

According to the Fig. 5, Fig. 6 and Fig. 7, at a distance of 50 m, BST 1 shows the increase in the reading up to a distance of 150 m and beginning to decline at a distance of 250 m. Likewise in BST 2, the reading be enhanced at the beginning of distance 50 m up to 100 m but began to decline until the distance of 150 m. Whereas, for BST 3, the reading voltage amplitude decreases gradually at a rather long distance ranging from 50 m to 250 m.

The distinctiveness of trends because of tilt degree of antennas are differences and the main beam direction for all BSTs are differ. However, clearly BST 2 and BST 3 shows a decline in the reading when the further the distance. Thus, it can be agreed that the further the distance from the source of exposure, the lower the exposure level.

But there is a difference in the pattern shown in Fig. 5, which shows the further the distance, the increasing amplitude of voltage readings. This may be influenced by other factors such as the height BST.

Table 3. Average difference between maximum and minimum voltage amplitude

Sites	Height of Tower (m)	Average Voltage Amplitude of Highest Frequencies (dBmV)
BST 1	46.60	-74.74
BST 2	85.34	-84.55
BST 3	86.94	-84.88

The data that is shown in the Table 3 are the average voltage amplitude and the height of BST for each site were recorded.

The data obtained clearly show that BST height affect the readings voltage amplitude where found that average voltage amplitude of BST 1 is the highest compared to other sites, while the average voltage amplitude of BST 3 is the lowest. This can be proven because of the height BST 1 is the lowest, followed BST 2 and BST 3.

The trend of measurement obtained from BST 2 and BST 3 are quite similar where show the fluctuated trend. This is due to the similarity of environment classification for both site. The condition of environment that surrounded by trees, a small forest, small hills and village houses The sudden decrease significantly at a distance of 250 m to 300 m and 50 m to 200 m for BST 2 and BST 3 respectively. Thus show that at the distance signal propagate does not travel in LOS path. The attenuation of exposure level descends gradually when anyobstructions appear and cause reflection, diffraction and diffusion by the physical objects to occur [22, 24].

Studies showed that the NIR exposure has possible effects on human health which is not only can cause health effects such headaches, insomnia, dermatitis, miscarriage, effects on reproductive system but the most intimidate part is it may trigger and activate cancer cell [25]-[26].

The base station tower (BST) erected close to residential areas to provide high quality coverage in the context of Quality of Service (QoS) [2, 27] is one of the most worrying source of exposure and it may give off radiation at higher power levels compared to the other types of land-mobile antennas [8]. Therefore, mobile phone user especially by residents nearby were exposed to the both radiation sources (base station and mobile phone) at once [17] radiation in a long period as both of these sources are close to them.By conducting this

measurement, an initial overview of the exposure from BST in the study area at different distances can provided.

4. CONCLUSION

The main aim of the project is to measure and evaluate the RF EMF exposure in voltage amplitude reading from selected base station tower (BST). The measurements have been conducted on three selected communication towers and the results obtained are analyzed and compared. Before that, the frequency sources from data obtained by spectral analyser were determined referring to the MCMC. It can be concluded that RF signal strength emitted from the BST influenced by many factors such the main beam direction which is depends on the tilt and the direction of antennas on top of the BST, height of the antenna and BST installation, distance from the radiation sources and also the number of antennas. In addition, line of sight (LOS) path also is one of the factors that influences the exposure level caused by the existence of obstruction consisting of physical objects were not only may exist as buildings but also trees, foliages, hills or mountains along the receiver and communication tower [30] along the signal propagation. When signals do not travel in LOS path, the signal strength which associated to the exposure level will be lower than signals which travel in LOS path. Therefore, the factors mentioned is very crucial to take into account in this study. As a future study, the comparison between the exposure level measurement and the ICNIRP guidelines of NIR exposure limits for the general public should be done. Besides, from the NIR exposure obtained, a spatial model or map of ambient NIR exposure level can developed using GIS software to get clearer view of exposure at certain places.

5. ACKNOWLEDGEMENTS

This study is made possible by the usage of the grant FRGS (FRGS/1/2015/SG02/UNISZA/02/1), TPM (68006/2016/79), UMT (68006/INSENTIF/60), RACE-UNISZA (RACE/F1/ST1/UNISZA/15) and RACE-UM (CR0008-2015).

6. REFERENCES

[1] Engiz B K. Measurement and assessment of long term electric field strength in different locations. International Journal of Advanced Research in Computer and Communication Engineering, 2016, 5(10):455-458

[2] Durduran S S, Seyfi L, Avci C, Ozan A M. Measurement of electromagnetic signal strengths of four GSM base stations at 900 MHz in a pilot region. In World Congress on Engineering, 2013, pp. 1-4

[3] Islam M R, Khalifa O O, Ali L, Azli A, Zulkarnain M. Radiation measurement from mobile base stations at a university campus in Malaysia. American Journal of Applied Sciences, 2006, 3(4):1781-1784

[4] Abdelati M. electromagnetic radiation from mobile phone base stations at Gaza. Journal of the Islamic University of Gaza Natural Sciences Series, 2005, 13(2):129-146

[5] Henderson S I, Bangay M J. Survey of RF exposure levels from mobile telephone base stations in Australia. Bioelectromagnetics, 2006, 27(1):73-76

[6] Dawoud M M. High frequency radiation and human exposure. In International Conference on Non-Ionizing Radiation at UNITEN, 2003, pp. 20-22

[7] Ulcek J L, Cleveland R F Jr. Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields: Additional information for amateur radio stations. 1997, https://transition.fcc.gov/bureaus/oet/info/documents/bulletins/oet65/oet65b.pdf

[8] Mahadi W N L, Ali N M, Wen Q P. Evaluation of RF EMF exposure pattern on selected communication towers in Malaysia.In IEEE International Conference on Semiconductor Electronics, 2010, pp. 344-347

[9] Ahmed A J, Idris H E. Electromagnetic radiation evaluations of some cellular base stations in Kasala. Journal of Electronics and Communication Engineering, 2016, 11(1):53-60

[10] Chen H, Su T, Jhuang J. Electric fields radiated from a cellular phone base station antenna constructed on a roof-top. Electromagnetics, 2009, 29(3):235-249

[11] Felix O K. Investigation and analysis on electromagnetic radiation from cellular base station transmitters and the implications to human body. Journal of Environment and Ecology, 2014, 5(1):46-60

[12] Ahaneku M A, Nzeako A A, Udora N N. Investigation of electromagnetic radiations by

GSM base stations in Nigeria for compliance testing. Advances in Physics Theories and Applications, 2015, 47:10-17

[13] International Commission on Non-ionizing Radiation Protection (ICNIRP). Home. 2017, http://www.icnirp.org/en/home/home-read-more.html

[14] Kurnaz C. An emprical modelling of electromagnetic pollution on a university campus.Applied Computational Electromagnetic Society Express Journal, 2016, 1(2):76-79

[15] Miclaus S, Bechet P. Estimated and measured values of the radiofrequency radiation power density around cellular base stations. Environment Physics, 2007, 52(3-4):429-440

[16] Seyfi L. Measurement of electromagnetic radiation with respect to the hours and days of a week at 100 kHz–3GHz frequency band in a Turkish dwelling. Journal of Measurement, 2013, 46(9):3002-3009

[17] Baltrenas P, Buckus R. Measurements and analysis of the electromagnetic fields of mobile communication antennas. Journal of Measurement, 2013, 46(10):3942-3949

[18] Koprivica M, Slavkovic V, Neskovic N, Neskovic A. Statistical analysis of electromagnetic radiation measurements in the vicinity of GSM/UMTS base station installed on buildings in Serbia. Radiation Protection Dosimetry, 2015, 168(4):489-502

[19] Karadag T, Yüceer M, Abbasov T A. Large-scale measurement, analysis and modelling of electromagnetic radiation levels in the vicinity of GSM/UMTS base stations in an urban area. Radiation Protection Dosimetry, 2015, 168(1):134-147

[20] Malaysian Communications and Multimedia Commission (MCMC). Spectrum plan. 2014, https://www.mcmc.gov.my/skmmgovmy/media/General/pdf/Spectrum-Plan2014.pdf

[21] Karunarathna M AA, Dayawana I J. Human exposure to RF radiation in Sri Lanka. Sri Lanka Journal of Physics, 2005, 6:19-32

[22] International Commission on Non-ionizing Radiation Protection (ICNIRP). Base station (high frequency): Characteristics of the application and its use.2017, http://www.icnirp.org/en/applications/base-stations/index.html

[23] Voudouris K, Grammatikakis P. Electromagnetic radiation measurements at aperture antennae installation sites. In 5th WSEAS International Conference on Applied Informatics and Communications, 2005, pp. 419-424

[24] Ismail A, Din N M, Jamaluddin M Z, Balasubramaniam N. Electromagnetic assessment

for mobile phone base stations at major cities in Malaysia. In IEEE 9th Malaysia International Conference on Communications, 2009, pp. 15-17

[25] Camara P R S. Effect of exposure to non-ionizing radiation (electromagnetic fields) on the human system: A literature review. Journal of Interdisciplinary Histopathology, 2014, 2(4):187-190

[26] Bahaodini A, Owjfard M, Tamadon A, Jafari, S M. Low frequency electromagnetic fields long-term effects on testicular histology, sperm quality and testosterone levels of male rats. Asian Pacific Journal of Reproduction, 2015, 4(3):195-200

[27] Chitranshi R,Pancholi P. Analysis of cell tower radiations and practical realization of compliance distance. International Journal of Scientific and Research Publications, 2013, 3(5):12-18

[28] Meng Y S, Lee Y H, Ng B C. The effects of tropical weather on radio-wave propagation over foliage channel. IEEE Transactions on Vehicular Technology, 2009, 8(8):4023-4030

How to cite this article:
R. S. N. Dianah, S. N. Hazmin, R. Umar, Kamarudin M.K.A, Dagang A.N., Exposure level from selected base station tower around Kuala Nerus: a preliminary analysis, J. Fundam. Appl. Sci., 2017, *9(5S), 367-380.*