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Non-Ionizing Radiation: Exposure Level at UMT and UniSZA Campus

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Nowadays, the wireless technology has become a lifestyle; even the children have their own mobile phones, although they are categorized as high risk susceptible to health problems due to radiation. Thus, the public exposure that stemmed from electromagnetic radiations become public concern since studies have been done and the finding showed that the repetitive and long term exposure may have adverse health effect. This study was conducted to evaluate the exposure level at UMT and UniSZA campuses by measuring the electric field strength. This measurement was conducted using omni-directional antenna below 4 GHz, connected to spectrum analyzer. In this paper, the measured values are compared with the previous study from several locations and then the spatial maps of exposure level are developed. The result shows that high exposure level was recorded at UMT and UniSZA. From this study, the findings may assist the Ministry of Health to monitor the public health due to non-ionizing radiation (NIR) exposure. This is crucial to make sure the international commission of non-ionizing radiation protection (ICNIRP) limit is complied. Moreover, the development of public NIR exposure policy can be initiated to the Malaysia government for health concern. For future study, the investigation of the suitable material used as antenna and casing or exposure reduction tool can be done to reduce NIR exposure rate on human body.

Keywords: Non-ionizing radiation, exposure, ICNIRP, Electromagnetics

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I. INTRODUCTION

In parallel with technological developments, the uses of wireless systems, such as mobile phones, are very widespread around the world, have led to an inevitable increase in electromagnetic exposure levels [1]. Electromagnetic field (EMF) is a combination between electric and magnetic field which can be divided into ionizing and non-radiation (NIR) [2]. Electromagnetic radiation (EMR) is a kind of energy emitted from a source that can travel through a vacuum at the speed of light, which is also can be described in terms of its frequency and wavelength [2] and carrying some amount of energy [3]. EMR energy transferred in form of wave, so it can be reflected, refracted, transmitted absorbed, modulated and received through any medium by depending on the conductivity of the exposed medium and the frequency of the field [4][5].

There are several sources that emit electromagnetic waves such as radio and TV transmitters, base station, power line transmission, transformers, and all electrical and medical equipments have also increased with an increase in the number of users [6]. There are some rumours stated that the construction of the base station has possibility of negative effects due to electromagnetic radiation (EMR) scattered from the base station antenna [7].

Some of them trusted that the NIR exposure are probably effects on human wellbeing especially to living things [8]. NIR are low vitality radiations that they don't have enough vitality to modify the cell structure or DNA, but over discharged of these radiations can damage the skin [9]. Numerous epidemiological examinations began lately have concentrated principally on possible biological and adverse human health conditions that may be connected with the activities of media transmission system [10]. Notwithstanding, the other paper said that, the high exposure levels were found in the region of the base stations [11] and the general population living inside the radius up to 10m from the tower will get 10,000 to 10,000,000 times more powerful signal than required portable communication [12].

According to some of previous studies, in some residential populations that exposed to radio and radio programs, the elevated cancer rates have been reported [13][14]. When the energy is exposed to human, it may cause some biological effects on human, these effects may result from heating of tissues particularly the brain and the human immune system. It is called thermal effects due to the ability of RF energy to penetrate and heat biological tissue, but the evidence of the harmful biological effects is unproven [5][10][15]. Thermal effects are divided into two which are thermal and non-thermal effects. Thermal effect is defined similar to that cooking in the microwave oven, otherwise, non-thermal effects are not well defined but it has been reported that non-thermal effects are 3 to 4

times harmful than thermal effects. In addition, children whose skulls are not fully developed, can receive twice as much of the radiation as do adults [9]. According to World Health Organization (WHO), they stated that the non-thermal effects are linked with hematologic, neurologic, reproductive and cardiovascular disorders [13].

Based on research conducted by [16], they performed the measurement at eight different locations around International Islamic University of Malaysia (IIUM) Gombak Campus to evaluate the EF levels. The portable EMF measurement system, consists of the tri-axis probe connected to TS-EMF from Rohde and Schwarz operates from $300kHz$ to $3GHz$ was used to measure the EF strength from mobile base station. From the findings, they found that EF at Central Library is $37.8V/m$ while at student hostel is $38.4V/m$ which are 62% and 63% of safety limit, respectively. This findings is somewhat worrying. Thus this study is crucial to investigate the exposure level at UMT and UniSZA campus as health is of concern.

Several international and governmental organizations such as ICNIRP, the Institute of Electrical and Electronic Engineers (IEEE), the European Union (EU) and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) have created safety guidelines to protect the general public and workers from excessive RF or microwave radiation emitted from the RF sources [17]. In this study, the main purpose is to evaluate the exposure level trend at UMT and UniSZA campus by measuring the electric field (EF) strength. By performing this research, public health due to NIR exposure monitoring could be done and public NIR exposure policy for health concern can be initiated to the Malaysia government.

II. EXPERIMENTAL SECTION

The flow of methodology is as shown in Figure 1, begun with site selection for data collection. Then the collected data was analysed and compared with reference level recommended by ICNIRP to make sure this standard limit of exposure is not exceeded. We also compared the value with other campus from previous study to examine the exposure level.

We compared the highest value of exposure from previous study which was conducted at International Islamic University Malaysia (IIUM). Then a graph was created to see the differences of exposure level between current study and previous study. Finally the exposure maps (spatial model) were developed using geographic information system (GIS) technique to obtain clearer view of exposure around campuses.

In this study, we have selected 4 locations around Kuala Nerus, the selection of locations based on several characters such as accessible areas, residential area and nearby base stations. They were Universiti Sultan Zainal Abidin (UniSZA), Universiti Malaysia Terengganu, Batu Rakit, and Kampung Jati. Several

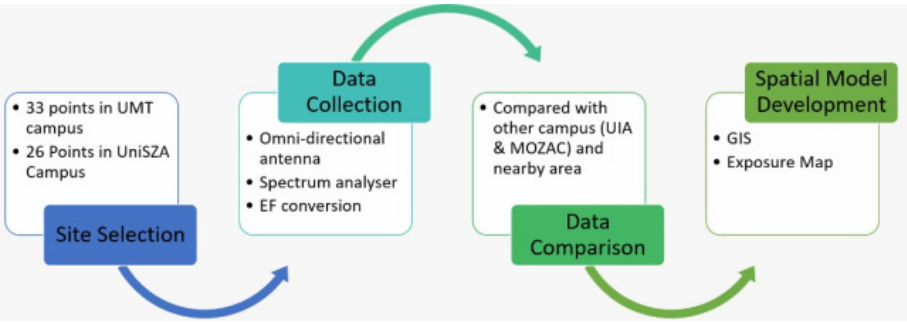

Figure 1. The flow of methodology

points were selected for each location to conduct the EF strength measurement Table 1.

The measurements were carried out using the N9935A FieldFox Handheld Microwave spectrum analyzer, it is capable to detect the level of strength at a very wide range of frequency up to 9000 MHz [1] and the omni-directional antenna below 4 GHz, its able to detect signal radiated in ambient [18]. The equipment set up is as shown in Figure 2. The measurement of exposure was performed for 10 minutes for each point.

Before the observation was performed, the coordinate of each point were recorded using Global Positioning System (GPS) to ensure the accuracy of the longitude and the latitude for each point. This is essential for the spatial model development using GIS to make sure the map and the plot is accurate. The exposure recorded were in the term of power level ($dBmV$) against frequencies (f). The data obtained from the measurement were converted into electric field (EF) strength in form V/m using equation (1)

$$\frac{V}{m} = (\frac{dBmV}{20}) \times 0.021f \times 1000$$

Figure 2. Equipment set up

where $(\frac{dBmV}{20})$ is the voltage amplitude received from the measurement, f is the frequency received during measurement in MHz. 0.021 is multiplication factor on leakage measurement with included the antenna factor of a resonant half-wave dipole.

Then the spatial maps of exposure level

Location	Points	Category of Areas
Universiti Malaysia Terengganu	33	Campus
Universiti Sultan Zainal Abidin	26	Campus
Batu Rakit	27	Residential
Kampung Jati	27	Residential

Table 1. Description of selected locations.

are developed using Inverse Distance Weighted (IDW) interpolation method and Multiple Ring Buffer. The IDW interpolation is used to interpolate the EF strength data according to the geographical location. While the Multiple Ring Buffering tool is used to represents the range of EF strength from the points. Both techniques then were layered and act as exposure map. Next, the data obtained were also compared with the previous study for several campus around Malaysia to investigate the level of exposure inside the campus [2].

III. RESULTS AND DISCUSSION

In this study, the measurement of exposure level has been carried out at 2 locations of campus area and 2 locations at residential area as shown in Table 1. The locations are selected at the point where there exist telecommunication transmission tower. Figure 3 shows the EF strength value versus distance from the tower so the distance of maximum value recorded can be determined. Then, the maximum and average EF strength for all location are recorded in Table 2.

A. NIR Exposure Level

Figure 4 show the exposure level at 4 different location which are at residential and campus area. UMT recorded the highest electric field (EF) strength which is $37.82V/m$ at frequency $1867.5MHz$ while the highest EF strength for UniSZA is $14.63V/m$ at frequency $945MHz$. Besides, the highest EF strength at Batu Rakit is $19.53V/m$ at frequency $1867.5MHz$ and the highest EF strength for Kampung Jati is $14.63V/m$ at frequency $945MHz$. By comparing EF strength for all locations, UMT campus lead with the highest value of exposure level. By referring to the Malaysian Communications and Multimedia Commission (MCMC) Allocation Spectrum Plan 2014, frequencies detected at these locations are referred to telecommunication signals and broadcasting which might be the main contributor to EF strength level [5]. The installation of base station nearby also one of the factor that believed causing stronger exposure due to the layering of the antenna radius patterns. When two waves with same frequency proliferating in the same direction through each other, the construction disturbance will happen.

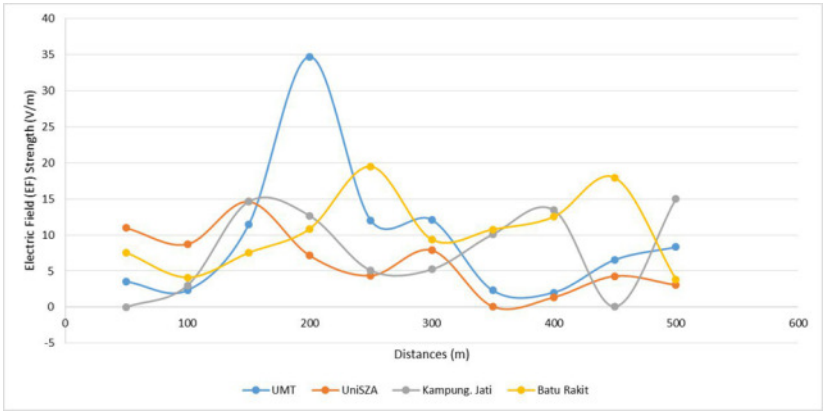

Figure 3. Exposure level against distances

In this manner, the bigger exposure will be performed ([4]). Moreover, according to [19], this result probably due to the effectiveness radiation power of the antennas or numerous number of user at that area.

B. Spatial Model of NIR Exposure Level

Figure 5 and Figure 6 show the spatial model of NIR exposure level at UniSZA and UMT campus. Based on the data obtained from this study, the spatial model of NIR exposure level has been developed to illustrate the exposure level at both campus by using GIS technology (ArcGIS 10.2 software). Besides, this spatial model can be used to provide a clearer vision to identify factors influence contribute to the value recorded such as base station towers located nearby or land use factor such as residential, commercial, plantation or industrial area. By using Inverse Distance Weighted (IDW) interpolation method, the scattering of NIR exposure level can be seen obviously with indicator used, where the highest exposure level represented as red colour, down to medium exposure represented as orange colour and the lowest exposure level represented as yellow colour.

Based on the comparison for both spatial model, it was found that UMT campus has higher exposure compared to UniSZA campus which might due to population density. This is because that area are close to hostel, sport complex and students complex. As well-known that, these area are where students spend their time and do their activities which might contribute to high exposure. Therefore, that area also are heavy usage of Wi-Fi provider and mobile phone user might be the reason of such results. There are also other surrounding factors that can affect the exposure level such as moving vehicles [2].

C. Comparison the maximum electric field strength with previous study

The electric field obtained from the measurement were compared with the previous study

Location	Frequency (MHz)	Highest Recorded Value (V/m)			Average Recorded Value (V/m)		
		Electric field (EF) strength	Standard Deviation	Standard Error	Electric field (EF) strength	Standard Deviation	Standard Error
UMT	1867.5	37.82	6.13	0.52	1.78	0.28	0.02
UniSZA	945.0	14.63	2.16	0.16	2.63	0.39	0.03
Kampung Jati	945.0	14.63	1.62	0.12	1.52	0.01	0.00
Batu Rakit	1867.5	19.53	3.07	0.23	1.66	0.32	0.02

Table 2. Calculated maximum and average electric field (EF) strength for all location.

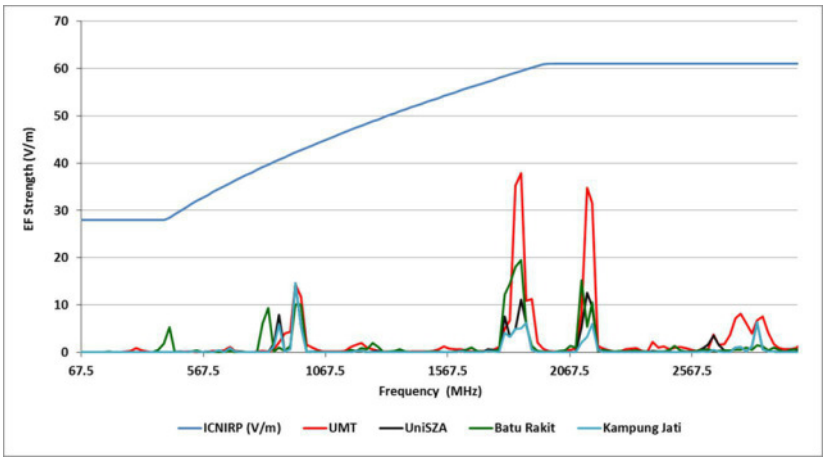

Figure 4. Exposure trend at residential and campus area.

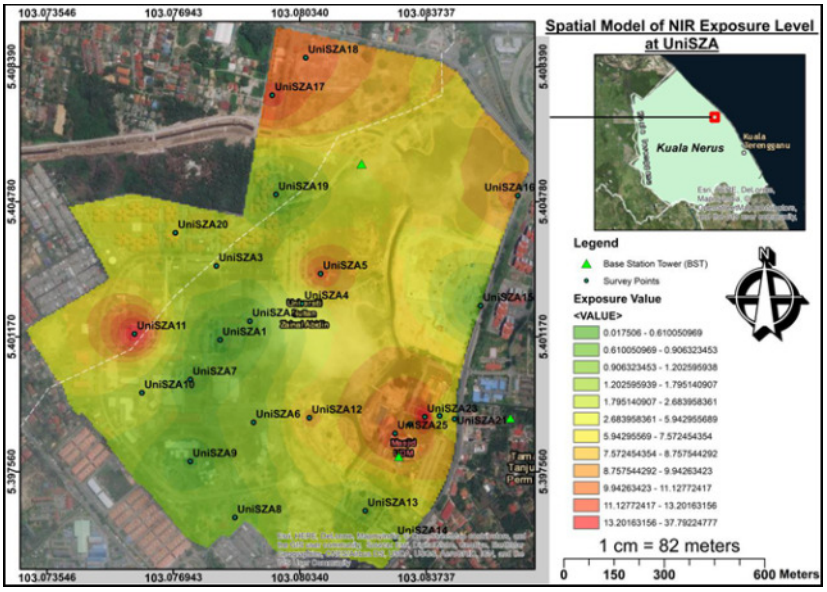

Figure 5. Spatial Model of NIR level at UniSZA.

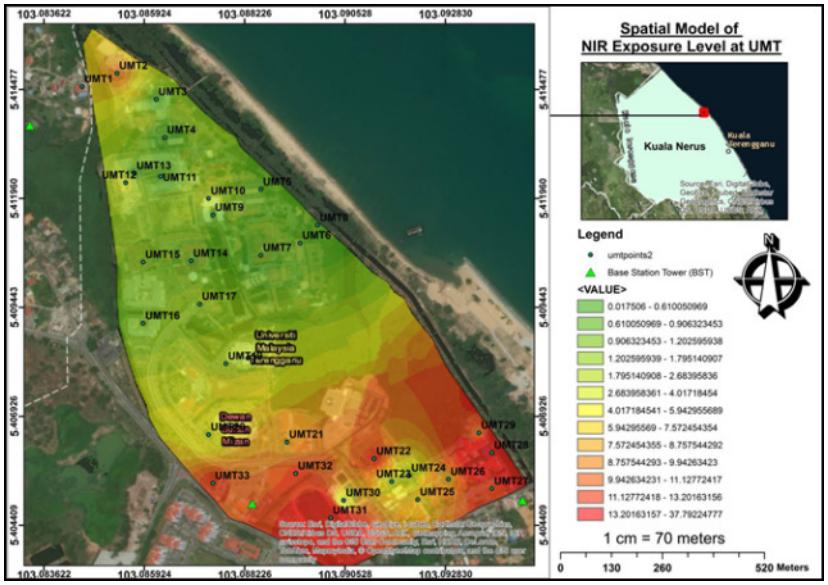

Figure 6. Spatial Model of NIR level at UMT.

from several locations around Malaysia. Figure 7 shows the different result between the current study and the previous study. This differences might be due to several factors such as measurement techniques, equipment used, location criteria and others [4].

Table 3 shows the detail description about the comparison between maximum EF strength with previous study. Based on others study, they stated that the maximum EF strength was found at frequency $2.4GHz$ which refers to Wi-Fi frequency bands [16][4]. It is because Wi-Fi is always available at the institution area and cause the higher user for the frequency. Besides, the exposure level might be probably due to selected point located closer to busy roads where the signal sources from the moving vehicles and surrounding objects may influence the level of EF strength [4][8]. According to the previous study carried out by [20], they stated that, the exposure from base stations increase with distance in the near source zone, to a maximum where the main beam intersects the ground. According to the inverse square law, the power densities measured influenced by the distances from the antennas of the base stations. Therefore, it can be concluded that the exposure level not only influenced by signal sources such as base station but also by other factors.

IV. CONCLUSIONS

It can be concluded that the exposure level at UMT and UniSZA have been influenced by telecommunication transmission tower where the network coverage is better to serve the denser populated area. This encourage the service providers to install their transmitter for better services in order to increase customer sat-

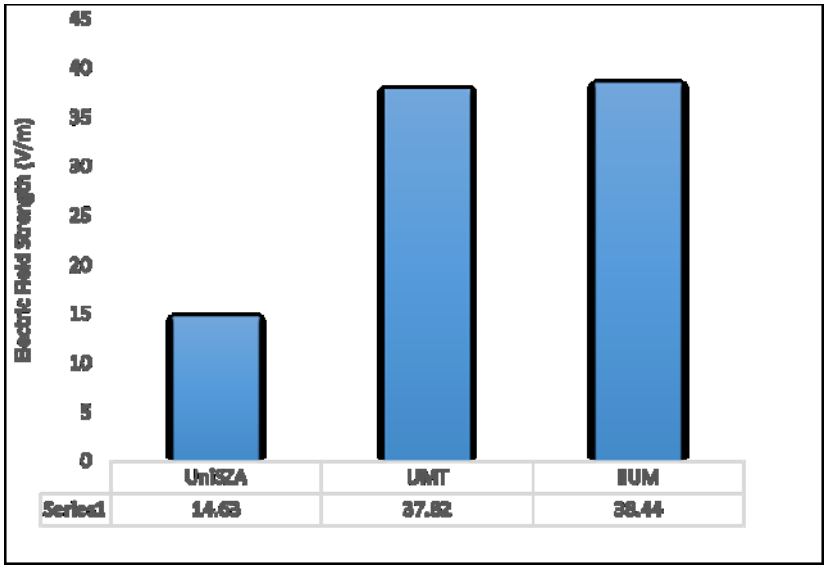

Figure 7. Comparison the maximum electric field strength with previous study.

Locations	Maximum EF Strength (V/m)	Equipment used
IIUM	38.44	1. Tri-axis probe
UniSZA	14.63	1. Omni-directional antenna 2. Spectrum Analyzer
UMT	37.82	1. Omni-directional antenna 2. Spectrum Analyzer
Kampung Jati	945.0	14.63
Batu Rakit	1867.5	19.53

Table 3. The maximum EF strength for each site.

isfaction. In addition, the surrounding factor such as moving vehicle and surrounding objects also influenced the exposure. The result of this study could be used for further study to determine the public exposure at campus in monitoring the health effect beside propose the policy to the Malaysian government such as Malaysian Communication and Multimedia Commission (MCMC).

V. ACKNOWLEDGEMENT

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