Relationship between Non-Ionizing Radiation (NIR) Exposure Level and the Base Station Tower Installation around Kuala Nerus

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Abstract. The rapid development of wireless technology nowadays has led to the increases of erection of base station telecommunication (BST). However, the exposure transmitted from BST generated the public concern on health problem because it is said can causes high risk to the human and surroundings. Therefore, this study will focused on the influence of selected BST installed around Kuala Nerus towards the ambient NIR exposure value at surroundings. By using spectrum analyzer connected to receiving omni-directional antenna, the NIR exposure level in terms of electric field (EF) strength is measured horizontally at 50 m until 500 m around the BSTs. The comparison between the measured values and the international reference levels of ICNIRP were done. Besides, the exposure values were compared among the BSTs area by considering the other influenced factors at surroundings. The result shows that the highest exposure level was recorded at BST located in sub-urban area and has the higher number of antennas installed on the top. It can be concluded that the number of BST nearby, the number of antennas, the direction of the antenna and the presence of other sources influenced the ambient NIR exposure at that area.

1. Introduction

The used of electromagnetic (EM) wave spread very fast nowadays, radio frequency especially used in electronic equipment and it almost used in human gadgets \cite{1,2}. Nowadays radio frequency interference (RFI) is everywhere, to understand this RFI, the studies must be done to proof that there are relation between biological effect to human those are highly exposed to radio wave. However there is no proven that the effect of this EM wave to the human. Many researches have been done in worldwide and some finding shows that the most of people who highly exposed to radio frequency has higher chance to diagnose to have brain tumour and affect the reproductive system. As we know in lowfrequency window is usually used for industrial or commercial activities, and also in military systems \cite{2,3}. So that peoples always exposed to this frequency in daily activity. The industry sectors which are active users, they can also transmit signals as well as receive them. The difference between
the two users (active and passive) are active users will radiate a strong radio wave signal while passive users only detect weak radio signals from space\cite{4}\cite{5}.

In Universiti Kebangsaan Malaysia (UKM), the policy is developed based on the Occupational Safety and Health Act 1994 (Act 514) (2006), safety guidelines, supplemented with exemplary nonionising radiation policies of other well-known international institutions of higher education. As for the monitoring activities, results obtained from the six identified hotspots suggest that both RF and ELF exposure levels are far lower than the suggested ICNIRP (International Commission on Non-Ionizing Radiation Protection) exposure limits, at a ratio percentage of RF and ELF of 0.2% and 2.8%, respectively. With the development of the UKM Non-Ionising Radiation policy and the progress of the monitoring activities being carried out periodically, the final element calls for the reintroduction of an academic subject on non-ionising radiation, as was offered before the revision of the Bachelor of Science (Nuclear Science) programme. Health concern if overdose NIR BST distribution and distance form residential area.

In this study, the focus will be on how the base stations influence the ambient NIR exposure value at surroundings. This research findings will provide the ambient NIR exposure value at various distances from the BST. Nearby sources will be determined to identify other influence factors contribute to the exposure level. This is important to determine the influence of the base stations on the production of NIR. This will help Malaysia Malaysian Communications and Multimedia Commission (MCMC) to organize and plan the suitable location for base stations and transmitter approvals for the spectrum provider. This is essential to make sure the recommended public exposure value by International Radiation Protection Association (IRPA) is complied. Moreover, the public health monitoring could be conducted and future clinical studies will be assisted by data provided such in this study.

2. Methodology

The measurement of NIR exposure level for frequencies between 65.2 MHz and 4 GHz has been conducted at distances ranging from 50m to 500m from every 14 BSTs. The flow of methodology is as shown in figure 1, begin with site selection for data collection. The selection of locations was chosen based on different locations such where located close to the residential, campuses and public areas.

![Figure 1. Flow of methodology](image)

Before the observation was performed, the instrument was set up and installed at distances of 50m, 100m, 150m, 200m, 250m, 300m, 350m, 400, 450m, 500m from each BST. The coordinate of latitude and longitude for each distance were recorded using Global Positioning System (GPS) model GPSMAP® 62sc for mapping process as shown in Table 1. The measurement was recorded 10 minutes for each distance. After that, the measurement obtained was extracted from spectrum analyser to computer for the analysis process. The data obtained were compared with the permitted international standard public exposure limit recommended by ICNIRP limit. Then, the relationship between the highest NIR exposure values and the BST existed around the study area were discussed. In overall, this study is conducted to prove whether BST installation affects the increase of radiation in an area.


### Table 1. Description of locations.

| BST Sites               | Latitude (N)         | Longitude (E)         | Category of Area |
|------------------------|----------------------|-----------------------|------------------|
| Kubang Badak           | 5°24'17.94"          | 103°5'40.40"          | Sub-urban        |
| UMT                    | 5°24'17.66"          | 103°5'18.33"          |                  |
| Kampung Jati           | 5°23'56.39"          | 103°5'9.50"           |                  |
| Kampung Pak Tuyu       | 5°24'49.13"          | 103°4'59.90"          |                  |
| Masjid UniSZA          | 5°23'52.69"          | 103°4'58.81"          |                  |
| UniSZA                 | 5°24'20.86"          | 103°4'55.13"          |                  |
| Gong Badak             | 5°23'57.60"          | 103°4'18.60"          |                  |
| Mengabang Telipot 1    | 5°25'23.26"          | 103°3'20.02"          |                  |
| Mengabang Telipot 2    | 5°25'14.49"          | 103°3'15.89"          |                  |
| Batu Rakit 1           | 5°26'48.52"          | 103°3'2.73"           |                  |
| Batu Rakit 2           | 5°26'55.67"          | 103°2'57.51"          |                  |
| Batu Rakit 3           | 5°26'59.19"          | 103°2'51.50"          | Rural            |
| Batu Rakit 4           | 5°26'57.36"          | 103°2'47.39"          |                  |
| Batu Rakit 5           | 5°26'57.97"          | 103°2'44.73"          |                  |

### 3. Results and Discussion

In this measurement, the NIR exposure data were collected roughly from 10.00 am until 4.00 pm with the averaging time is 10 minutes for each survey point. Based on the ICNIRP postulate, the temporal average value of exposure over any 6 minutes interval must be used for the comparison with the reference levels suggested [6].

Figure 2. The comparison of NIR exposure trend with ICNIRP reference levels [6]-[8]

The maximum NIR exposure values (electric field (EF) strength) obtained in each study areas were then compared with the international reference levels for general public exposure provided by ICNIRP as shown in Figure 2. Figure 2 reveals that all the maximum values recorded are below the reference levels.
Even though residents in this study areas do not exposed to the higher radiation level, but a repetitive exposure may cause the negative health effect such headaches, insomnia, dermatitis and other effects. Some studies also proved that the long-term adverse effects from long duration exposure to NIR can cause the thermal effect thus the changing of Deoxyribonucleic Acid (DNA) structure may be occurred [8][9].

Since this study areas were classified as rural and suburban area, thus, it can be seen that the telecommunication system, especially for the second-generation (2G) and third-generation (3G) be the main sources to the highest EF strength level and the high quality of signal coverage could be provided. Some of previous studies also mentioned that GSM 900 (2G) is more often installed in rural areas meanwhile GSM 1800 (2G) and UMTS (3G) technologies are found more in the denser area [10][11]. However, the higher EF strength level means that the higher the exposure level was around the area. Therefore, it can be concluded that the installation of BST and the existence of users nearby might be one of the factors that believed causing strong exposure. Then, the maximum exposure value was compared among the 14 BSTs as shown in Figure 3.

![Figure 3. The highest NIR exposure values among 14 BSTs](image)

Based on Figure 3, it is clearly shown that Kubang Badak performs the highest maximum exposure value which is about 64% approaching the reference levels for public exposure of ICNIRP, then followed by UMT. Meanwhile, the lowest maximum exposure value was shown by Batu Rakit 3 where the tower is surrounded by trees with dense and depth foliage at lower altitude than the BST antennas. Since VHF and UHF is a kind of LOS propagation characteristic, thus these radio signals had a strong attenuation rate due to the leaves as the main contributor to the received signal for short distances [12]. Meaning that, the foliage canopy is said to be obstructed either in line of sight or point-to-point communication [13]. It is also observed that the slow rate of attenuation occurred even at rural areas due to the less obstruction at surrounding.

According to the previous studies that have been reviewed, the radiation exposure level around BST is not only influenced by the power transmitted from the antenna of BST but is also influenced by the antenna position on top of BST. This is because the tilt and direction of antennas on the BST are related to the direction of the main beam radiation and the distances of highest level of power transmission distributed on the surface of the earth [14]. Since the power radiated from the main beam of antenna is higher than the side beam, thus, resulted the radiation exposure level varies according to the direction and distance of around BST that influenced by the beam. Table 2 shows the description of each BST selected in this study.

According to the table 2, it can be proved that each BST that has been studied has maximum exposure value at different distance varied from 150 m to 400 m. As expected, it is was found that this case shared the same finding with previous NIR level assessment conducted in Sri Lanka where the main beam to
reach ground level typically between 50 m and 300 m from the foot of BST by considering the heights and the tilt of antennas. Awad, (2014) also found from analysing the radiation pattern of a mobile phone tower that the high exposure level from main beam propagation reached the ground level in about 50 m to 300 m. In addition, the exposure level becomes more increasingly high when the locations are facing toward the BST antennas.

Meanwhile, the low exposure area is found when out from the main beam radiation either further from the main beam or directly under the BST. This low exposure is known as side beam radiation [15]. Radiation power level are higher in several kilowatts within the main beam transmission area and will be much lower once distant from the main beam [9][16].

Table 2. The description of the surveyed BST and the highest NIR exposure values.

| BST Sites       | Height of Tower (m) | Number of Antennas | Highest Exposure Value (V/m) | At Distances (m) | ICNIRP Comparison (%) |
|-----------------|---------------------|--------------------|------------------------------|------------------|------------------------|
| Kubang Badak    | 61.18               | 23                 | 37.82                        | 150              | 64                     |
| UMT             | 36.73               | 6                  | 34.74                        | 200              | 60                     |
| Gong Badak      | 72.00               | 13                 | 22.35                        | 250              | 38                     |
| Batu Rakit 1    | 60.00               | 5                  | 19.51                        | 250              | 33                     |
| Mengabang Telipot 2 | 61.19           | 8                  | 19.25                        | 150              | 32                     |
| Batu Rakit 2    | 40.99               | 12                 | 17.95                        | 400              | 30                     |
| Batu Rakit 4    | 50.53               | 18                 | 16.52                        | 300              | 28                     |
| Batu Rakit 5    | 14.61               | 7                  | 16.52                        | 300              | 28                     |
| Mengabang Telipot 1 | 75.52           | 17                 | 15.99                        | 250              | 26                     |
| UniSZA          | 34.00               | 5                  | 14.63                        | 150              | 25                     |
| Kampung Jati    | 46.60               | 18                 | 14.63                        | 150              | 25                     |
| Masjid UniSZA   | 40.00               | 10                 | 11.13                        | 350              | 19                     |
| Kampung Pak Tuyu| 44.67               | 14                 | 11.04                        | 250              | 19                     |
| Batu Rakit 3    | 58.40               | 16                 | 10.06                        | 200              | 17                     |

Besides, in the presence of multiple antennas on single BST, the total exposure level radiated is referred to the total power produced by all the functioning antennas installed on BST [17]. The more transmitting antennas installed, the possibility of increased exposure level is higher. Referring back to the Table 2, the highest exposure value belongs to Kubang Badak BST which it has the largest number of antennas installed compared to other BST. However, the number of antennas is not a major factor affecting the value of radiation because there are many other factors as discussed previously. Table 3 shows the number of BST detected at each of the highest exposure location.

4. Conclusions
The exposure levels in terms of EF strength were measured at 50 m until 500 m surroundings the selected BSTs. The exposure levels were below the international limit of reference levels set by ICNIRP. The highest exposure level was found at 150 m from Kubang Badak’s BST area which is has the largest number of transmitting antennas on top of it compared to other BSTs. Besides that, this BST located at sub-urban area where the highest exposure level probably due to the other radiation sources nearby such the moving vehicles from heavy road network traffic or the higher number of mobile users. Meanwhile, the lowest exposure level was found at Batu Rakit 3 at distance of 250 m from BST. This area was categorized as rural area where less human activities and mobile users. However, the exposure level at Batu Rakit area is higher compared to Kampung Pak Tuyu which even also categorized as rural area. This is because there are five BSTs erected at Batu Rakit site. Therefore, it is well known that the BST
erected may influenced the ambient NIR exposure level surroundings. It is important to take note that cancer caused by NIR is not instantaneous but would develop over years. Since the radiation from BST can’t turn off, thus, it is crucial to reduce the NIR exposure from other sources.

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