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A PRELIMINARY STUDY ON RADIO FREQUENCY (RF) ELECTROMAGNETIC FIELDS EXPOSURE FROM 5G AND NON 5G TRANSMITTER IN LANGKAWI

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ABSTRACT

5G is the 5th generation mobile network which is the latest wireless communication technology. The existence of this technology caused public concern towards the exposure of radio frequency (RF) radiation from 5G system will affect human health. A preliminary study has been conducted to evaluate the RF radiation level produce by 5G transmitter in Langkawi Island. In this study, RF level assessment was done at 11 locations where 5 locations are 5G Use Cases Area while 6 locations do not have 5G transmitters. The safety assessment was conducted using broad band electromagnet probe and spectrum analyser at frequency range of 100 MHz and 90 GHz. The strength of RF level was measured in unit V/m and μW/cm^2. Measured RF radiation levels were compared to the exposure limits toward human as mentioned in Mandatory Standard issued by the Malaysian Communications and Multimedia Commission (MCMC) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Result of the study show that RF radiation level at areas with 5G transmitter are higher compared to areas without 5G transmitter. However, the RF radiation level produced by 5G transmitter is still far below the permissible exposure limit by MCMC and ICNIRP.

INTRODUCTION

Non-Ionising Radiation (NIR) Group was collaborated with Malaysian Communication Multimedia Commission (MCMC) for research on Radio Frequency (RF) Electromagnetic Field (EMF) radiation exposure from 5G transmitter system in Langkawi. There were 5G demonstration project conducted in 6 states but this study carried out in Langkawi, Kedah. 5G use case is referring to an area with installed 5G transmitter to use the 5G application which are Smart Agriculture, Smart Airport, Smart City, Smart Traffic Light Solutions, Real Time Medical Data Transfer, 5G Live Video Surveillance, Remote Consultation and Virtual Tourism. Since the expanding of technology communication in the late 90's, the issue on radio frequency safety was already a concern. As the latest wireless communication, 5G technology implementation had caused a raise on public concern towards the exposure of radio frequency (RF) [4]. 5G technology was expected to use higher frequency and more transmitters to get faster speed connection compare to the previous technology. These facts trigger the public on how safe is actually 5G to be installed in Malaysia.

Due to this issue, a study had been conducted to determine the RF radiation level emitted by 5G transmitter. The measurement encompassed at five (5) 5G Use Cases Area and six (6) selected location without 5G Use Cases in Langkawi. The measurement was arranged to include both the electric field strength and power density at identified locations. Measured radiations were assessed and evaluated against the exposure limits and the recommendations of standard guidelines issued by the MCMC Mandatory Standard, determination No.1 of 2010 and ICNIRP.

OBJECTIVE

The objectives of this research were to investigate the RF radiation level radiations emitted by the 5G transmitter and to study the comparison of the RF radiation level at 5G use case designated area with non 5G use case area. The radiation level will be compared with the permissible exposure limit as stated in MCMC Mandatory Standard and International Commission on Non-Ionizing Radiation Protection (ICNIRP).

SITE DESCRIPTION

The site involved in this study is around Langkawi (see Figure 1). It was assumed that the radiation levels at the time of the measurement were from the background radiation and sources from the rectangular antennas on the telecommunication structure at a few locations. Rectangular antennas operate within the frequency range of 778/723 – 3750 MHz for TM, 3350 MHz for Edotco, 3450 - 26900 MHz for UMobile, 3450 – 3550 MHz for Digi and Celcom. The total radiations measured are not only from the antennas on the structure but including other radiation sources in this area.

Fig. 1: The location of assessment on the Langkawi Map

The assessment on the level of electromagnetic radiation were carried out at 11 locations around Langkawi. A total of 32 measurement points were identified from the selected location. The areas selected for RF assessment and the number of points is stated in the Table 1 as following:

Table 1: Location and points of RF measurement

No.	Location	Number of measurement points	Area
1.	Hospital Sultanah Maliha (LH)	9	5G Use Cases
2.	Berjaya Hotel & Resort (BR)	6	5G Use Cases
3.	Langkawi International Airport (LA)	9	5G Use Cases
4.	Teluk Burau (L01)	1	Non 5G
5.	Pantai Datai (L02)	1	Non 5G

6.	Teluk Yu (L03)	1	Non 5G
7.	Tanjung Rhu (L04)	1	Non 5G
8.	Durian Perangin (Waterfall) (L05)	1	Non 5G
9.	Kilim Geoforest Park (L06)	1	Non 5G
10.	Jalan Kelibang Kuah (L07)	1	5G Use Cases
11.	Pantai Chenang (L08)	1	5G Use Cases

MATERIALS AND METHODS

Broad band frequency was measured by using Narda NBM-550 attached with isotropic Probe EF9091 (100 MHz – 90 GHz) and Narda NBM-550 attached with isotropic Probe EF0691 (100 kHz – 6 GHz). For detailed spectrum analysis of radiations involved, measurements were made using a Narda-Safety Test Solution Instrument Model SRM-3006 attached with Three-Axis-Antenna, E-Field Model K-0818 and Model SRM-3000 with Antenna E-Field Model K-0818 which measure radiofrequency and microwave electric field strength from (420 MHz – 6 GHz) and (27 MHz – 3 GHz) respectively.

Table 2: Type of probes and instrument used in the measurement

Equipment	Model Probe/ Antenna	Frequency Range
Narda NBM-550	Probe EF9091	100 MHz – 90 GHz
Narda NBM-550	Probe EF0691	100 kHz – 6 GHz
Narda instrument Model SRM-3006	Antenna E-Field	420 MHz – 6 GHz
Narda instrument Model SRM-3000	Antenna E-Field	27 MHz – 3 GHz

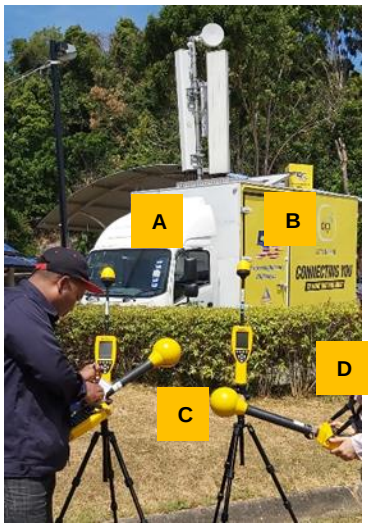


Fig. 2: Set-up of measurement equipment using:

A. NBM 550 attached with probe model EF9091 (100 MHz – 90 GHz)
B. NBM 550 attached with probe model EF6091 (700 MHz – 3 GHz)
C. SRM 3006 with antenna E-Field (420 MHz – 6 GHz)
D. SRM 3000 with antenna E-Field Model K-0818 (27 MHz – 3 GHz)

Each measurement data was set for a period of 6 minutes for RF radiation level detection. These standard procedures are recommended by ICNIRP 1998, IEEE 2005, Canadian Safety Code 6 and Australia Standard, ARPANSA 2002. Results of Radiofrequency (RF) measurement were recorded and presented as RF electrical field strength (V/m) and power density (µWatts/cm^2).

Details measurement was conducted at three 5G Use Cases area namely; Hospital Sultanah Maliha, Berjaya Hotel & Resort and Langkawi International Airport and another 8 locations was conducted as reference.

All measured radiations were assessed and evaluated against the exposure limits based on the guideline by MCMC and ICNIRP [1] [6]. For the lowest frequency radiation expected to be transmitted by the antennas at Langkawi International Airport which is 723 MHz, the limits for public are 361.5 µWatts/cm^2 or 36.9719 V/m of electric fields strength and 0.0995 A/m of magnetic fields strength. The frequency range for the Use Cases of 5G at other location during this assessment is from 3,350 MHz – 26,9000 MHz, limit for public is 1000 µWatts/cm^2 or 61 V/m of electric fields strength and 0.16 A/m of magnetic fields strength.

The exposure limit of EMF emission from a radiocommunication infrastructure site for general public was given by this Table 3 [6]:

Table 3: Exposure limit for general public

Frequency range	E-field strength (V/m)	Power density (µWatts/cm^2)
400 MHz – 2GHz	1.375 f $^{0.5}$	f/2
2GHz – 300GHz	61	1000

*f = frequency

The exposure limit at Langkawi International Airport was different compare to other location because of using different range of frequency.

RESULTS AND DISCUSSION

Generally, the results indicate that radiation levels present at all measurement locations of the area were very low and in compliance with the current exposure limit as stated in the MCMC Mandatory Standard for members of the public [6]. The readings of broadband measurement by Narda NBM-550 with probe EF 9091 (100 MHz – 90 GHz) indicate the total RF radiations present onsite during measurement at the selected points and locations.

At Hospital Sultanah Maliha (5G Use Cases Area), the averaged radiation levels were found to vary between 0.001 µWatts/cm^2 to 0.885 µWatts/cm^2 (0.072 V/m to 1.827 V/m) of which the highest level measured at Location LH06 (In front of Digi Telecommunication Structure) that corresponds to about 0.09% or over 1,129 times lower than the MCMC exposure limit for public.

At Berjaya Hotel & Resort (5G Use Cases Area), the averaged radiation levels were found to vary between 0.002 µWatts/cm^2 to 0.122 µWatts/cm^2 (0.095 V/m - 0.679 V/m) of which the highest level measured at Location BR01 (Garden) that corresponds to about 0.01% or over 8177 times lower than the MCMC exposure limit for public.

At Langkawi International Airport (5G Use Cases Area), the averaged radiation levels were found to vary between 0.079 µWatts/cm^2 to 3.389 µWatts/cm^2 (0.546 V/m - 3.575 V/m) of which the highest

level measured at Location LA08 (Airport Taxi Centre) that corresponds to about 0.94% or over 106 times lower than the MCMC exposure limit for public.

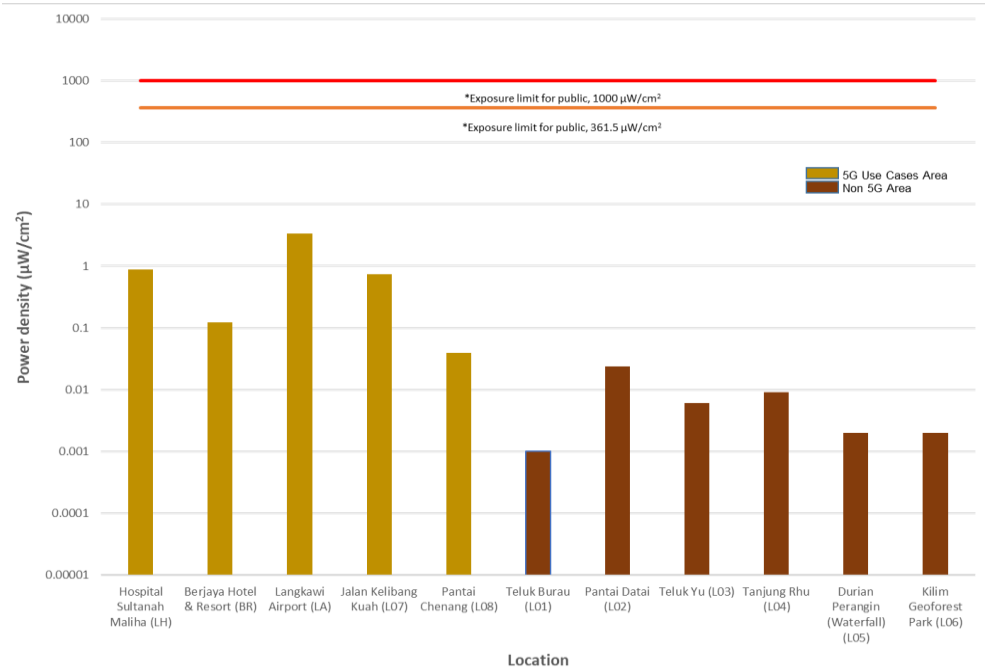
At other locations namely; Teluk Burau, Pantai Datai, Teluk Yu, Tanjung Rhu, and Durian Perangin (Waterfall), and Kilim Geoforest Park (Non 5G Area) and Jalan Kelibang Kuah (L07) and Pantai Chenang (5G Use Cases) selected around Langkawi, the averaged radiation levels were found to vary between 0.000 µWatts/cm^2 to 0.734 µWatts/cm^2 (0.010 V/m - 1.663 V/m) of which the highest level measured at Location L07 (Jalan Kelibang Kuah) (5G Use Cases Area) that corresponds to about 0.07% or over 1363 times lower than the MCMC exposure limit for public.

From the RF Assessment conducted, the comparison between the highest measurement reading at 5G designated area and non 5G area is given in Table 4.

Table 4: The highest radiation level at 5G designated area and non 5G area

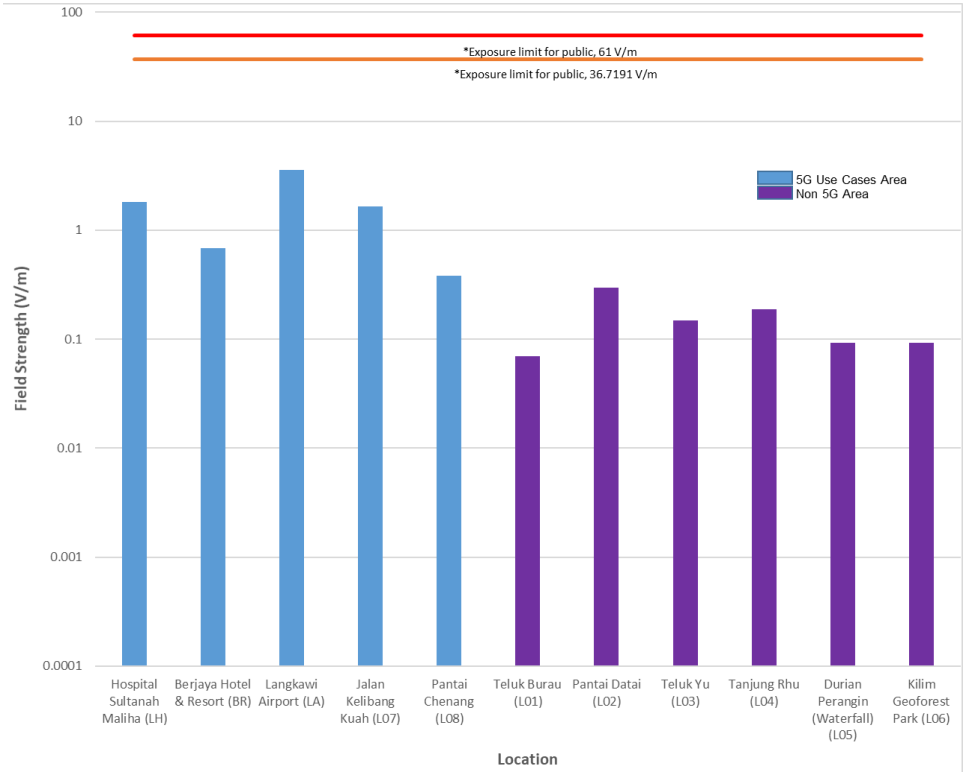
Location	Power density (µW/cm^2)	Comparison with exposure limit for RF radiation (%)	Field strength (V/m)	Comparison with exposure limit for RF radiation (%)	Area
Hospital Sultanah Maliha (LH)	0.885	0.0885	1.827	2.9951	5G
Berjaya Hotel & Resort (BR)	0.122	0.0122	0.679	1.1131	5G
Langkawi International Airport (LA)	3.389	0.9375	3.575	9.6695	5G
Jalan Kelibang Kuah (L07)	0.734	0.0734	1.663	2.7262	5G
Pantai Chenang (L08)	0.039	0.0039	0.383	0.6279	5G
Teluk Burau (L01)	0.001	0.0001	0.070	0.1148	Non 5G
Pantai Datai (L02)	0.024	0.0024	0.298	0.4885	Non 5G
Teluk Yu (L03)	0.006	0.0006	0.148	0.2426	Non 5G
Tanjung Rhu (L04)	0.009	0.0009	0.189	0.3098	Non 5G
Durian Perangin (Waterfall) (L05)	0.002	0.0002	0.093	0.1525	Non 5G
Kilim Geoforest Park (L06)	0.002	0.0002	0.092	0.1508	Non 5G

The plots of Figure 2 and Figure 3 indicate the highest radiation levels at selected location and their comparison with MCMC exposure limit for public.



*Note: Exposure Limit for Langkawi International Airport is 361.5 µW/cm^2 while other location is 1000 µW/cm^2

Figure 2: A plot of highest radiation levels in microwatts per unit area (µW/cm^2) against location of measurement (and their comparison with MCMC exposure limit for public)



*Note: Exposure Limit for Langkawi International Airport is 36.9719 V/m while other location is 61 V/m

Figure 3: A plot of highest radiation levels in V/m against location of measurement (and their comparison with MCMC exposure limit for public)

There were differences between the radiation level in 5G Use Cases Area with the Non 5G Area. 5G designated areas shows higher RF level compared to the non 5G areas. At all of measurement locations, the averaged radiation levels were found to vary between 0.000 µWatts/cm^2 to 3.389 µWatts/cm^2 (0.010 V/m to 3.575 V/m) of which the highest level measured at Location LA08 (Airport Taxi Centre) at Langkawi International Airport which is one of the 5G Use case area. This value corresponds to about 0.9375 % or over 106 times lower than the MCMC exposure limit for public.

Besides of broadband measurement, assessment of RF exposure was measured by using the spectrum analyser SRM-3000 with Antenna E-Field Model K-0818 (27 MHz – 3 GHz) and SRM-3006 E-Field Model at selective frequency range (3450 MHz – 3550 MHz). The readings of SRM-3000 with Antenna E-Field Model K-0818 (27 MHz – 3 GHz) indicate the RF radiations present onsite during measurement. At all measurement locations, the average radiation levels were found to vary between 0.00007 µWatts/cm^2 to 0.00242 µWatts/cm^2 (0.12809 V/m to 4.93232 V/m), of which the highest level measured at Location LA07 (Bus Parking, Langkawi International Airport) that corresponds to about 0.00067% or over 149,380 times lower than the MCMC exposure limit for public.

The results of the measurement from SRM-3006 E-Field at selective frequency range (3450 MHz – 3550 MHz). The 5G Use Cases at the particular location were within this frequency range. The measurement of electric field for the selective frequency were found to vary between 0.00000 µWatts/cm^2 to 0.07300 µWatts/cm^2 (0.00024 V/m to 0.52300 V/m) of which the highest level measured at LH03 (Inside Tent 1) at Hospital Sultanah Maliha. This level corresponds to about 0.0073 % of power density of the exposure limit as stated in MCMC Mandatory Standard.

5G mobile communication systems require different frequency for every application. A global harmonisation of the spectrum will be important for developing 5G for a lot of benefit [5]. Thus, varying of frequency could be able to be reduce and the exposure limit will become easier to be analysed.

CONCLUSIONS

5G designated Use Cases areas shows higher RF radiation level compared to Non 5G Use Cases areas. But, the highest RF level is only 0.9375% of the exposure limit and still far below the permissible exposure limit for members of public. Based on the measurement, the presence of the RF radiation emitted by the antennas installed on the telecommunication structure for 5G Malaysia Demonstration Projects in Langkawi with the present loads and the background radiation would not lead to any significant radiation exposure received by members of the public working or living in the area of concern. However, any modification on the antennas requires a new assessment to be carried out on site.

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