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Mobile Phone Base Station Radiation Study for Addressing Public Concern

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Abstract: Problem statement: The proliferation of mobile phone base stations had increased concerns from the public on the radio frequency radiation hazards that might come from them. The world wide public concern involved health risk due to radio frequency radiation. In Malaysia also public interest has increased, although it is not as intense as probably in other parts of the world, but had also resulted in tearing down of a few base stations. Due to this growing concern, a study was conducted to evaluate the radio frequency radiation levels near several mobile phone base stations in two major cities in Malaysia. **Approach:** Measurements in terms of electric field strength, power density and specific absorption rate were made to check the exposure level at public locations. Broadband meter were first used to survey the sites near the base stations. From the survey, spots with relatively higher readings will be further investigated using narrow band measurements. The measured values were then compared with the recommended international maximum permissible exposure limit. **Results:** The study showed that the measured values were found to be less than 1% of the maximum permissible exposure. **Conclusion:** The amount of radio frequency radiation from the selected base stations in the two major cities are adhering to the international limits although the physical radio base station infrastructures spawning out everywhere in these areas may give the reverse impression.

Key words: Mobile phone base station, International Commission on Non-Ionizing Radiation Protection (ICNIRP), exposure level, Maximum Permissible Exposure (MPE)

INTRODUCTION

Mobile phones are preferred due to its advantage of unrestricted means of communication, regardless of where the users are. In Malaysia where the population was 28.02 million in year 2008, there were more than 27.7 million mobile phone subscribers at the end of year 2008. That is to say, the penetration rate of mobile phone is 98.9% in 2008. The number increases to about 28.9 million subscribers out of 28.16 million populations at the first quarter of 2009, or increment rate of about 1.2% in 3 months. If this increment rate maintains, we would expect more than 29.9 million subscribers at the end of year 2009 in Malaysia (MCMC, 2009).

An approach to meet the increasing demand of mobile phones users is by deploying more mobile phone base stations in the country, especially in main cities such as Kuala Lumpur, Penang and Johor Bahru. Along with the increment of base stations is the public concern on safety hazards from them.

Researches had been carried out to assess the radiation exposure levels such as at universities in Malaysia (Islam *et al*., 2006) and Macau (Chiang and Tam, 2008).

A study on radio frequency radiation was made to assess the exposure level from mobile phone base stations in Kuala Lumpur and Johor Bahru, Malaysia. The locations for measurements were chosen based on the accessibility of the areas by the general public and places where the public used to spend their time. The measured values were than compared with the maximum permissible exposure set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). This study discusses the findings of the study.

MATERIALS AND METHODS

Measurements were carried out at areas accessible to the public. Places such as children's playgrounds and

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public pathways that are near to the base stations were purposely chosen. A broadband portable electric field strength meter was used to determine the area that gives the highest exposure level within the area of interest. The electric field strength meter was design with three mutually orthogonal antennas (also known as tri-axial design) where three omni-directional antennas were laid in x, y and z-axis. This design produces a response that is independent of direction and polarization of the field (i.e., isotropic in nature) (Hitchcock, 2004).

Then, a portable spectrum analyzer connected to a broadband omni-directional antenna was used to assess the exposure level at that area. The receiving antenna was placed at a height of 1.5 m above ground level as illustrated in Fig. 1.

The readings from the spectrum analyzer (in dBm) were converted to calculate electric field, E (in dBμV m^{-1}) using the following equation:

$$E = P_{Rx}+107+AF+CL \quad (1)$$

Where:

E = The electric field strength in dBμV m^{-1}

P_{Rx} = The received signal amplitude in (dBm)

AF and CL = The antenna factor and cable loss respectively, in dB

The measurement was repeated with the antenna laid at the x, y and z axis. Then, the equivalent electric field strength, E_{eq} in V m^{-1}, was then calculated using formula (2):

$$E_{eq}^2 = E_x^2 + E_y^2 + E_z^2 \quad (2)$$

where, Ex, E_y and E_z are the electric field strength (in V m^{-1}) with the antenna laid at x, y and z axis respectively. The E_{eq} value was then used to calculate Specific Absorption Rate (SAR).

SAR is the parameter used in assessing the level of radiation absorbed by tissue and has units of watts per kilogram. SAR can be calculated from electric field, E using the following equation (ANSI/IEEE C95.1, 1999):

$$SAR = \sigma|E_{eq}|^2/\rho_{md} \quad (3)$$

Where:

σ = The conductivity

ρ_{md} = The mass density

The conductivity and mass density value for the brain can be obtained from Federal Communications Commission (FCC) (2006) and are summarized in Table 1.

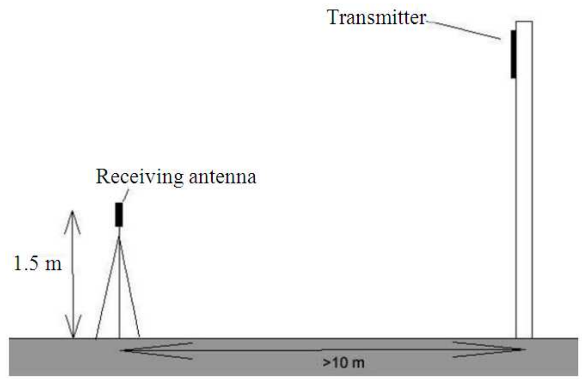

Fig. 1: Illustration of measurements equipment setup

Table 1: Human brain tissue dielectric parameters

Frequency (MHz)	Conductivity (Ω^{-1} m^{-1})	Mass density (kg m^{-3})
900	0.7665	1030
1800	1.1531	1030
2100	1.3102	1030

Table 2: Summary of ICNIRP's general public safety guidelines for limiting radiation exposure and SAR

Frequency	E-field (V m^{-1})	H-field (A m^{-1})	Power density (W m^{-2})	Whole body average SAR (W kg^{-1})	Localized SAR (head) (W kg^{-1})
400-200 MHz	1.375f1/2	0.003f1/2	f/200	0.08	2
2-300 GHz	61	0.16	10	0.08	2

The calculated E-field and SAR values were then compared with ICNIRP guidelines for the general public. Table 2 summarizes ICNIRP's general public safety guidelines for limiting radiation exposure and SAR respectively (ICNIRP, 1998).

RESULTS

Measurements were carried out at 5 randomly identified locations each in Kuala Lumpur and Johor Bahru. Table 3 summarizes the description of the measurement locations.

Figure 2 shows location A where the study on the exposure level has been carried out. The Fig. 2 shows four monopole towers exist next to a children's playground. The highest value obtained for measured E-field, power density and SAR were then compared to the ICNIRP guideline, as in Table 2. The highest value for E-field strength was 0.3978 V m^{-1} or 0.9644% of the compared limit. For power density, the highest value was 0.042 μW cm^{-2} or 0.0093% and the highest recorded value for SAR was about 0.0002 W kg^{-1} or 0.01%. Table 4 summarizes the exposure level for the measured E-field, power density and SAR for GSM 900, GSM 1800 and 3G.

Table 3: Descriptions of locations studied

City	Location	Description
Kuala Lumpur	A	Children playground
	B	in a shopping mall
	C	Public pathway
	D	children pathway
	E	Schools waiting point
Johar Bharu	F	School s field
	G	Public pathway
	H	Public pathway
	I	Public pathway/bus stand
	J	Inside hotel

Table 4: Percentage of highest exposure level measured at location A

	E (%)	S (%)	SAR (%)
CSM 900	0.9644	0.0093	0.0150
GSM 1800	0.1093	0.0001	0.0002
3G	0.1726	0.0003	0.000

Fig. 2: Base station nearby playground in location A

Measurements were carried out in front of the towers, based on the highest reading of E-field strength meter. Figure 3-5 show the results for the GSM 900 E-field strength, power density and SAR measurement in the area respectively.

The highest value of measured E-field, power density and SAR were then compared to the ICNIRP guideline, as in Table 2. The highest value for E-field strength was 0.3978 V m^{-1} or 0.9644% of the compared limit. For power density, the highest value was 0.042 μW cm^{-2} or 0.0093% and the highest recorded value for SAR was about 0.0002 W kg^{-1} or 0.015%.

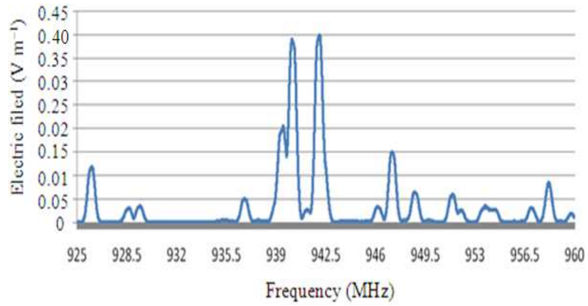

Fig. 3: Electric field strength measured at location A for GSM 900 system

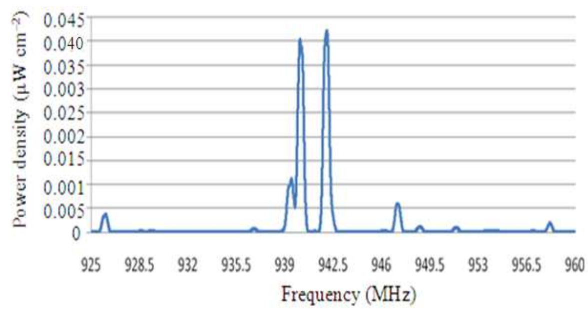

Fig. 4: Power density measured at location A for GSM 900 system

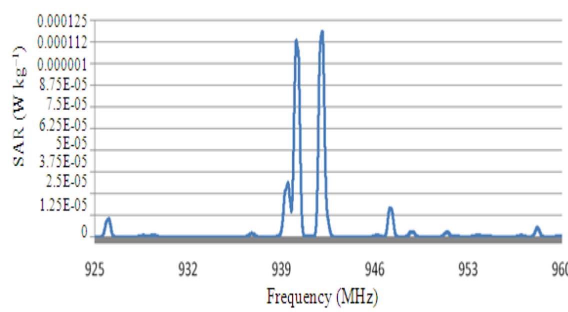

Fig. 5: SAR measured at location A for GSM 900 system

Table 4 summarizes the highest exposure level for the measured E-field, power density and SAR for GSM 900, GSM 1800 and 3G in location A.

The same procedure was applied to assess the exposure level for all the locations identified. Table 5 summarizes the results obtained. The results show that exposure levels for all locations did not exceed 1% the guideline set by ICNIRP.

Table 5: Percentage of highest exposure level measured at all 10 locations

	GSM 900			GSM 1800			3G	
Site	S (%)	SAR (%)	E (%)	S (%)	SAR (%)	E (%)	S (%)	SAR (%)
A	0.9644	0.0150	0.1093	0.0001	0.0002	0.1726	0.0003	0.0007
B	0.3089	0.0006	0.1650	0.0003	0.0000	0.0500	0.0000	0.0002
C	0.5552	0.0020	0.0619	0.0000	0.0001	0.0820	0.0001	0.0001
D	0.3365	0.0007	0.1298	0.0002	0.0003	0.1582	0.0002	0.0006
E	0.1321	0.0001	0.1073	0.0001	0.0000	0.1684	0.0003	0.0007
F	0.2677	0.0005	0.0219	0.0000	0.0000	0.0141	0.0000	0.0000
G	0.0199	0.0000	0.0208	0.0000	0.0000	0.1162	0.0001	0.0003
H	0.1982	0.0003	0.0082	0.0000	0.0000	0.0233	0.0000	0.0000
I	0.1821	0.0002	0.1106	0.0001	0.0002	0.2632	0.0007	0.0016
J	0.1893	0.0002	0.1853	0.0003	0.0007	0.0300	0.0000	0.0000

DISCUSSION

Measurements were carried out to assess the radiation exposure level from mobile phone base stations in Kuala Lumpur and Johor Bahru. The highest recorded electric field strengths, power densities and Specific Absorption Rate (SAR) were compared with the ICNIRP guideline. The results show that the highest recorded exposure levels in all locations are well below the guideline.

CONCLUSION

The era of pervasive and ubiquitous communications are inevitably coming and are very much dependent on the non-ionising radio frequency radiation for communications. However, measures need to be taken so that it would not be at the expense of public health and other environmental hazards from RF pollution.

Generally, the authors proposed that the national and local government and industry should all become actively involved in addressing public concerns about the installation of mobile phone base stations by propagating awareness programmes amongst the public.

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