Proceedings of the Technical Sessions, 31 (2015) 97-104
Institute of Physics – Sri Lanka

Study of Electromagnetic Pollution in Sri Lanka

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ABSTRACT

This paper represents the Electromagnetic RF radiation levels in selected areas in few main cities and few hospitals in Sri Lanka due to wireless networks such as FM, VHF, UHF and CELLULAR which are using RF radiation emitters to transmit signals. Most of the measurements were performed in the proximity of these communication towers near to population denser areas. A Digital RF spectrum analyzer with an accuracy of ± 2 dB and a directional antenna was used to measure the RF radiation levels. A comparison was made using measured data with Telecommunications Regulatory Commission of Sri Lanka (TRCSL) guidelines based on International Commission on Non-Ionizing Radiation Protection (ICNIRP). RF radiation level is found to be higher in Colombo area (maximum 0.00262 W/m^2 in the GSM 900 band) than in other areas of the country. The National Hospital of Sri Lanka premises in Colombo shows a higher RF radiation level than two other hospitals dealing with pediatric patents. However, the measured data values are well below (0.131%) the ICNIRP standards.

1. INTRODUCTION

Many scientific reports found that exposing to the electromagnetic radiation RF radiation can be harmful to the human being as well as to the animals if they are in high density RF radiation zones and when they are exposed to some longer intervals of time to RF radiation [1-3]. The heating of biological tissues is the main health risk for living organisms. Living organisms are exposed to RF radiation from many sources, such as Radio and TV transmitters, mobile phones and their supporting transmitters (base stations), Wi-Fi zones and many more. These heating effects depend on the physical properties of the objects which is exposed to this radiation and environmental facts. Exposure to RF radiation intensity (S) is greater than 2 W/m^2 will result in heating effects of living organisms [4]. Two important areas of the body, the eyes and the testes, are known to be predominantly vulnerable to heating by RF energy [4] due to the relative insufficiency of available blood flow to dissipate the excessive heat (blood circulation is one of the body's major procedure for subsist with excessive heat). Cataracts in rabbits have observed in Laboratory experiments when they exposure short-term (e.g. 30 minutes to one hour) to very high levels of RF radiation (1000-2000 W/m^2) [4]. After exposure of the testes to high-level RF radiation interim sterility, changes in sperm count and in sperm motility are reported.

When considering health issues, three main factors mainly considered. The RMS electric field strength (E) measured using volt per meter (V/m), magnetic field strength (H) measured using ampere per meter (A/m), RF radiation intensity or plane wave power density (S) measured by watt-per square meter (W/m^2), magnetic flux density (B)

measured using Tesla (T) and The Specific Absorption Rate (SAR). International organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), Federal communications commission (FCC), National Radiation Protection Board (NRPB) and the Institute of Electrical and Electronic Engineers (IEEE) are published standards for RF radiation. ICNIRP published Guidelines mainly for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz) [5]. But countries such as Italy and Switzerland announced limitations for their countries well below the international standards.

In Sri Lanka, Telecommunications Regulatory Commission (TRC) has been published Reference levels for general exposure to time-varying electric and magnetic fields [6]. There are nearly 47 radio channels, 22 television channels and 5 mobile communication network providers. The Frequency reservation for different telecommunication systems are as follows. 88 MHz-108 MHz for FM radio broadcasting, (30-300) MHz for VHF television broadcasting, (300-820) MHz for UHF television broadcasting and for mobile communication systems, there are two types of GSM (2G) band, GSM 900 (880-960 MHz) and GSM 1800 (1710-1880 MHz). The frequency bands used for the Universal Mobile Telecommunications System (UMTS) or 3G are in the frequency ranges 1885-2025 MHz and 2110-2200 MHz.

In 2005, Karunarathna and Dayawana [7] presented a report about Human exposure to RF radiation in Sri Lanka. They did a study about the exposure levels in populated areas of few cities in Sri Lanka for different wireless network categories and about the safe distances for communication towers.

The main objective of this project is to get an understanding about RF radiation levels in the Sri Lankan environment by considering the RF radiation emitters such as FM Radio broadcasting stations, VHF Broadcasting stations, UHF broadcasting stations and cellular communication base stations. High dense population areas have considered for the RF level measurements of the environment. The electric field strength, magnetic field strength and plane wave power density were measured and analyzed to compare with the reference levels given by Telecommunications Regulatory Commission of Sri Lanka (TRCSL).

2. THEORY

An RF Electromagnetic wave consists of the electric field component and magnetic field component, i.e. Electric field and Magnetic field. Therefore, it is a convenient way to represent the intensity of electromagnetic wave with electric field strength (E) and magnetic field strength (H).

Power density and electric field intensity are related as follows,

$$S = E \text{ x H} = \frac{E^2}{377} = 377H^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

S - Power density of a particular point
E - Electric field intensity
H - Magnetic field intensity

Where, 377 Ω is the intrinsic impedance of free air.

By considering the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines Telecommunications Regulatory Commission of Sri Lanka (TRCSL) has given the reference levels for general public exposure to time-varying electric and magnetic fields [6]. Table 1 shows the Reference Levels for time-varying electric and magnetic fields.

Table 1: Telecommunications Regulatory Commission of Sri Lanka declared Reference levels for general public exposure to time varying electric and magnetic fields

Network	Category	E-field strength (V/m)	H-field strength (A/m)	B-Field Strength (μT)	Equivalent plane wave power density (W/m^2)
Radio	FM	28	0.073	0.092	2
Television	VHF	28	0.073	0.092	2
	UHF	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	f/200
Mobile	GSM 900	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	f/200
	GSM 1800	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	f/200
	UMTS	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	f/200

Note: The frequency f is the center frequency in the order of MHz

3. METHOD

Populated Places such as railway stations, bus stands in different geological locations and few main Hospitals in Sri Lanka were considered in this project and the readings were taken in the day time. The reason for selecting the day time is most of the wireless communication mediums are used in daytime.

The digital spectrum analyzing instrument AARONIA SPECTRAN HF 6065 spectrum analyzer was used with ± 2 dB accuracy. The frequency range of the instrument was 10 MHz to 6 GHz. A directional antenna was used with the instrument to take the readings. Fig. 1 shows the instrument setup used in this study. To analyze the frequency spectrum, MCS spectrum analyzer software were used.

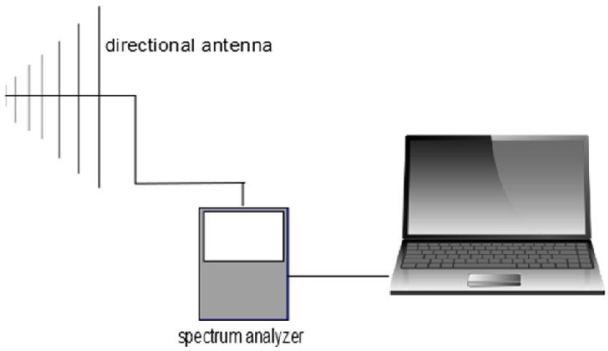

Fig. 1: The instrumental set-up

4. RESULTS AND DISCUSSION

Measured electric field strength, magnetic field strength, magnetic flux density and equivalent plane wave power density for different geological locations in Sri Lanka are given in the Table 2.

Table 2: Measured Values of electric field strength, magnetic field strength, magnetic flux density and equivalent plane wave power density for some major cities.

City	Network	Category	E (mV/m)	H (μA/m)	B (μT)	S (μW/m^2)	Center Frequency (MHz)
Colombo	Radio	FM	34.10	90.52	N/A	3.0872	103.6
	TV	VHF	51.95	137.90	N/A	7.1640	103.5
		UHF	67.22	178.40	N/A	11.9900	663.0
	Mobile	GSM 900	993.60	2637.50	N/A	2620.8000	944.5
		GSM 1800	413.00	1096.30	N/A	452.8000	1836.5
		UMTS	189.40	502.70	N/A	95.1900	2122.0
Kandy	Radio	FM	14.79	39.26	N/A	0.5806	104.0
	TV	VHF	12.54	33.28	N/A	0.4174	106.5
		UHF	17.09	45.36	N/A	1.0000	711.0
	Mobile	GSM 900	175.80	466.70	N/A	82.0400	944.0
		GSM 1800	276.70	734.60	N/A	203.3000	1845.5
		UMTS	223.90	594.40	N/A	133.1000	2113.0
Nuwaraeliya	Radio	FM	3.85	10.24	N/A	0.0300	107.6
	TV	VHF	20.52	54.47	N/A	1.1200	189.0
		UHF	11.07	29.37	N/A	0.8000	684.0
	Mobile	GSM 900	131.00	347.80	N/A	45.5700	947.0
		GSM 1800	389.50	1033.80	N/A	402.6000	1830.5
		UMTS	92.69	246.00	N/A	22.8100	2137.0
Gampola	Radio	FM	0.43	1.28	N/A	0.0006	94.0
	TV	VHF	0.40	1.08	N/A	0.0004	31.5
		UHF	2.53	5.82	N/A	0.1000	350.0
	Mobile	GSM 900	53.37	141.70	N/A	7.5600	938.0
		GSM 1800	171.40	454.90	N/A	77.9700	1808.0
		UMTS	52.77	140.10	N/A	7.3900	2167.0

Galle	Radio	FM	2.81	7.47	N/A	0.0211	92.0
	TV	VHF	2.56	6.81	N/A	0.0175	31.5
		UHF	2.22	5.91	N/A	0.0132	301.5
	Mobile	GSM 900	69.01	183.20	N/A	12.6400	945.5
		GSM 1800	22.65	60.11	N/A	1.3613	1836.5
		UMTS	71.21	189.00	N/A	13.4600	2137.0
Matara	Radio	FM	0.70	1.86	N/A	0.0013	90.0
	TV	VHF	1.96	5.21	N/A	0.0102	138.0
		UHF	2.87	7.63	N/A	0.0220	301.5
	Mobile	GSM 900	34.57	91.77	N/A	3.1724	944.0
		GSM 1800	11.63	30.86	N/A	0.3588	1764.5
		UMTS	13.58	36.05	N/A	0.4896	1927.0

Electromagnetic pollution levels in few hospitals dealing with pediatric patients were also considered in this study and measured values are represented in Table 3.

Table 3: Measured electric field strength, Magnetic field strength, Magnetic flux density and equivalent plane wave power density inside some hospitals.

Hospital	Network	Category	E (mV/m)	H (μA/m)	B (μT)	S (μW/m^2)	Center frequency (MHz)
General Hospital, Colombo	Radio	FM	44.97	119.40	N/A	5.3690	92.4
	TV	VHF	38.85	103.10	N/A	4.0060	106.5
		UHF	211.90	562.50	N/A	119.2000	766.5
	Mobile	GSM 900	52.77	140.10	N/A	7.3900	934.0
		GSM 1800	149.20	395.90	N/A	59.0600	1835.0
		UMTS	30.86	81.91	N/A	2.5278	2117.5
General Hospital, Kandy	Radio	FM	2.03	5.39	N/A	0.0110	90.8
	TV	VHF	1.87	4.98	N/A	0.0094	33.0
		UHF	4.27	11.27	N/A	0.0536	766.0
	Mobile	GSM 900	17.43	46.27	N/A	0.8070	872.0
		GSM 1800	28.48	75.61	N/A	2.1540	1827.5
		UMTS	36.19	96.07	N/A	3.4770	2153.5
Lady Ridgeway Hospital for Children, Colombo	Radio	FM	11.81	31.34	N/A	0.3700	106.4
	TV	VHF	9.43	25.05	N/A	0.2360	93.0
		UHF	17.80	47.26	N/A	0.8410	504.0
	Mobile	GSM 900	168.4	447.10	N/A	75.3100	958.0
		GSM 1800	140.3	372.40	N/A	52.2400	1824.5
		UMTS	94.83	251.70	N/A	23.8700	2153.5

A graphical analysis can be done for different cities to compare E field, H Field and plane wave power densities. Fig. 2 and Fig. 3 shows the variation of Electric field strength and Magnetic field strength with network category.

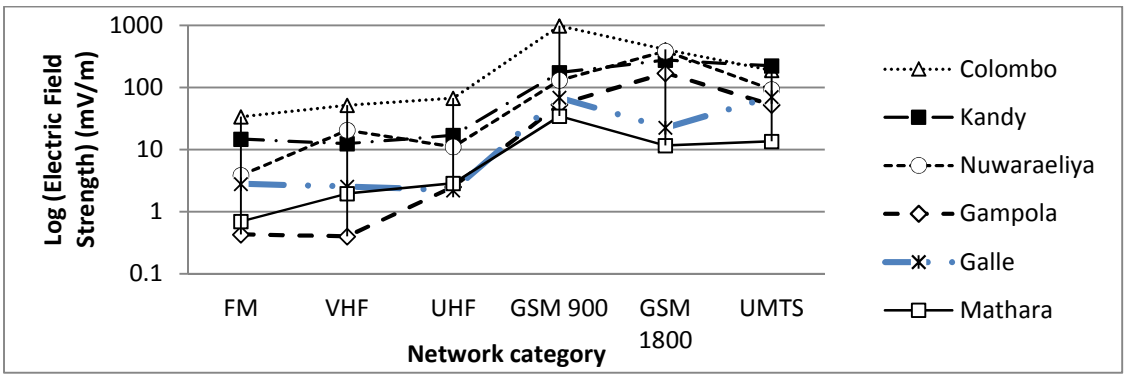

Fig. 2: Variation of electric field strength with different network categories for different locations.

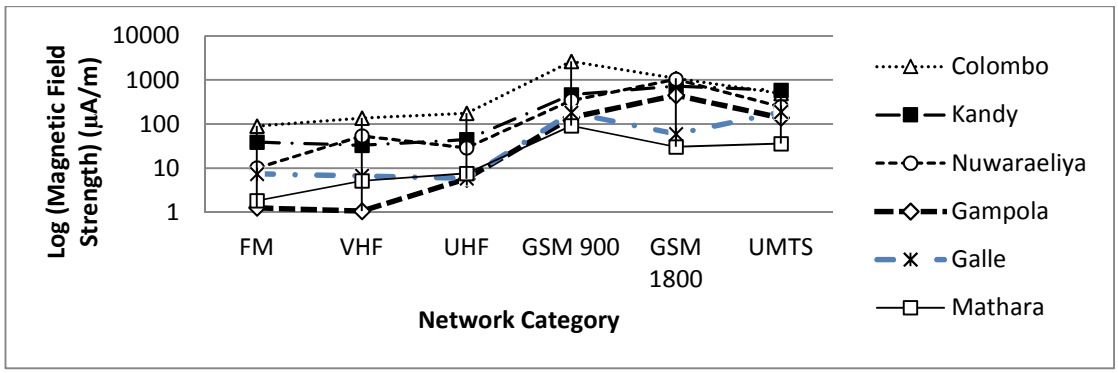

Fig. 3: Variation between Logarithmic values of magnetic field strengths with network category for different regions.

Variation of plane wave power density is another important factor. The variation of plane wave power density with network category for different geographical locations is given in Fig. 4.

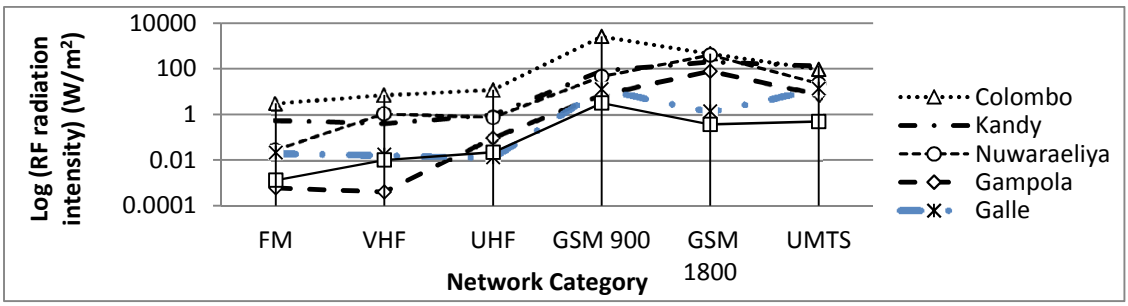

Fig. 4: Variation of plane wave power density or RF radiation intensity with different network categories for different geological locations.

The above figures indicate that the electric field intensity, magnetic field strength and plane wave power density are high in the Colombo area. Colombo General Hospital

(National Hospital of Sri Lanka) shows increased RF radiation levels than other two hospitals. Fig. 5 shows the plane wave power density for each hospital.

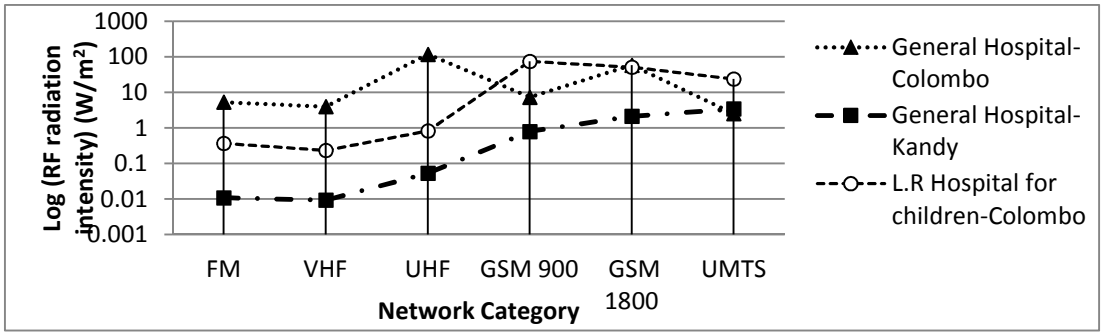

Fig. 5: Variation of plane wave power density with different network categories for three hospitals

Colombo fort railway station shows the highest RF radiation intensity value among other cities and Colombo General Hospital shows the higher RF radiation intensity values than that level of other two hospitals. Here it should be noted that reference levels are changing with frequency, but in this paper the minimum reference level has considered. Table 4 shows the maximum percentage power densities compaired with reference level.

Table 4: Percentages of power densities to the reference plane wave power density. 2 W/m^2 value is taken as the minimum reference plane wave power density as per ICNIRP standards.

City & Hospital	Maximum Measured Plane Wave Power Density (mW/m^2)	Percentage to Ref. Plane Wave Power Density (%)
Colombo	2.6208	0.1310
Kandy	0.2033	0.0101
Nuwaraeliya	0.4026	0.0201
Gampola	0.0779	0.0038
Galle	0.0126	0.0006
Matara	0.0031	0.0001
Gen.Hospital Colombo	0.1192	0.0059
Gen.Hospital Kandy	0.0034	0.0001
Lady Ridgeway Hospital for Children	0.0753	0.0037

When considering above table it can be seen that the power densities measured in the Colombo fort railway station and General Hospital in Colombo are very much below than minimum reference level.

5. CONCLUSIONS

The RF radiation intensity, electric field strength and magnetic field strength for different locations in Sri Lanka were found to be well below the TRCSL and ICNIRP reference levels. Therefore the effect of those levels will not be harmful to people. But it is better

to perform a further study about RF radiation levels in hospitals in and around Colombo because very sensitive electronics devices as well as pregnant woman, children and pediatric patients are more vulnerable to the electromagnetic fields.

ACKNOWLEDGEMENTS

The authors are grateful to the TRCSL for the support given.

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