Exposure assessment in the vicinity of 900 MHz GSM base station antenna

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Abstract: Daily exposure to GSM electromagnetic fields has raised public concern of possible adverse health effects to people living in the vicinty of base station antennas.
In this paper are presented measurements of field strength and power flux density performed on locations few meters away from base station antenna, in different levels, with and without usage of mobile phones, during day and in peak hours of GSM system usage.
Measurements are performed in accordance with standards using EMR-300 radiation meter.
Results are compared with ICNIPR Guidelines , IEEE and CENELEC standards. The measured values were well below the maximum permissible exposure levels.

Key-Words: base station antennas, field strength, power density, GSM, measurement

1 Introduction

Increased use of cellular mobile communication led to sitting of GSM base station antennas even in close of houses, schools etc, in densely populated areas.
This raised public concern regarding safety of population exposed to such radiation. Many studies have been done and are on going regarding potential biological and thermal effects of GSM electromagnetic fields.
Cancer, hyperthermia , neural and behavior effects of people exposed to GSM fields are being studied.
Interaction of GSM electromagnetic fields and humans should include all particularities of "system": [3]

- The "material"(human body)has very unusual electromagnetic properties values: electric permittivity, electric conductivity
- These properties are not well known and depend on activity of person
- This material is an active material at cell scale
- In most cases, the problem is actually a coupled problem: the thermal effect is one of the major effects and it is affected by the blood circulation
- The geometry is complex and generally environment of the human body has to be taken into account

Almost all guidelines and recommended limits on human exposure to GSM electromagnetic fields are given in terms of SAR(Specific Absorption Rate).
SAR is defined as:

$$SAR = \frac{\sigma \left| E^2 \right|}{\rho_m} \text{ W/kg}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

σ -Conductivity of body tissue, E- root mean square of intensity of electrical field at

considered point, ρ_m -mass density of tissue at that point.
Since SAR, time rate of RF energy absorbed per unit mass, is very difficult and complex to be measured in biological tissues, standards permit the use of reference levels of power flux density(W/m^2)s in free space.
IEEE standard established the limits for rms electric and magnetic fields, so called maximum permissible exposure(MPE) and similarly ICNIRP standard defines reference limits for free-space incident fields. Meeting these limits SAR compliance should be ensured.
So instead of complex SAR measurements, for compliance assessments above mentioned standards let us use simpler field measurements as rms of electric field.
In this paper we have presented results of measurements of field strength and power density flux in the vicinity of base station antennas. Exposure assessment is done on request of Ministry of Environment in order to give feedback regarding level of exposure, assessment of radiation, to concerned people living on the vicinity of GSM 900 MHz base station antenna.

2 Measurement of field strength and power density in vicinity of base station antenna

In order to have more accurate results power flux density is measured at considerable distances from radiating antenna.
When the humans are located in near field of antenna, significant influence in antenna parameters is to be expected. If distance is greater than 0.7m-0.8 m the human phantom influence can be almost completely omitted [2].
Assuming far-field exposure, magnitude of electrical field can be expressed as superposition of the incident field and reflected field components. [1-2]
Figure 1 shows ground-plane of suburb Emshir, Prishtina –Kosovo, where is located GSM 900 MHz base station antenna.

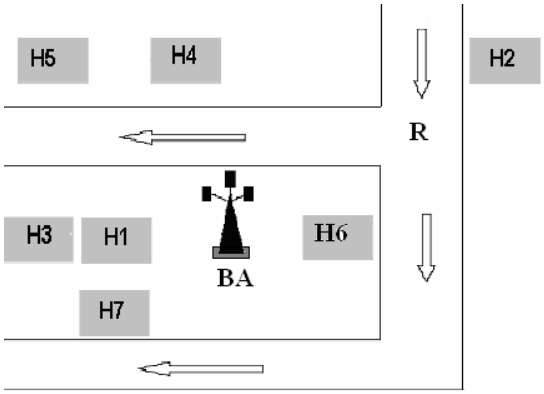

Figure 1

H1- House Nr.1; H2- House Nr.2; H3- House Nr.3, H4- House Nr.4; H5- House Nr.5;
H6- House Nr. 6; H7- House Nr.7; R- Road, BA- Base of Antenna.

Measurements are performed using radiation meter EMR-300, sensor type 8 E- field probe, 200 KHz -3 GHz, three axial sensors, so measurements are done independently of direction or polarization of emitter.
For more technical parameters of instrument check at www.wg.com.

Based on given parameters the field strength can be calculated as follows:

P- Effective Isotropic Radiated Power
S-Power density flux W/m^2
Z_v- Air Impedance $=120\pi$

$$P = S\frac{\lambda^2}{4\pi} \text{ ……..(2)}$$

$$S = \frac{E^2}{Z_v} \text{ ……. (3)}$$

$$10\log S = 10\log P - 20\log\lambda + 10\log 4\pi$$
… ……(4)

For downlink GSM frequency 935 MHz:

$$10\log S = 10\log P - 0.2 \text{ ……. (5)}$$

Referring to expression (3) we obtain:

$$20\log E = 10\log PmW + 55.5 \text{… ……(6)}$$

$$E\frac{V}{m} = 10^{(measuredvalue+55.5)/20} \quad \text{..... (7)}$$

Technical parameters of base station antenna are listed on Table 1:

Operational Frequency	GSM downlink band (935-960)Mhz
Number of sectors	3
Main radiation directions	Sector A: 0^0 Sector B : 120^0 Sector C: 240^0
Antennas	6 antennas /sector
Antenna system height	25m
Max. No. of channels per sector	6
EIRP per channel	60 dBm
Antenna Gain	14 dBi
Horizontal beam-width	65^0
Vertical beam-width	9^0

Table 1

3 Results of measurements

The precise experimental determination of power density on complex and dynamic environment is a difficult task. This is mainly due to reflection, absorption and interference of electromagnetic waves. Different measurements can lead to quite different results due to changing of conditions[5].

In Table 2 are presented results of measurements of instant values of electrical field, average values over 6 minutes, power density and power level. Presented measurements are done at 11:30 at different sites, different heights from ground level, indoors and outdoors, with and without usage of few mobile phones. In order to include worst case scenarios we have presented as well maximum of instant values and maximum of average values.

In order to assess exposure at peak-usage time, we have measured and presented in Table 3 values of electrical field and power density and in peak –usage of system, at 21:30.

In Figure 2 are compared measurements of average intensity of electrical field at 11:30 with measurements of 21:30 at two sites, House 3, 31 m far from base of antenna and at point 4 m far from base of antenna.

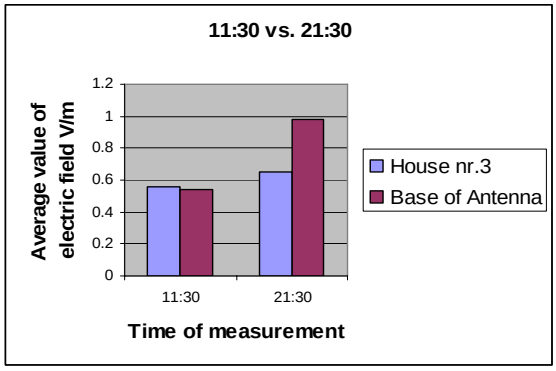

Figure 2

In Figure 3 are presented values of electric field at different sites surrounding base station antenna. Measurements are done at same ground level, at garden of houses.

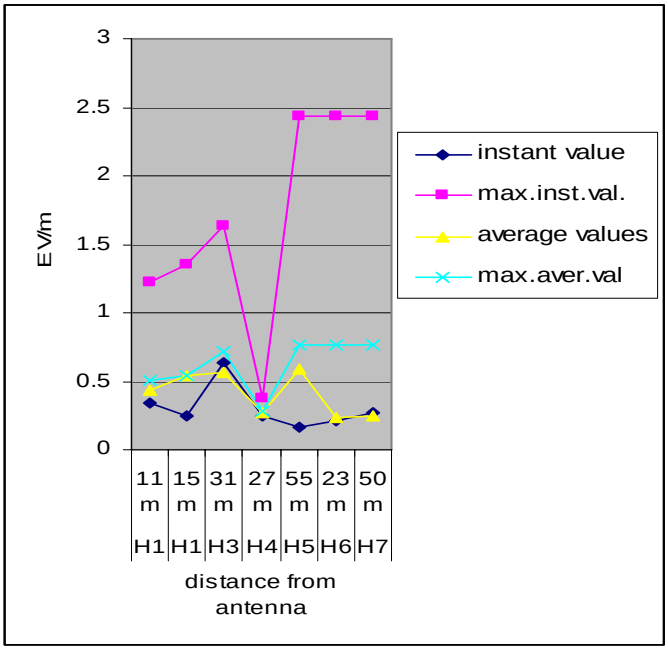

Figure 3

Nr.	Place of measurement	Distance from base of antenna (m)	Intensity of electrical field E(V/m)				Others		
			Instant value	Maximum of instant values	Average value	Maximum of average values	Power density (mW/cm^2)	Power level dBm	Chanal of main frequency
1.	House nr.1	11 (garden)	0.34	1.22	0.44	0.51	-	-33	62
2.	House nr.1	11 (second floor)	0.4	1.22	0.47	0.51	-	-40	62
3.	House nr.1	15 (garden)	0.25	1.35	0.54	0.54		-47	62
4.	House nr.2	56 (second floor)	0.59	1.35	0.48	0.59	-	-42	65
5.	House nr.2	66 (third floor)	0.61	1.35	0.48	0.59	0.0001	-35	65
6.	House nr.3	31 (garden)	0.64	1.63	0.56	0.72	0.0001	-38	62
7.	House nr.3	31 (garden-with usage of mobile phones)	0.64	1.63	0.55	0.72	0.0001	-	-
8.	House nr.4	27 (garden)	0.25	0.38	0.27	0.28	-	-48	23
9.	Base of antenna	4	0.63	1.45	0.54	0.55	0.0001	-38	23
10.	Base of antenna	4	0.63	1.45	0.54	0.55	0.0001	-45	65
11.	House nr.5	55 (garden)	0.16	2.43	0.59	0.76	0.0001	-35	62
12.	House nr.6	23 (inside a house)	0.16	2.43	0.43	0.76	-	-	-
13.	House nr.6	23 (garden)	0.21	2.43	0.24	0.76	-	-40	65
14.	House nr.7	50 (road)	0.27	2.43	0.25	0.76	0.0002	-40	62

Table 2

Nr.	Place of measurement	Distance from base of antenna (m)	Intensity of electrical field E(V/m)				Others		
			Instant value	Maximum of instant values	Average value	Maximum of average values	Power density (mW/cm^2)	Power level dBm	Chanal of main frequency
1.	House nr.3	31 (garden)	0.75	1.34	0.65	0.83	0.0001	-38	62
2.	Base of antenna	4	1.12	1.16	0.98	0.83	0.0003	-36	23

Table 3

Conclusion

Analyzing results of practical measurements performed in limited number of locations, the field strength and power density levels from GSM 900 MHz base station antenna never exceed the reference levels as per ICNIRP guidelines.

We can conclude that even in peak-time of usage, in different sites, different heights from ground level, indoors and outdoors, with and without usage of few mobile phones, in the vicinity of base station antennas, measured field strength and power density levels were well below safety guidelines.

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