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Assessment of GSM HF-Radiation impact levels within the residential area of Craiova city

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Abstract

The present study aims at analyzing the level of exposure to non-ionizing radiation for the population inside central residential area of Craiova, Romania This type of EM (electromagnetic radiation) is generated mainly by GSM (Global System for Mobile Communication) technology of wireless communication based on the electromagnetic emitters (GSM antennas) needed for covering wider territorial areas. They produce constant pulsed microwave radiation even when nobody is using the phone, affecting the people inside and outside public and residential buildings. Contributions in this filed show that there is a direct link between continuous exposure to microwave radiation from cell phone towers and serious health problems over the years. The paper is based on selective measurements of HF radiations within GSM 900-1800 MHz range at cell towers and at distance both inside and outside residential buildings within the study area. In most cases the exposure zones were located in the vicinity of base stations antenna where recorded levels of HF radiation were superior to recommended values. One main objective is to establish some residential compliance exposure zones inside the study area in relation with international regulations and standards concerning GSM radiation limits.

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Keywords: non-ionizing radiation, EMF radiation, GSM, compliance zone, non thermal effects, residential areas, environment, Craiova, Romania

1. Introduction

Nowadays cities are facing large scale electromagnetic pollution due to GSM technology for wireless

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communication. In this respect, cities face the most intense electromagnetic pollution in terms of non-ionizing radiation due to the presence of transmitters for mobile communication in crowded areas. This type of sources registered constantly growing in last years because of the large number of mobile services providers and antennas sites. Health effects of cell phone radiation were scientifically approached by James C. Lin, concerning electromagnetic field in living systems [1] which provides a fundamental understanding of (RF) electromagnetic interaction with biological systems. There is to be considered also (Lyn McLean, 2011) with basic information concerning safe life in a world of electromagnetic pollution [2]. Main contributions in the assessment of HF radiation levels are the studies of Thomas Haumann, Uwe Munzeberg, based on power density measurements in residential areas close or far to antennas sites, which point out HF-Radiation levels of GSM cellular phone towers urban environmnet [3], Damiano Urbinello 2014 [4] with a comparison of electromagnetic (RF-EMF) mean exposure levels in outdoor areas across four European cities but also the studies carried out by GAE Vandenbosch [5], R.K Singh with the assessment of electromagnetic radiation from base station antennas which focuses on equivalent isotropically radiated power calculations [6].

Official international and national standards on exposure limits to non-ionizing HF radiation are mainly based on ICNIRP recommendations with reference limits for potential exposure to EMF [7] and STOA Commission for European Parliament (STOA, 2001) [8]. Similar studies show that cell towers transmit radiation 24 hours/day, so most people living within 15 meters radius from the tower will receive 10,000 times stronger signal than required for mobile communication [9]. They indicated also that present threshold limits prescribed by ICNIRP are considered to be rather too generous and are to be reviewed in order to comply with biological limits [10,11,12]. Some published exposure limits in Russia and some eastern European countries have been generally more restrictive than existing or proposed recommendations for exposure developed in North America and other parts of Europe [13].

The purpose of this paper is to selectively measure EM radiation generated by GSM activity and to indicate the magnitude of radiation levels at the source (antennas base stations) and at the distance both in direct and indirect line of sight. One of the main objectives is to establish some residential compliance exposure zones inside the study area in relation with international regulations and standards of GSM radiation limit

2. Methods

Assessment of exposure levels can be approached by measurement, by numerical calculation or by electromagnetic software simulation. All these methods have almost similar level of uncertainty and accuracy depending on the method and equipment or software used [14,15].

The methodology is focused on three main directions:

- Identification of a representative residential area with high density of base stations antenna and establishment of measuring sites for HF GSM [900/1800 MHz] radiation
- Power density ($\mu W/m^2$) measurements in selected areas performed with **8GHz RF EMF Strength Meter** only for down-link frequencies of the GSM cellular base stations optimized for 900 MHz, 1800 MHz.
- data analysis and establishment of some residential compliance exposure zones inside the study area. Recorded values will be related to international regulations and standards of GSM radiation limits.

Study area

Craiova is a medium-sized city located in the south-western part of Romania. Its territory stretches along the Jiu Valley and is located at the contact of Getic Piedmont and Oltenia Plain. The administrative territory covers and area of almost 85 square kilometres and has a relative plane morphology with altitudes varying between 60-120 meters.

In Craiova most GSM base stations antennas are mounted near the residential and office buildings in order to provide with good mobile phone coverage for users. A base station and its transmitting power are designed in such a way that mobile phone should be able to transmit and receive enough signal for proper communication up to a few kilometres. The cell tower transmits in the frequency range of 869 - 894 MHz (CDMA), 935 - 960 MHz (GSM900) and 1805 - 1880 MHz (GSM1800) [16].

For the purpose of this study, it was selected a central territorial unit of Craiova representative for the density of GSM base stations antenna **(fig. 1)**

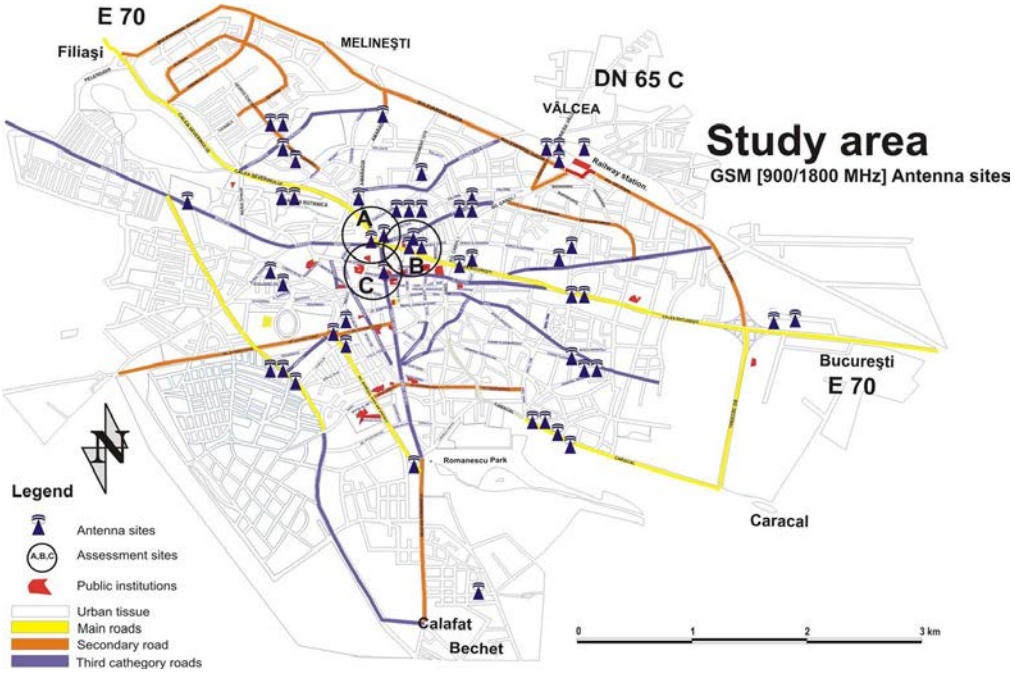

Fig. 1. Location of the main GSM [900/1800 MHz] base stations antenna inside the residential area of Craiova with the indication of the assessment sites

Measuring points were established according to the spatial location of GSM base stations antenna and the constructive typology of the residential areas. The assessment sites enabled us to measure power densities (Pd μW/m²) inside residential area and offered the technical framework necessary to compare radiation levels RF both to the distance from the source and location of the measuring points. Presented area is made up of residential, public and commercial buildings with different structural characteristics, which can influence radiation levels generated by GSM antenna sites. Base stations antenna **A** and **B** are located in an area characterised by the presence of tall buildings made of reinforced-concrete structures, while base stations **C** is located in the down town historical area where most buildings are made of bricks and stone. The study area is located at the cross-road of two important streets, Calea Unirii and Calea Bucuresti which allowed us to take measurements both with and without line of sight to the base stations antenna.

Power Density measurements (PD/μW/m²)

Measurements were performed with a 3 Axis Radio Frequency Electromagnetic Field Tester (Model: **8GHz RF EMF Strength Meter (fig. 2**). This equipment is specially developed for measuring or monitoring electromagnetic field strength, mobile phone base station antenna radiation, RF power measurement for transmitters, wireless LAN (Wi-Fi), wireless communication applications (CW, TDMA, GSM, DECT) and microwave leakage. It allows measurement optimized for 900MHz, 1800MHz, 2,7 GHz, 3,5 GHz and 8GHz with three-channel (triaxial) measurement probe. For the purpose of this study, power density measurements were performed only for down link frequencies optimized for 900 MHz, 1800 MHz.

Fig. 2. 8 GHz RF EMF Strength Meter (10MHz-8GHz frequency range)

Measurements of frequency band 900-1800 MHz were conducted in three different residential areas **(fig 3)** during 7 days from 9:00 AM to 4:00 PM, local time in Craiova, 2015. Measuring points location was established in every area at base station and at distance up to 500 meters with and without direct line of sight, indoor and outdoor of the residential buildings.

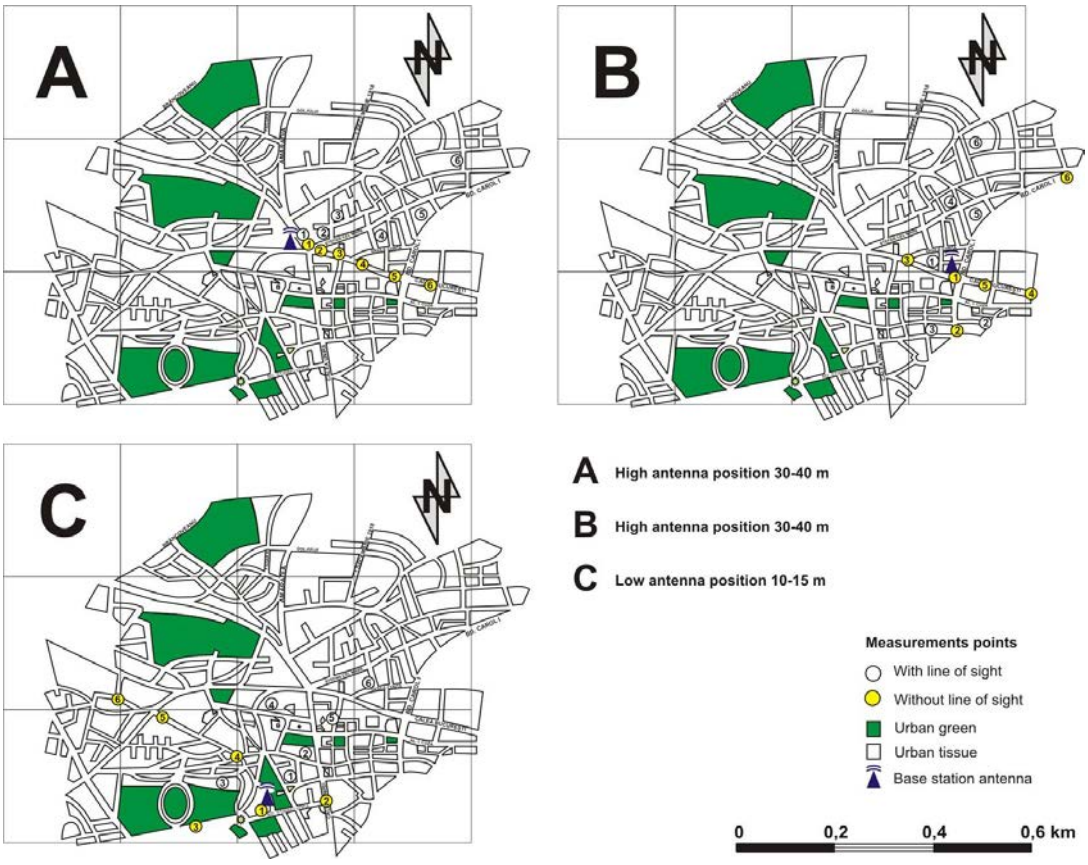

Fig.3. Measurement sites (A, B, C) for three different GSM base stations antenna in central residential area

On each day, measurements were taken every 1 minute for approximately 10 minutes at measuring points. Distance profiles were taken for selected measuring points taking into account antenna heights and spatial position. The power density levels are given in μW/m² (micro watt per square meter), with a limit of detection between 0,001-0,002 μW/m² per channel power density. Frequency selective spectrum analysis was used to obtain GSM power densities of EM. The measurements included a total of 72 locations (54 outside/18 inside) of which 18 with line of sight and 18 without line of sight. The power density of GSM downlink frequency was taken for selected location by summation to the maximum possible total power density and documentation of the distance and line of sight to the domination antenna site. The power radiated by base stations are highly dependent on the number of subscribers making calls at the same time. Thus, the measured radiated power depends on time, place, direction, distance of measurement and season.

Results

The power density values are displayed in table 1 and 2 in respect to line of sight/no line of sight. In the proximity of the antenna (<100 m) the GSM radiation levels are superior to 100,000 (μW/m²). For high antenna position (e.g. 30-40 m, pole mount position - fig. 3 A and B) the maximum power at ground level was reached in about 100 meter and is quite moderate. For low antenna position (e.g. 10-15 m, typical roof top position - fig. 3 C), the maximum power at ground level is relatively high and is reached in a range of 50-100 meter (table 2).

Table 1 - Power density levels at measuring point with and without line of sight (μW/m²)

Assessment sites		Site A (high antennas position)		Site B (high antenna position)		Site C (low antenna position)	
Measuring point number	Distance from antenna base station (m)	Line of sight (μW/m²)	No line of sight (μW/m²)	Line of sight (μW/m²)	No line of sight (μW/m²)	Line of sight (μW/m²)	No line of sight (μW/m²)
1	0	>102962.00	-	>101896.00	-	> 98068.00	-
2	100	18650.00	18050.00	18350.00	18120.00	19320.00	19280.00
3	200	6800.00	5890.00	6850.00	5250.00	7300.00	7210.00
4	300	840.00	810.00	865.00	806.00	796.00	765.00
5	400	580.00	560.00	568.00	510.00	565.00	560.00
6	500	65.00	58.00	59.00	53.00	61.00	60.00

Table 2 - Power density levels at measuring point indoor and outdoor (μW/m²)

Assessment sites		Site A (high antennas position)		Site B (high antenna position)		Site C (low antenna position)	
Measuring point number	Distance from antenna base station (m)	Outdoor (μW/m²)	Indoor (μW/m²)	Outdoor (μW/m²)	Indoor (μW/m²)	Outdoor (μW/m²)	Indoor (μW/m²)
1	0	102962.00	23023.00	101896.00	21560.00	98068.00	54250.00
2	100	18610.00	17050.00	18320.00	17896.00	19420.00	18980.00
3	200	6580.00	5990.00	6860.00	5380.00	780.00	690.00
4	300	842.00	760.00	875.00	712.00	815.00	655.00
5	400	585.00	490.00	558.00	486.00	585.00	460.00
6	500	68.00	48.00	53.00	40.00	62.00	42.00

Measured power densities are presented in table 1 and 2 with median distances of 100-500 meter, which is the range of typical residential distances to GSM base stations in medium sized cities. Data analysis indicates lowest values for PD in a range of 40.00-68.00 μW/m² at 500 meter distance from antenna base station which can be considered as residential background GSM radiation level in the central area of Craiova. At 400 metres distance profile, recorded values ranged between 460.00-585.00 μW/m², indicating a high level of EM radiation even at distance from the base station antenna. Recorded values (table 1, 2) indicate an exponential decrease of GSM power density levels with distance ranges from a maximum value of 19,610 μW/m² in a 100 meter range to a minimum value of 460.00 μW/m² in 400 meter range and under 42 μW/sq.m at more than 500 m. Table 1 indicates significant differences between the recorded values from line of sight and without line of sight at all measuring sites (A,B,C) in the study area. The differences range between 600-1,000 μW/m² and increase up to 1,200 μW/m² in Site C as a result of high conductivity of the built environment (fig. 4)

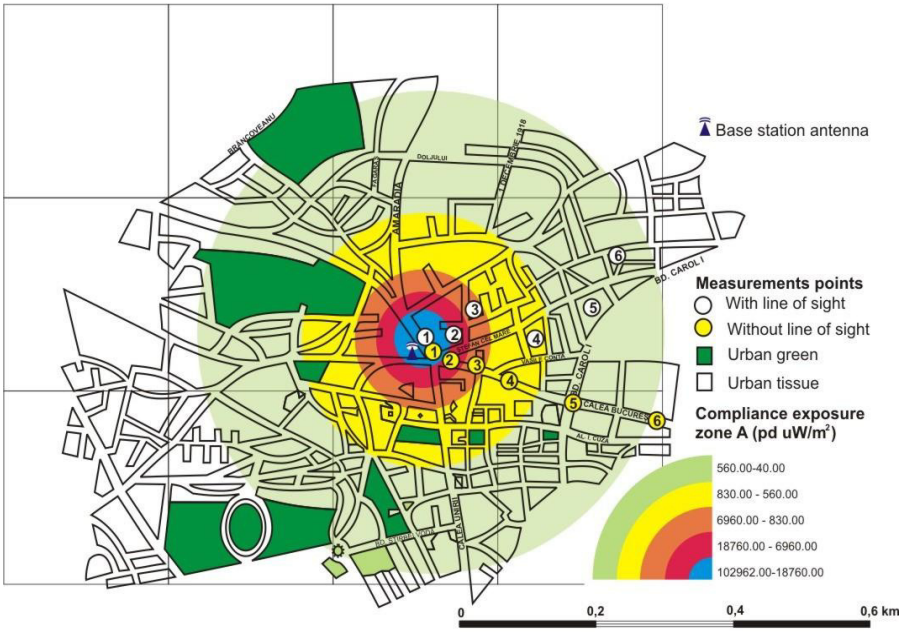

Fig. 4 - Compliance exposure levels to EM radiation in site A

Table 2 contain data recorded both outdoor and indoor and shows significant exposures in the range <100 m especially in Site C, were we noticed an exponential increase with higher values in the range of 0-100 m as a result of antennas position. The highest exposure levels in range of 10,000-100,000 μW/m² were recorded very close to low antenna (site C) both inside and outside measurement location in line of sight at <50 meters.

Exposure zones inside the study area in relation with international regulation.

Official international and national standards on exposure limits to non-ionizing HF radiation are mainly based on ICNIRP recommendations with reference limits for potential exposure to **EMF (table 3)**

In the table above "occupational" refers to operational and maintenance staff. Thus the reference levels for general public and occupational exposure to electromagnetic field are very broad. Therefore, very limited information is available on the exposure to cellular base station radiation in residential area at different distances and directions to antenna sites. At this point should be mentioned that most of the official public exposure levels are performed in broadband and not frequency selective measurements.

Table 3 - Reference levels set by ICNIRP

Type of exposure	Frequency range (f*) MHz	Power density (μW/m²)
General public	400-2000	f/200
	2000-30000	10,000,000
Occupational	400-2000	F/40
	2000-30000	50,000,000
**f – the frequency in MHz*		

Recorded data indicates that power density levels of radiated power exponentially decrease by distance to the base station antenna (fig. 4). It is important to note that the present threshold limits prescribed by ICNIRP are considered too generous. In order to establish compliance ranges within the study area, there have been grouped main categories of recorded values so as to experimentally fix compliance exposure zones far below exposure levels mentioned by ICNIRP recommendations (table 3).

Taking into account the reference levels set by ICNIRP, there have been determined 3 compliance ranges both in terms of power density EM radiations values and distances from base station antenna (table 4).

Table 4 - Levels of exposure to HF radiation in **site A**

Level of exposure	Range (m)	Pd (μW/m²)
Low	>400	<1,000
Medium	200-400	1,000-99,999
High	<100	>100,000

Compliance zone (low exposure) in which potential exposure to EMF is below the applicable limits; occupational zone (medium exposure) with potential exposure to EMF below the limits for occupational exposure but over the limits for general public exposure; exceedence zone (high exposure) with potential exposure to EMF exceeding the limits for both, occupational and general public exposure.

Conclusions

The results of this study indicate that HF GSM base station antennas are the main HF radiation source in residential area of Craiova. Average power density (PD) was in the range of 650.00-700.00 (μW/m²) with a maximum value exceeding 100,000 (μW/m²). No location exceeded the official standard of ICNIRP recommendations but many locations in this study are long term exposed to levels high above 1,000 (μW/m²), which are considered the average threshold value for non-thermal biological effects. Worlds Health Organisation (WHO) Independent Group on Mobile Phones (IEGMP) INTERPHONE and Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) recent studies has been indicated that electromagnetic radiation can contribute to heals deficiency such as increased risk of brain tumours, eye cancer, testicular cancer and leukaemia [17].

This levels were recorded mainly in the proximity of base station antenna, directly below antenna sites and in line of sight in a distance <300 meters. We can conclude that most important limiting factors are the distance and the line-of-sight to antenna site, but also constructive typology of the residential area.

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