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EXPOSURE TO NON-IONIZING RADIATION OF AREA IN URBAN ZONE OF THE BANJA LUKA CITY

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ABSTRACT

Intensity of electromagnetic pollution is followed by rapid increasing of new telecommunication technologies over the years. In order to prevent enlarged exposed of general population with doses of electromagnetic radiation above allowed for general population, living as well as working environment around antenna systems should be tested. Using sophisticated measurement equipment we measure intensity of electric field emitted from base station located at shopping center in urban zone of the Banja Luka city. Theoretical estimation of exposition was preceded to measurement procedure, resulting in mapping of exposure at different altitude around antenna system. This thorough investigation of electromagnetic pollution will become a part of typical systematic testing of high frequency non-ionizing radiation pollution. Tested area, around shopping center, where are located educational institution and sports center is found safe from emitted radiation.

Keywords: *exposition, electromagnetic pollution, telecommunication antenna system*

INTRODUCTION

Widespread of modern telecommunication systems caused increasing of electromagnetic pollution.More and more base stations with antennas surround us, especially in urban zone, where requirementfor intensity of communication signals rapidly increases. Development of new technology induces enlarging of new emitters, but not necessarily elimination of previous ones,results in higherdensity of electromagnetic radiationisalso followed by increasing electromagnetic pollution.

Effects of exposure to the high frequency non-ionizing radiation on human is not stillcompletely known [1]. Currently it is attractive topic of many modern investigations, whilefrom alreadypublished results until now were shown harmful effects on human health in the case of exceeding of determined limits for generalpopulation. Several biological effects of electromagnetic radiation are found, and between them mostly manifested iswarming of exposed tissues [1,2].

We perform systematic testing of environmental on electromagnetic pollution using experimental and theory methods. Here are presented results, obtained from investigation of total exposure over the area of shopping center Merkator, placed in Banja Luka the capital of Republic of Srpska, cowered with high frequency electromagnetic radiation (HFEMR) emitted from base station of the type DBS3900 HUAWEI.

MEASUREMENT METHODS AND PREPARATION THROUGH
THEORETICAL ESTIMATION OF HFEMR

Prediction ofplace with increased intensity of high frequency non-ionized radiation, in order to determine relevant measurements points, every time before measurements were done by calculating of total exposure,over the wide range of area around sources at differentaltitudes. Calculations of total exposure around base station (or different antenna) was performed under the consumption that emitted power from source is maximal [3]. Time dependent variation of intensity was not considered, either we know that time dependence is significant. But the applied assumption, gives best overview of the worst possible scenario of exposure during the high frequency radiation emission. Also, developed model givesspatial distribution of maximal values of electric and magnetic fields.

Theoretical predictions can be used to determine places, permanently or temporarily populated by general population, maximally exposure at certain altitude. They can be performed using different methods, among which is method of plane waves, detailly explained in [4]. Even lower than limited values at given frequency, recommended by Regulations and law, discovered of points with largest values of radiation intensity at certain altitude (*hot spot*) is beneficial for all populations.Public knowledge of their existence is long-term useful for health protection, especially if children spend time in vicinity of area that contain hot spots.Likewise,it is important todeterminealong withmapping of excessively exposed points in space surrounding source of high frequency non-ionizing radiation, as a primarily aim of performed predictions.Thefirstof all, these locations should be labeled and prohibited for staying of general population.

In order to optimize exposition of general population to the electromagnetic radiation, duration as well as distance from the source during exposition, due to the it is well known that radiation intensity in far-field approximation decreased rapidly with inverse square power of distance from source. Another relevant factor which influence on radiation level over the space is antenna diagram. Anisotropy of antennas is defined with patterns (or diagrams), which contain horizontal and vertical characteristic of spreading in vertical and horizontal plane respectively. It describes how intensity depends on angle of spreading, measured from axis of antenna'sorientation. These characteristics are peculiar for any specific antennaand originated from specification given by producer. Other data, relevant for exposure estimation,like height, mechanical angle, emitted poweraregiven by provider.

Using all previously mentioned, we are capable to predict exposure at different levels, over the large specific investigated area. This allow us to predict level of electric/magnetic field even at hardly accessible places.As it is shown on following images, total exposure over the urban area which includes shopping center, aqua park and part of student campus, is shown over the large surface at various heights.Anisotropy of antenna gives three distant separated hot spots over the tested area. Obtained results are in agreement with theoretical expectations [4, 5], that means intensity of radiation at hot spots increases with altitude between ground and level of antenna due to the approaching to the source of radiation as well as decreasing distances between hot spots and source with height. This is illustrated through array of images Figure 1 a) -d), where expositionsarerepresented as iso-lines respectivelyat 2, 5, 10 and 15 m above the ground.

From the aspect of safety, it is very important to exactly determine space around the antenna, where exposure is above allowed values for general populationas given in [6, 7]. We are able topredict positions of all points in space in vicinity of emitter,that must be avoided due to the overrun of radiation intensity and give true display. Expectedly the largest intensity of radiation is found along direction of antenna at all altitudes,as shown on images above and label as red lines Figure1. b), c) and d). It means that the lowest (A-point),as well as furthest (B-point) point in vicinity of antenna in the space shown on Figure 2., where radiation is above limit determined forgeneral population ($n \geq 1$), belongsto the plane in the direction of emitter.

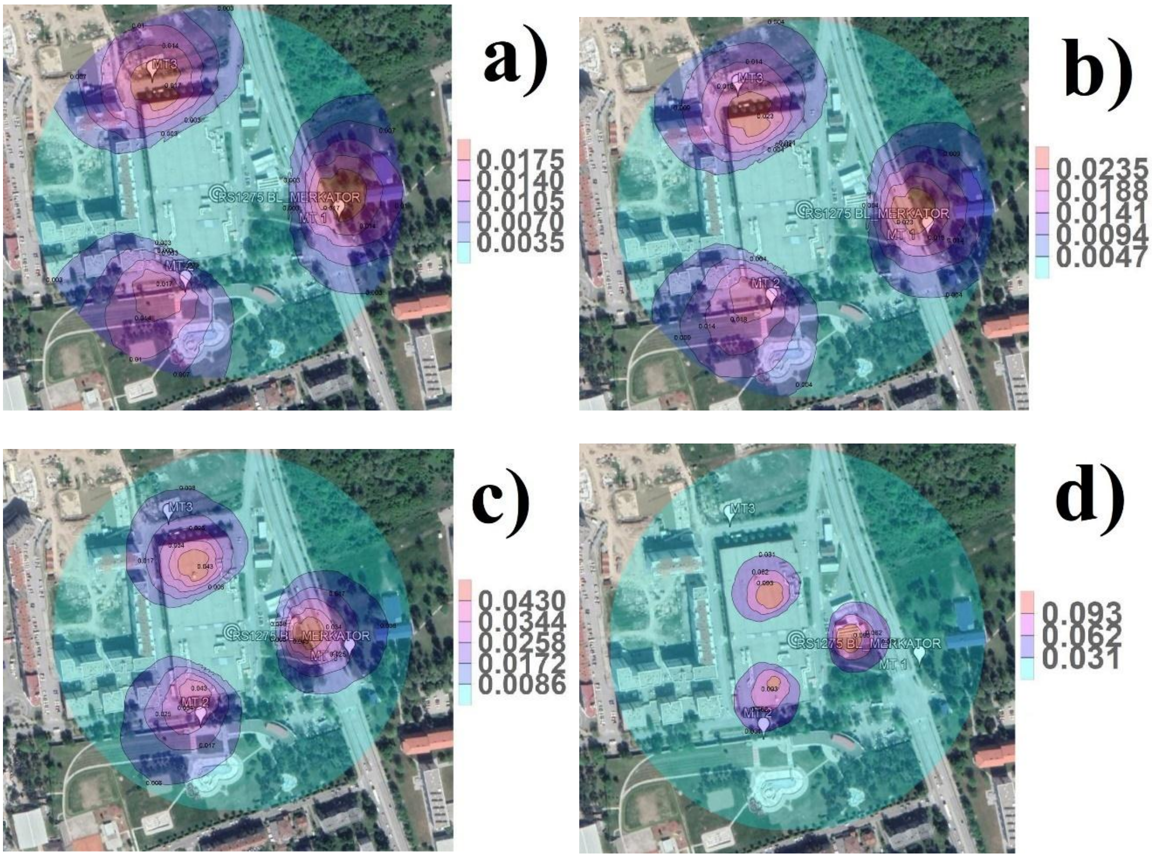

Figure 1. Estimation of exposure of target location at h=2 m
(a), 5 m (b), 10 m (c) and 15 m (d) with labeled measuring points

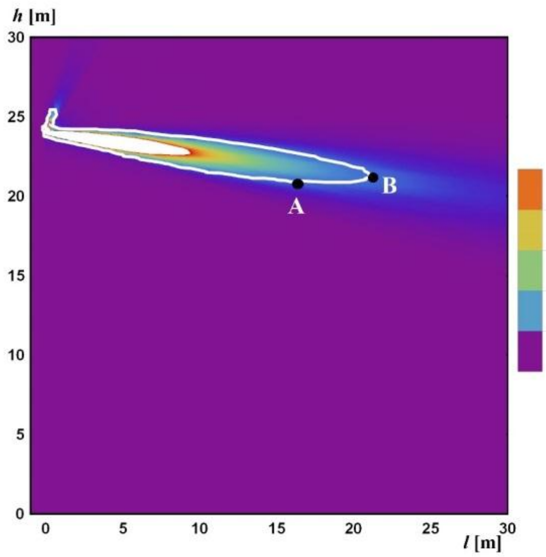

Figure 2. Plane in direction of antenna with surface, inside white curve line,
where intensity radiation is above allowed for general population

Very sophisticated equipment, used during the measurements of intensity of high frequency non-ionized radiation, contain isotropic antenna of type EMF SYSTEM TRAGBAR, connected with analyzer of type FSH8, both manufactured by Rohde & Schwarz shown on Figure 1. Antenna is sensitive to electric fields independent to the fieldpolarization, in a wide range of frequency spectra between 3 MHz and 3 GHz, and measuring range of electric field between 1 mV/m and 100 V/m. Analyzer is used for collecting, processing and presenting of measured data of electric field in the high frequency range between 100 kHz and 8 GHz.

Picture 3. Measuring equipment antenna and analyzer, used during research

Measurements at given location are performed at four different and distant point, positioned in space such that is accessible to the general population and with the highest exposure at givenaltitude as it is shown at Figure 3. a). First measurement point labeled with MT1 is at sidewalk near student campus, where mostlyexposed population are students from campus.

The MT2 is in the aqua park,during the summer mostly used by schoolchildren. Hot spot of the sector at different height is placed over aqua park, where general population including children of different ages could be exposed near the pools, at restaurant and sidewalk areas.

he third measurement point labeled with MT3 is behind shopping center Merkator, far away from main entrance, where finding of general population is rarely. Measurement pointsMT1 and MT3 are almost at equal distant from the BSl $= 132.4$ m and l $= 138.5$ m respectively, positioned at the main directions of radiation.

RESULTS AND DISCUSSION

All measured and calculated values of total exposure are estimated in accordance with valid Regulationsas well aswith requirements of Standard. In order to obtain information about presented high frequency non-ionized radiation in particular frequency range, every timeat beginning of measurement are performed by scanning of radiation spectra at given location. Obtained reports like one presented below Figure 4., gives overview of radiation intensity dependence on frequencyover the whole measurementspectra.

Measured values are in the proper way expanded in accordance with measurement uncertainty and specific requirements of individual technologies. Consequently, from the measured values of electric field E_f,objective estimated values $E_{f,max}$are obtained. Other relevant values, that describes exposure to the electromagnetic radiation,as intensity (S), average values of total elelctric field $\Sigma \mathrm{E_{uk}}$ and total factor of exposure are received from $E_{f,max}$, whosereview is given in the table below.

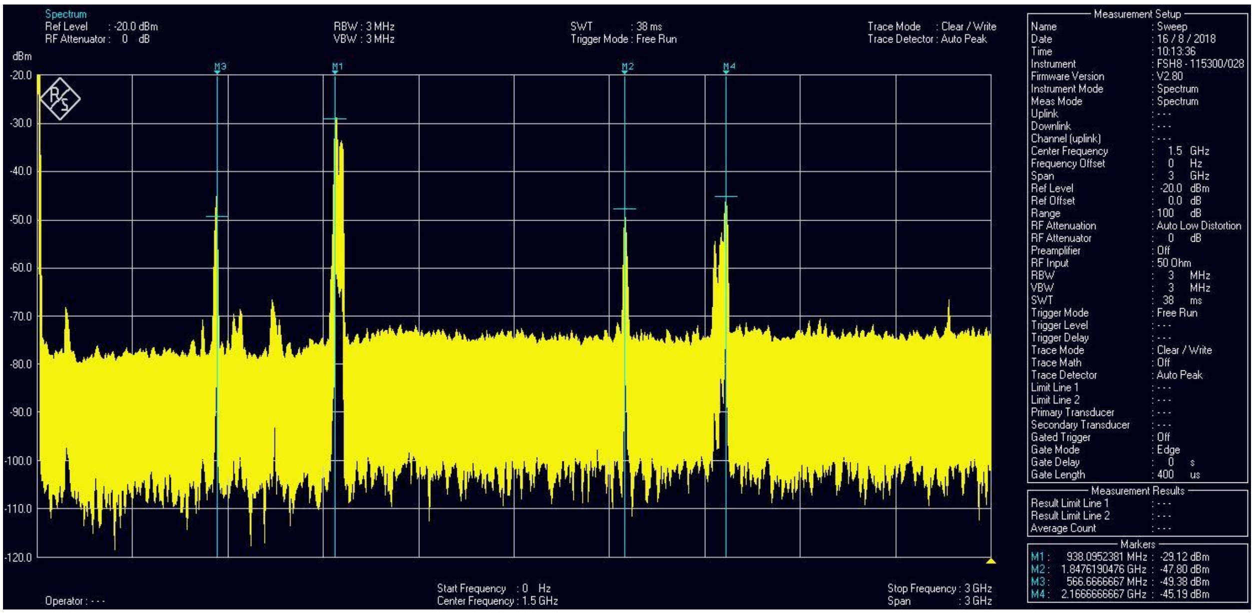

Figure 4. Frequency spectra of radiation emitted from base station RS 1275 BL_MERKATOR at MT3

Table 1. Overview of measuredvalues of electric field (E_f) generatedfrom different technologiesof telecommunication network, accompanied with prediction of maximal electric field ($E_{f,max}$), magnetic field (H), intensity of electromagnetic radiation (S), average intensity of total electric field (ΣE_{uk}) and total factor of exposure related with general population (n)

MT	Frequency range	$E_f\,[V/m]$	$E_{f,max}$ $[V/m]$	H $[mA/m]$	S $[mW/m^2]$	ΣE_{uk} $[V/m]$	n
1.	DVBT_Ch21-66	0.0422	0.0557	0.1478	0.0082	1.8854	0.008905
	GSM1800	0.0248	0.0655	0.1737	0.0114		
	GSM900	0.2554	0.4768	1.2646	0.6029		
	UMTS_2100	0.3358	1.4017	3.7180	5.2116		
	UMTS_900	0.2789	1.1642	3.0880	3.5950		
2.	DVBT_Ch21-66	0.0371	0.0490	0.1299	0.0064	1.7316	0.005881
	GSM1800	0.0894	0.2360	0.6260	0.1478		
	GSM900	0.1729	0.3228	0.8561	0.2763		
	UMTS_2100	0.3783	1.5791	4.1886	6.6142		
	UMTS_900	0.1402	0.5852	1.5523	0.9085		
3.	DVBT_Ch21-66	0.0937	0.1237	0.3281	0.0406	3.6842	0.043595
	GSM1800	0.1008	0.2661	0.7059	0.1878		
	GSM900	0.4114	1.0861	2.8809	3.1289		
	UMTS_2100	0.3565	1.4881	3.9472	5.8739		
	UMTS_900	0.7611	3.1770	8.4270	26.7726		

All experimentallyobtained results,evaluated from the measured values given in third columnof Table 1., as well as theoretical prediction, show that typical values of electric field over the whole populated area is far below limit value for general population. In this regard, exposition caused by radiation of any individual technology, developed for telecommunication purpose, is much weaker than total. Measured values of total exposure at different points is in accordance with theoretical prediction. For example, at measurement point MT 1 total exposure is around 0.01 that is about 30% lower than theoretically estimated values at the given point.

CONCLUSION

In a proper way we demonstrated systematicallyexamination of the exposure of livingenvironment to the irradiation with non- ionizinghigh frequency electromagnetic field,applied both measuring and theory methods.All mentioned techniques confirmed presence of approximately 100 times lower level of high frequency electromagnetic field at tested location, emitted from base station positionedat the roof ofshopping center Merkator in Banja Luka, Republic of Srpska (BiH). It isvery important to emphasis that presented complementary methods, that have been developed in our team, such thatobtained results from theoretical predictions and measured data are in good agreement.

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