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THE PHYSIOLOGICAL AND ENVIRONMENTAL POTENTIAL EFFECTS OF GSM TECHNOLOGY

POTENŢIALE EFECTE FIZIOLOGICE ŞI ENVIRONMENTALE ALE TEHNOLOGIEI GSM

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Abstract: The present study aims at analysing the level of exposure to non-ionizing radiation for the population of the cities. 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. The study is based on the statistical evaluation and research of relevant scientific contributions, both stressing upon UN and European Parliament Regulations. There are considered the average threshold values for non-thermal biological effects in order to establish the potential risk for harmful exposure inside cities. Finally, there are considered some prevention and minimization procedures for residential exposure as long as non-thermal effects are not considered in any official standard and guideline.

Key-words: *non-ionizing radiation, electromagnetic radiation, GSM, bio-active, non - thermal effects, residential areas, environment*
Cuvinte-cheie: *radiaţii non-ionizante, radiaţii electromagnetice, GSM, bioactiv, efecte non - thermal, zone rezidenţiale, mediul*

I. INTRODUCTION

Nowadays we are facing more and more electromagnetic polution as a consequence of the increasing number of eletromagnetic sources and specifically electromagnetic emitters needed for covering wider territorial areas. I this respect, cities face the most intense electromagnetic pollution in terms of non-ionizing radiation due to the presence of a large variety of sources. EM radiation from the transmitters for mobile communication is one source which registered constantly growing in last years as the high density of buildings and reinforced concrete strutures are among the barriers in mobile comunication within city. Present studies point out that significant biological effects result form the non-thermal effects of extremely periodic – pulsed - HF radiation used by digital cellular and cordless phone systems worldwide. Official international and European standards and safety

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guidelines (based on ICNIRP recommendations) are taking into account the risk of thermal effects of high energy HF – radiation only by broadband and not frequency selective measurements. These type of measurement would be necessary in order to differentiate the cellullar base station downlink frequencies from other radiation sources such as FM radio or TV transmitters. Therefore, very limited information is avaialable on the exposure to cellular base station radiation in residential areas at different distances and direction to antenna sites.

II. RESULTS AND DISCUSSIONS

The potential health and environmental effects of EM radiation from the transmitters for mobile communication are the subject of on-going researches. There are to be mentioned contributions of Hauman, T; Munzenberg, U., 2003 which focus on the HF – radiation levels of GSM cellular phone towers, Hirata, A, 2009 with the estimation of core temperature elevation in humans and animals, Giliberti C., F. Boela with electromagnetic mapping of urban areas. There were also been made direct studies concerning the assessment of human head exposure to wireless communication devices which combined electromagnetic and thermal studies for diverse frequency bands by Zygiridis, T. T. and T. D. Tsiboukis 2008, but also investigation concerning the interaction between human head and a smart handset for 4G mobile communication systems by Mahmoud, K. R., M. El-Adawy, S. 2009 and RAYmaps (Fig. 1).

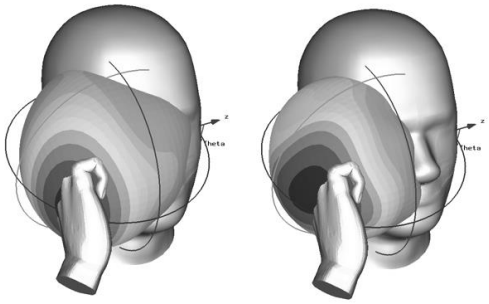

Fig. 1 GSM Band Antenna Radiation Pattern from a Cell Phone in Presence of Head and Hand

(http://www.raymaps.com/index.php/some-common-antenna-radiation-patterns/)

Recent studies focused on the direct impact on brain such are the contributions of M. B. and R. S. Kshetrimayum, with SAR reduction in human head from mobile phone radiation using single negative metamaterials in 2009, as also Ozdemir, A. R., with Radio frequency electromagnetic fields levels in urban areas of Istanbul, Ankara and Izmir and protection techniques.

Most of these studies are concerned with the levels of EM radiation effects of the devices operating in GSM bands in the crowded residential areas trying to assess and estimate de potential impact.

The analysis of physiological effects of GSM technology should be preceeded by the basic understanding of electromagnetic radiation (EMR).

Wireless communication links using the frequency of Electromagnetic Spectrum, have been used as solutions for connectivity in point-to-point and point-tomultipoint applications. The most common wireless solutions are represented by AM and FM radio, television broadcast stations, mobile and cellular phones, radar and microwave systems. The electromagnetic (EM) spectrum contains an array of electromagnetic waves increasing in frequency from Extremely Low Frequency and Very Low Frequency (ELF/VLF), through Radio Frequency (RF) and Microwaves, to Infrared (IR) light, Visible Light, Ultraviolet (UV) light, X-rays, and Gamma rays (Zamanian and Hardiman, 2005) (Fig. 2).

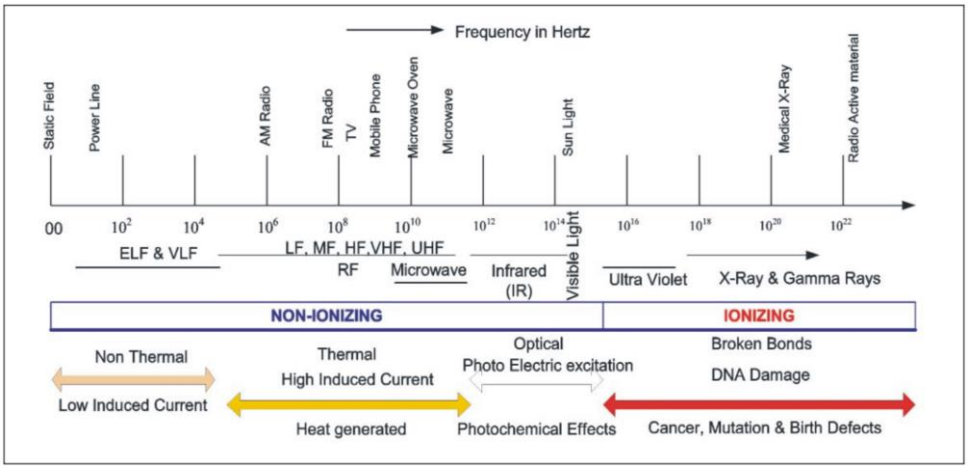

Fig. 2. Graphical representation of the spectrum of electromagnetic energy or radiation in ascending frequency (decreasing wavelength). The general nature of the effects is noted for different ranges (Ali Zamanian, Cy Hardiman, 2005)

Ionizing Radiation

According to the final report of UNSCEAR 2008 (UNSCEAR, 2008) ionizing radiation is considered to carry sufficient electromagnetic energy to strip atoms and molecules from the tissue and alter chemical reactions in the body (converting molecules totally or partly into ions). X-Rays and Gamma rays are two forms of ionizing radiation. These rays are known to cause damage, which is why a lead vest must be worn when X-rays are taken of our bodies, and heavy shielding surrounds nuclear power plants (Fig. 3).

The natural occurence of this types of radions is known as natural backgroud radions and consists mainly of: visible light, ultraviolet light and infrared light (sunlight), different radioactive materials on the earth's surface (contained in coal, granite, etc.), radioactive gases leaking from the earth (radon) but also cosmic rays from outer space entering the earth's atmosphere through the ionosphere and natural radioactivity in the human body.

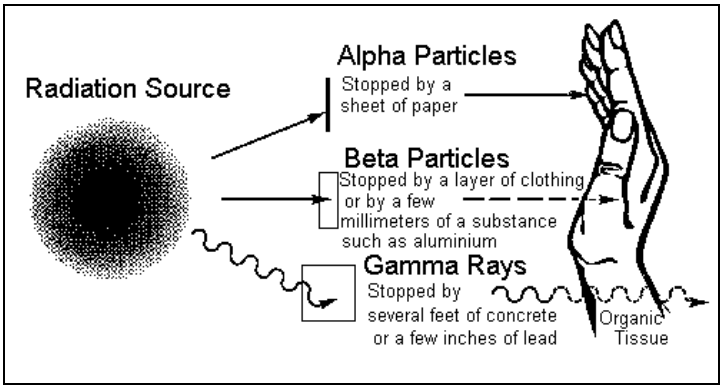

Fig. 3. The Penetrating Powers of Alpha and Beta Particles and Gamma Ray
(http://www.ndhealth.gov/AQ/RAD/ionize.htm)

Non-Ionizing Radiation

The lower part of the frequency spectrum with non-ionizing Electromagnetic Radiation (EMR) effect is characterized by energy levels below that required for effects at the atomic level. In this respect should be mentioned static electromagnetic fields from direct current (0 Hz), low-frequency waves from electric power (50-60 Hz), radio frequencies (RF), including Low Frequency (LF), Medium Frequency (MF) High Frequency (HF), Very High Frequency (VHF), Ultra High Frequency (UHF) and Microwave (MW) and Millimeterwave (30 kHz to 300 GHz), Infrared (IR) light, Visible light and Ultraviolet (UV) light (above 300 GHz) (UNSCEAR, 2008).

There is to be noticed that some heating effect is generated by all of these waves but they produce insufficient energy so to cause any type of damage to human tissue.

In some cases the studires pointed out that it is probable that higher power densities, such as those densities very near high-voltage power lines or high-power (megawatt) broadcast transmitters, could have long-term health effects and become harmful. In this respect is to be considered the contribution of scientific article Nerve Cell Damage in Mammalian Brain after Exposure to Microwaves from GSM Mobile Phones and Hauman, T; Munzenberg, U., with HF – radiation levels of GSM cellular phone towers.Most of the measurements concerning GSM radiation were carried out on narrow band regions of interest (GSM900 and GSM1800) and focused on the downlink frequencies of the GSM cellular base stations **(**Fig. 4**)**.

The power density of any source of EMR is related both to the power level at the source, and to the rapid increase as the distance from the source decreases.

The large scale usage of cell phones is of great concern as more and people are using cell phones whose antennas radiate near a person's head. Cell phones, however, radiate very little power. So, even while close to the head, they are not considered a danger. Some studies suggest that potential health hazards

could be linked to excessive exposure to high-power densities of non-ionizing radiation.

The percentiles of the power density levels **(**Table no. 1**)** measured by Haumanna and Muzenberg, point out a medium distance of 150 meters from the GSM cellular tower base which is considered the range of typical rezidential distances to GSM base station in larger cities.

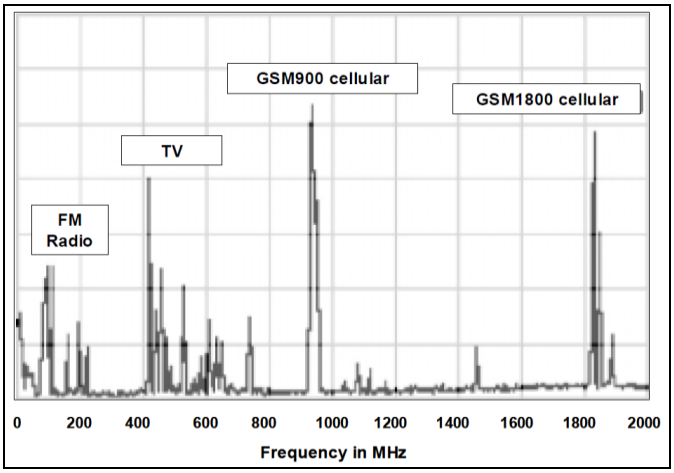

Fig. 4. HF – spectrum analysis (Haumann and Muzenberg, 2011)

Table no. 1. Density levels (percentiles) measured at a GSM cellular tower base station (Haumann and Muzenberg, 2011)

	Total	**With line of sight**	**Without line of sight**	**Outside**	**Inside**
Number of measurements (n)	**272**	177	95	140	132
Distance in meter (median)	**150**	100	250	200	100
Power density in µW/m^2					
Mean	**1,800**	2,650	130	1,150	2,450
20th percentile	**10**	70	2	20	10
50th percentile (median)	**200**	430	20	200	170
70th percentile	**640**	1,700	70	580	640
90th percentile	**3,400**	5,200	280	3,260	3,770
95th percentile	**6,300**	8,500	610	6,490	5,330
99th percentile	**23,000**	25,000	1,340	12,350	32,000
Maximum	**103,000**	103,000	2,200	14,400	103,000

Statistical measurememnts carried out by Haumann and Muzenberg, pointed out that the 20th percentile value is 10µW/sq.m and can be considered as residential background of GSM radiation level, while 95th percentile is observed at 6300 µW/sq.m and can be considered a significant exposure radiation level **(**Fig. 5).

The diferent levels of exposure in residental areas can be achieved by swiching mesurements conditions. Generally, the radiation exposure is predominantly determined by several parameters:

- distance (m) to the antenna site
- types of antennas – omnidirectional ori directional antennas
- number, power and orientation of the antenna
- capacity of the antenna (number of channels and frequencies
- vertical distance between location and antenna site
- type of building structure (reinorced concrete, steel, glass)
- degree of environmental reflection

The studies (Haumann et al., 2002) indicate an exponential decrease of GSM power density levels with distance ranges from 5327 µW/sq.m in a 50 m range to 2576 µW/sq.m in 50-100 m range and under 15 µW/sq.m at more than 750 m (Pachuau et al., 2014).

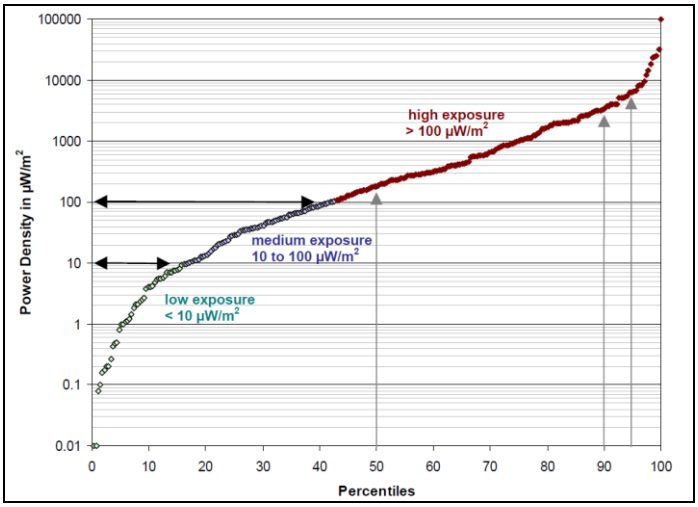

Fig. 5. Exposure levels to HF radiation of a GSM cellular tower base station (Haumann and Muzenberg, 2011)

The **biological effects** of HF radiation are proportional to the rate of energy absorption, and the level of absorption varies little with frequency. HF radiation has the ability to heat human tissue, much like the way that microwave ovens heat food, and can be hazardous if the exposure is sufficiently intense or prolonged. Damage to tissue may be caused by exposure to high levels of RF energy because the body is not equipped to dissipate the excessive amounts of heat generated. Possible injuries include skin burns, deep burns, heat exhaustion and heat stroke. Eyes are particularly vulnerable to extended exposure to RF energy; the lack of blood flow to cool the cornea can result in cataracts (Hyland, 2001).

The **biological effects** of HF radiation are quantified through the so-called specific absorption rate, or *SAR* - the rate at which the external electromagnetic field deposits energy in unit mass of the body, averaged over a certain period of time. It is generally believed that for *humans* adverse effects can arise only from excessive heating. This is reflected in the relative leniency of the Safety Guidelines2 issued by the International Commission for Non-ionising Radiation Protection (*ICNIRP*), which

permit humans to be exposed to electric fields that are *over ten times stronger* than the limit of 3V/m, limit that is applicable to all electronic goods offered for sale in *EU* under current *EMC* legislation on electromagnetic compatibility (*EMC*).

The **bio-active functions** of low intensity, pulsed microwave radiation currently used in *GSM* can exert non-thermal influences on the alive human organism because microwaves are *waves*, and they have properties other than solely intensity. In particular, *GSM* radiation has certain rather well defined frequencies, which facilitate its discernment by the living organism, and *via* which the organism can, in turn, be affected. This is so because the *alive* human organism itself supports a variety of oscillatory electrical biological activities, each characterised by a particular frequency, ***some of which happen to be close to those used in GSM!*** (European Parilament - STOA, 2001)

More over, there are clear evidence (Fröhlich, 1998) that adequately metabolising systems themselves support highly organised, oscillatory electrical activities at the cellular level, whose frequencies generally lie in the **microwave** band, in terms of which the dramatic effects of ultra-low intensity microwaves of specific frequencies on processes as fundamental as cell division and intercellular communication can be understood in a rather natural way (Hyland, 1998). It should be noted that this endogenous microwave activity is a quite general (nonequilibrium) prediction of modern, non-linear biophysics (Fröhlich, 1980) for living systems, under appropriate metabolic conditions.

Health of some people *is* adversely affected in various ways when they are exposed to this kind of radiation, despite its intensity being ***well below*** existing safety limits based on consideration of the *SAR*.

There is documented evidence (Goldsmith, 1995; Goldsmith, 1997) that long-term (involuntary) exposure to microwave radiation of intensities intermediate between that realised near an active phone and that found in the vicinity of a base-station (but at somewhat different carrier frequencies than used in *GSM*) *does* causes serious illness, such as *leukaemia* and *lymphoma*, in certain exposed people.

A good indicator of the potential harmful effects of the pulsed microwave fields emitted by base-stations is the increasing number of published reports of adverse effects on the health and well-being of various animal species, specifically cattle, dogs, birds and bees. In the case of the affected cattle reported in one particular study (Löscher and Käs, 1998), the cattle (which were found to line up, all facing away from the mast) displayed a variety of problems, including severely reduced 17 milk yields, emaciation, spontaneous abortions, and still births. Especially relevant are the following facts: (*i*) the condition of the cattle was found to improve dramatically when they were removed to pastures well away from the mast, only to deteriorate again once they were brought back, (*ii*) the adverse effects appeared only *after GSM* microwave antennae had been erected on a tower that had formerly been used to transmit only (analogue) TV and radio signals, associated with which there had, in this case, been *no* evident health problems. It should be noted that this is not an isolated occurrence, similar problems with cattle being reported from elsewhere (Firstenberg, 1999). In the case of domestic canine pets, there are a number of anecdotal reports of their

immune systems being adversely affected, again in a *reversible* way. Finally, there are reports of declines in bird and bee populations following the commissioning of new base-station masts.

It should be noted that the occurrence of adverse effects in *animals* is particularly significant, in that it indicates that the effects are real, and not psychosomatical, as is often claimed, in the case of human exposure, by those who maintain that base-station radiation is harmless. Furthermore, given that animals are often more highly electrosensitive than are humans, the serious nature of the health problems they have manifested over such a relatively short period of time could well portend a correspondingly serious noxiousness in the case of *long*-term exposure of humans, and constitute a valuable early-warning system, similar to the 'canary down the mine'!

A selection of some *in vitro* studies (Hyland, 2001) is given below:

- Epileptic activity in rat brain slices in conjunction with certain drugs (Tattersall, 1999),
- Resonant enhancement of cell division in the yeast, *Saccharomyces cerevisiae* (Grundler and Kaiser, 1992),
- Resonant effect on the genome conformation of *Escherichia coli* cells (Shcheglov, 1997),
- Synchronisation of cell division in the yeast *Saccharomyces carlsbergensis*19 and in *E. coli* (Belyaev, 1994),
- Alteration in the activity of the enzyme orthinine decarboxylase (*ODC*) (Byus, 1988; Litovitz, 1993),
- Reduced efficiency of lymphocyte cytoxicity (Lyle et al., 1983; Nageswari, 1996),
- Increased permeability of the erythrocyte membrane (Savopol et al., 1995; Sajin et al.,1997),
- Effects on brain electrochemistry (calcium efflux) (Bawin et al., 1975; Blackman et al., 1978),
- Increase of chromosome aberrations and micronuclei in human blood lymphocytes (Garaj-Vrhovac et al.),
- Synergistic effects with cancer promoting drugs such as phorbol ester (Balcer-Kubiczek and Harrison, 1991).

In vivo evidence of non-thermal influences, mainly under exposure to actual GSM phone radiation, comes predominantly from animal studies (Hyland, 2001):

- Epileptiform activity in rats, in conjunction with certain drugs (Sidorenko and Tsaryk, 1999)
- Depression of chicken immune systems (melatonin, corticosterone and IgG levels) (Youbicier-Simo et al., 2003)
- Increase in chick embryo mortality (Youbicier-Simo et al., 1999)
- Increased permeability of the blood-brain in rats (Salford et al., 1994)
- Effects on brain dopamine/ opiate electrochemistry (Repacholi et al., 1997)

- Increases in *DNA* single and double strand breaks in rat brain (Repacholi et al., 1997)
- Promotion of lymphomas in transgenic mice (Lai et al., 1987)
- Synergistic effects with certain psychoactive drugs (von Klitzing, 1995)
- Stressful effects in healthy and tumour bearing mice (Lai, 1996)
- Neurogenetic effects and micronuclei formation in peritoneal macrophages in mice (Lai, 1996)

III. CONCLUSIONS

Safety Guidelines based solely on consideration of the *SAR*, afford no Protection against the ***frequency***-specific90 effects, since they limit only the

intensity of the microwave radiation sufficiently to ensure that tissue heating by absorption of energy from the microwaves is not in excess of what can be coped with by the body's thermoregulatory mechanism, so that temperature homeostasis is not compromised.

It is to be stressed that this is **not equivalent to denying the existence of non-thermal influences of** this kind of radiation, or their potential to provoke adverse health reactions - as is often maintained by the Mobile Phone Industry – but simply that in *ICNIRP*'s view (because for the reasons stated) such effects cannot be used as a basis for setting exposure limits.

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