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# A COMPARATIVE STUDY OF IONIZING AND NON-IONIZING RADIATION LEVELS IN BRAŞOV

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***Abstract:*** *A group of residents of a new apartment block have health problems with symptoms similar to those produced by strong electric fields. Such problems arose in an area in close proximity to a group of antennas. This paper presents the results of ionizing and non-ionizing radiation measurements in the most used frequency range. The results are compared with the limit values allowed by national and international legislation and with values measured in a different location. The chosen location is similar to an apartment in a crowded area. The results of measurements lead to the conclusion that non-ionizing radiation level is within acceptable limits but the radon level is within the attention limit.*

***Key words:*** *non-ionizing radiation, ionizing radiation, radon level.*

## 1. Introduction

People are worried about radiation health effects due to the increasing number of antennas and the media which won't tackle the issue consistently. A group of residents in the immediate vicinity of antennas, as seen in Figure 1, exhibited symptoms which they suggested were due to a very strong electric field.

Fig. 1. *Location of measurements*

The antennas are placed on the Pedriatic Hospital of Brașov, although some research [7] urges caution regarding children's exposure to electric fields because of the developing nervous system.

Radiation is classified into:

1. Non-ionizing radiation (electro-magnetic) with health effects that are still under discussion, yet the carcinogenic effects could not be proved [12].
2. Ionizing radiation have shown carcinogenic effects.

Electromagnetic field measurements were made in two frequency ranges in which the field strength is greater, in the low frequency range around 50 Hz and in the high frequency range for mobile communications.

Ionizing radiation measurements were made with a Geiger Muller counter which determines the total amount of radiation

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and an electronic detector that measures the concentration of radon in air.

Various measurements were performed in different locations, usually following a single type of radiation. The results of electromagnetic field measurements in the frequency ranges for mobile communications CDMA800, GSM900, GSM1800, and 3G, in 5 cities in Australia, at distances between 50 and 500 m for 60 stations (base station), indicated that the measured levels were low, at around 2% from the limit allowed [3]. The same frequency range was used and the symptoms were analyzed for a group of 365 people [4].

The difficulty of distinguishing between the effect of the electromagnetic field and the psychological effect created by the proximity of antennas was mentioned. Mantiply et. al [6] have measured the average level of electric and magnetic fields in homes and offices in Sweden and Norway. The maximum values ranged from 54 V/m and 15 V/m [7] looked at a wide range of frequencies between 10 kHz and 30 GHz, and a wide range of field sources, the highest value being 500 V/m recorded in the vicinity of an antenna. Some significant results related to the measurement of ionizing radiation have been reported for a city in India where house building materials had a radon level of 89 $Bq/m^3$ and radiation dose of 0.8 mSv/year [1]. Another study has shown that in schools from Slovenia, the average radioactivity of radon produced is 168 $Bq/m^3$, yet there is a small percentage of schools from Slovenia in which the level reaches the attention value of 400 $Bq/m^3$ [8].

## 2. Measuring Equipment and Methods

The electric field measurements were performed with two spectral analyzers, one in the 1 Hz - 1 MHz range (NF 5010) and one in the 1 MHz - 6 GHz range (HF 6060). The analyzers are portable, store a number of measurements and can transmit measured data through a USB connection to PC. Data acquisition with allows further processing in Excel which contributes to understanding the electrical phenomena.

The Geiger Muller counter produced by Black Cat System measures the total amount of ionizing radiations. The counter can detect alpha, beta, and gamma radiations, including X-rays. The counter has an interface with the host computer and is powered by the interface. The software measures the number of discharges produced by ionizing particles in CPM (Counts Per Minute) but can transform this in more common units, such as the radiation level and dose level.

Radon is measured by an instrument produced by National Safety Products (USA) with a concentration range from 0.1 to 999.9 pCi/L. The sensor used is an ionization chamber supplied with 250 V DC in which alpha radiation produce a pulse counted by the digital processing system of the apparatus. The software transforms the transducer indication to particle concentration.

The device is approved in constructive terms by UL and CSA. The Bowser Morner accuracy test from 2004 shows that the precision of the measurements qualifies for EPA (US Environmental Protection Agency) standards which require an error less than ± 25%.

The measurements of the electric field and the radiation with the Geiger Muller counter were made over a period of 24 hours. The number of samples was different for each measurement due to the time it took to obtain them. The results were saved using software programs specific to each device and downloaded into Excel where some calculations were made: conversion of the measuring units, arithmetic mean and graphics. The graphs presented in the paper do not contain all samples taken in order to simplify the representation. Radon concentration measurement was done over a period of 72 hours because in the first 48 hours the electronic device does not show the results, which are irrelevant. In the last 24 hours samples were taken from 2 to 2 hours.

## 3. Measurement of High Frequency Electric Field Intensity

Figure 2 shows the measurement results in the 400 MHz - 2100 MHz range covering mobile communications. In Romania mobile communications are in the 900 MHz and 1800 MHz (2G) and 2100 MHz (3G) bands. Cosmote has communications also in the 450 MHz band.

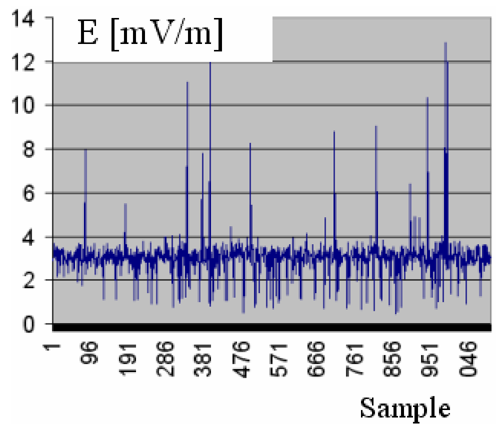



Fig. 2. *Electric field strength in the 400-2100 MHz range*

The frequencies at which the maximum field values were obtained are given in Figure 3. It can be seen in Figure 3 that most peaks are in the 900 MHz band, and then in the 2100 MHz band.

Field measurement results are given in Figure 4. A lower field strength was observed, therefore a scaled graph was superimposed on the chart, the peak value being 0.3 mV/m.

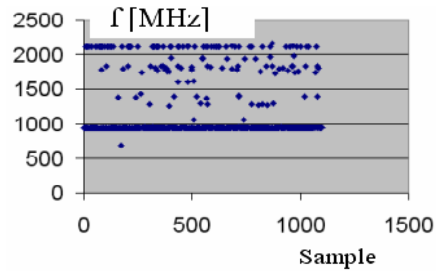



Fig. 3. *Frequencies at which field peaks occurred*

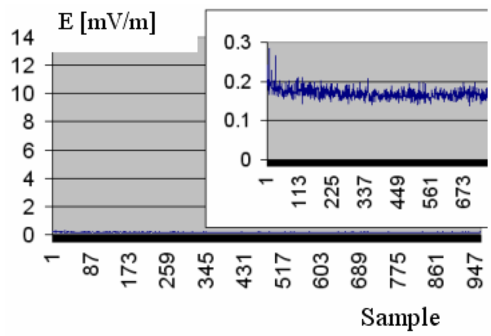



Fig. 4. *Electric field strength in the 400-2100 MHz range in the witness location*

The frequencies at which the field peaks occurred are mostly at 900 MHz and less at 1800 MHz. In this location there are no peaks for 3G communications.

## 4. Measurement of Low Frequency Electric Field Intensity

The electric field intensity of low frequency, around the 50 Hz value, is given in Figure 5.

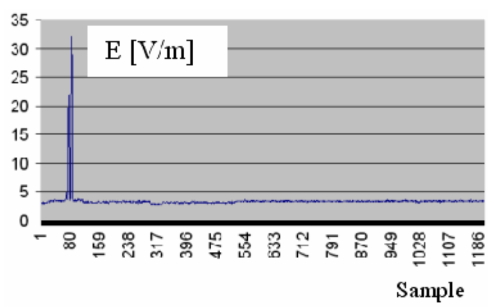



Fig. 5. *Electric field intensity in the 47-52 Hz range*

The uniformity of the electric field can be observed, excepting in the initial part where variations were caused by the presence of operators near the measuring probes.

Most of the field peak values were recorded at a frequency of 49 Hz, as seen in Figure 6.

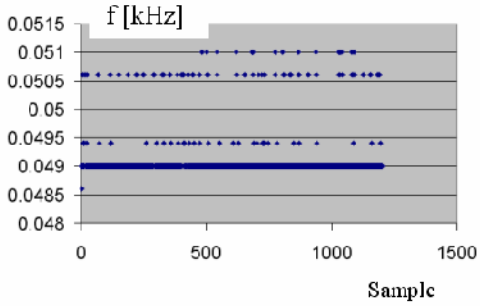



Fig. 6. *Frequencies at which field peak values occurred*

The field intensity graph in the witness location is seen in Figure 7 and presents the same characteristics as the location under test, the value of the field being smaller.

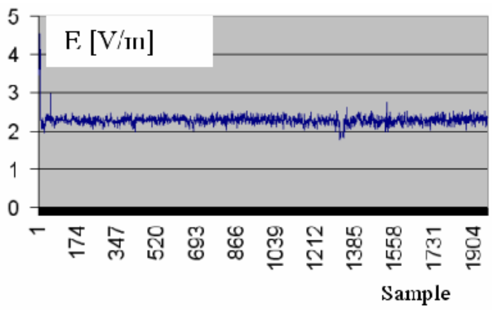



Fig. 7. *Electric field intensity in the 47-52 Hz range in the witness location*

## 5. Measurement with Geiger Muller Counter

The radiation dose measured with the Geiger Muller counter was expressed in μSv/h and is presented in Figure 8 for the marked location and in Figure 9 for the witness location.

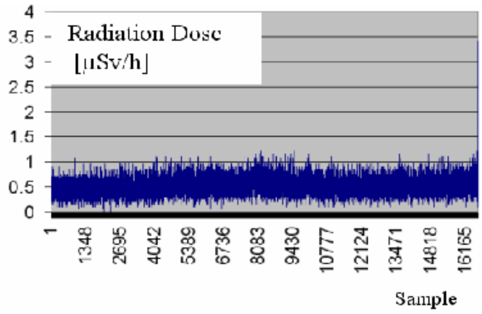
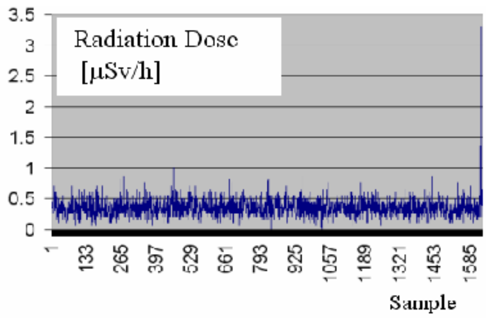
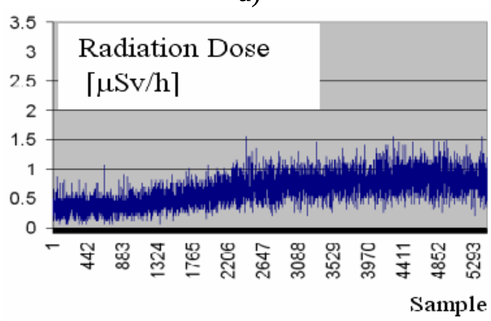



Fig. 8. *Radiation dose in the marked location*

In the witness location several measurements were made, Figure 9a and 9b. As one of them shows, represented in Figure 9b, a significant increase in radiation dose was observed, as the average value has increased from 0.35 μSv/h to 0.632 μSv/h for a period of 24 hours, due to the occurrence of maximum solar activity (January 2012). The mean values were close in the marked location and in the witness location.




a)




b)

Fig. 9. *Radiation dose in the witness location*

## 6. Radon Concentration Measurements in Air

Radon develops as radium, which is disintegrated, which occurs by decay of Uranium-238 contained by Earth's crust. In the outside air the concentration depends on the soil, air currents etc. and ranges from 0.2 to 0.7 pCi/L. The risk of disease is very low. A high concentration is found around uranium mines. In buildings the concentration is higher on the ground floor and underground and depends mostly on the soil, the building materials and ground insulation. The building type and the used materials as well as the ventilation system affect the radon concentration.

Measurement results of radon in air are given in Figure 10, the upper line is for the marked location and the lower is for the witness location.

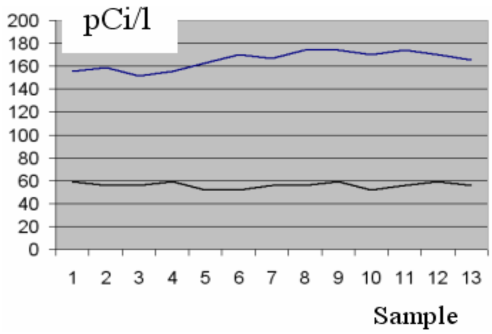



Fig. 10. *Radon concentration in air in the marked location (the graph above) and in the witness location (the graph below)*

The SI unit of measure is Bq/$m^3$ but the Safety Siren 3 device displays the concentration in pCi/L. The conversion from pCi/L to Bq/$m^3$ is done using the relation 1 pCi/L = 37 Bq/$m^3$.

Exposure to radon on the inside creates a significant risk of disease, as 3000 cases of cancer are reported each year. Radon is the second cause of developing lung cancer after smoking. The measured value in the marked location is much greater than the normal.

## 7. Results and Discussion

The limits for electromagnetic fields have been established for Europe [9] and for Romania [11]. The limits for population [11] depend on the frequency, so in the 0.025 kHz - 0.8 kHz range the limit is 250/f, and in the 400 MHz - 2000 MHz ranges the limit is 1.375 $f^{1/2}$.

The electric field intensity measurements at high frequency are summarized in Table 1, in mV/m.

The measurements were made on different days, the average value of the electric field varying according to the communication traffic. Thus, the following average values were recorded: 12.84, 5.38, 7.98, 24.97 and 24.29 mV/m.

Table 1

*Electric field intensity measurements at high frequency*

| Average value | Average value witness location | Allowed value |
|---|---|---|
| 3.05 | 0.17 | 40000 |

The measurements for the low frequency electric field intensity are summarized in Table 2, in V/m:

Table 2

*Electric field intensity measurements at low frequency*

| Average value | Average value witness location | Allowed value |
|---|---|---|
| 3.63 | 2.28 | 5000 |

The measurements for radiation dose are summarized in Table 3, in μSv/h. The maximum allowed value is in accordance with the USA NRC (Nuclear Regulatory

Commission) [10]. Near the Fukushima reactor the radiation dose from the nuclear accident in 2011 was 1 000 000 μSv/h.

Table 3

*Measurements for radiation dose*

| Average value | Average value witness location | Allowed value |
|---|---|---|
| 0.522 | 0.35 | 20 |

The measurements for radon in air are summarized in Table 4. The EPA (US Environmental Protection Agency) recommends that for values above 4 pCi/L corrective measures should be taken [13] and WHO (World Health Organization) recommends a lower level of 2.7 pCi/L [14]. The highest value measured in Brașov [12] was 6.7 pCi/L.

Table 4

*Measurements for radon in air*

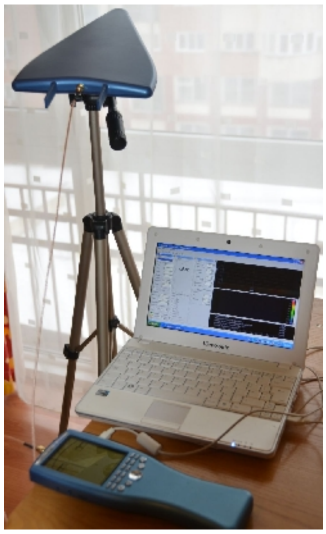
| Average value | Average value witness location | Allowed value |
|---|---|---|
| 4.46 | 1.50 | 4 |

In the ionizing radiation domain, the dose is below the permissible limit (2.61%) but the radon concentration in air is above the attention limit (111.5%) established by the EPA and above the attention limit established by WHO (165%). The measured radon value is above the normal values [2-12].

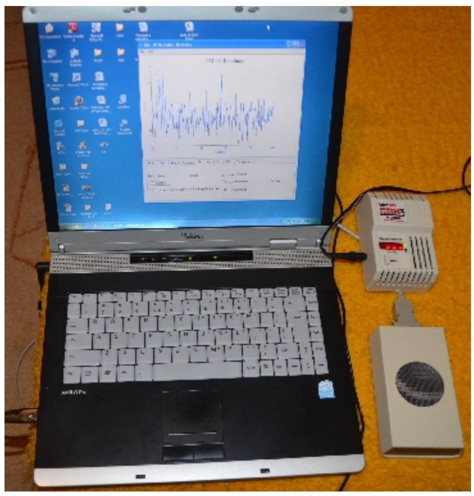
Images taken during measurements are given in Figure 11.

## 8. Conclusions

A final analysis of the measurement data shows that the value of the high frequency electric field is below the permissible limits (0.007%) and the average value of the low frequency electric field is also below the permissible limits (0.072%). Compared to the witness location, the electric field values are higher due to a greater proximity towards the GSM communications antennas and a higher density of cables carrying electric power through the public supply network.



a)



b)

Fig. 11. *Spectral analyzer mounted on a tripod and the laptop for computer data acquisition* (*a*), *Geiger Muller counter, Safety Siren 3 device and data acquisition computer* (*b*)

The value of radon is alarming and should require comparative measurements with a different type of sensor in order to confirm the measured data with the electronic device. Track detectors were placed in the marked location (alpha track radon detector). If they will show radon concentrations above the attention limit, then the cause of radon occurrence should be found, such as, for example, one of the construction materials used. It is also possible that the results are erroneous, because of electromagnetic interference, which can occur when measuring currents with very small values.

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