Personal Electromagnetic Exposure Measurements in the Radiofrequency and Microwave Range

THESIS OF DISSERTATION

Viktória Bánréviné Finta

PHYSICS PHD SCHOOL

STATISTICAL PHYSICS, BIOPHYSICS AND QUANTUMPHYSICS PHD PROGRAM

HEAD OF SCHOOL: Dr. Zalán Horváth /Dr. Ferenc Csikor

HEAD OF PROGRAM: Dr. Tamás Vicsek /Dr. Jenő Kürti

SUPERVISOR: Dr. Ádám Kiss, professor

CONSULTANT: Dr. György Thuróczy (NIRR)

Eötvös Loránd University

Faculty of Science

Department of Atomic Physics

Budapest

2012

Introduction

By spreading of wireless technology, radiation levels and the exposure of general public are getting higher and higher. Typical radiation sources in this 300 kHz-300 GHz radiofrequency (RF) range are TV and radio broadcast antennae, cellular phones and their base stations, microwave ovens, wireless and cordless telephones, internet, Bluetooth, navigation systems and radars. These applications and devices are essential parts of our modern life and their radiation affects everybody. It is incredible that in Hungary there is almost 12 billion active cell-phone numbers which is higher than the number of population. (www.nmhh.hu)

Meanwhile we do not have precise knowledge about health effects of these irradiations since we do not use these applications so long time en masse. Notwithstanding that according to WHO even a small health risk of radiation can be a huge public health problem because of the widespread usage (www.who.int). Therefore it was not a surprise that in 2011 radiofrequency electromagnetic radiation had been classified to the possible human carcinogenic class (2B) by IARC (International Agency of Research on Cancer). (www.iarc.fr)

Hence it is clear that thorough epidemiological studies are needed and the aim of exposimetry is to assist these surveys with measurements. For assessment of exposure level of a person we should use personal exposure meters since it is the most reliable method for this exercise (Thuróczy et al. 2008).

In Hungary, until 2007 only Department of Non-Ionizing Radiation in NIRR (National Institute of Radiobiology and Radiohygiene) was engaged in these examinations but now Department of Atomic Physics within Eötvös Lorand University is also concerned with exposure measurements, of course in cooperation with NIRR.

So personal exposimetry in the radiofrequency range is one of the most topical problems of public health, however, instrumentation and methods of this research are still under development.

Objectives

As I mentioned above, the basic problem of exposimetry is that there is not an international protocol nor for measurement and data processing, neither for statistical analysis.

According to this, my main aim was ***to develop an appropriate procedure for tasks like data gathering, processing and evaluating***. Nevertheless, these improvements can be done

only in practice, so I started the improvements in connection with a survey. Later, I used these developments also in other examinations.

The target of my first study was a group of undergraduates because they have been using mobile phones since their childhood and they probably will for the rest of their lives, additionally they are receptive to new technologies.

The second survey, which was made in cooperation with NIRR, regarded to ***inhabitants live near mobile phone base stations***.

In the third one we aimed at ***assessing children's exposure*** with different methods.

In addition, my further goal was that ***this type of research started first at Eötvös University in Hungary and this issue got into education***. Beside this, it is also important ***to get publicity***.

Method

Measurements were carried out with three different kinds of exposimeters: DSP090 (Antennessa, France), ESM-140 (Maschek, Germany) and EME Spy 121 (Satimo, France). The latter one is the most modern device that can determine the electromagnetic exposure in the range 80-2500 MHz. Except one case of our studies we used this instrument. In EME Spy 121 a three-axis antenna detects the electromagnetic field strength in 12 frequency bands: FM radio, TV-VHF and UHF, TETRA, DECT, GMS 900 phone, GSM 900 base station, GSM 1800 phone/base station, 3G phone/base station, WLAN. During personal measurements subjects wear the exposimeter for 24 hours and note their daily activities in a special diary, especially for the usage of radiating tools. The exposimeter save the measurement data to its memory and later we can download them to the PC by an USB-cable. Then the software of the exposimeter shows the spectrum of the subject.

Next step of the procedure is data processing, i.e. digitalizing the personal daily log and connecting it with the measurement data. There is not any protocol for this, too, so we are looking for the appropriate methods and characteristic quantities. So I had to work out my own way of process and evaluation. After a long improvement and testing in 2009 autumn user-friendly Perl®-based software was made for these exercises.

Also for the statistical analysis there is not a standard procedure, moreover, it is not a trivial challenge. Since data do not have regular distribution the significance-tests can be done only with non-parametric probes. Therefore, at first I plotted the data in Microsoft Office Excel® with simple average and standard deviation, after that I used five-point statistical plot (Box&Whiskers plot) and non-parametric Friedman and Kruskal-Wallis tests in Statistica®.

Between September 2007 and June 2010, 100 measurements were performed with the help of 90 University students monitoring their exposure. Three different kind of PEMs were used, namely DSP090, ESM-140 and EME Spy 121. Some students were wearing two or three of them at the same time and this way the performances of the devices could be compared. Students were divided into three groups: urban, commuter, rural. The research aimed at defining the most effected residential environment considering the RF exposure.

In 2010 summer we aimed to find a relationship between the distance from base stations (BS) and daily exposure of a person. Altogether 104 measurements were taken near 6 base stations in this survey. Three groups of people according to their residence's distance from the base station were looked at, and the subjects had to suit strict requirements. In each group there were people who live below the BS (0m), near the BS (20-50m), and relatively far from the BS (200-300m), respectively distributed. The measurements covered both single houses and apartment blocks, but in case of the latter only certain floors were regarded.

In 2009 and 2010 I cooperated with NIRR in the determination of RF exposure of 81 kindergarten caretakers and teachers and 51 government workers in three districts of Budapest and in three cities of Hungary. Exposure of children aged between 1 and 14 was assessed by using the measurements of the exposure of the staff caring them. The activities of the staff were divided into 5 categories according to the distance between the children and the adults. The government workers provided as control-group.

In 2012 winter I made further measurements on 25 kindergarten caretakers and 25 parents. In this study two EME Spy 121 personal exposure meters were used in the same time. The volunteer caretakers wore one of the PEMs on their bodies in a small belt-bag (moving PEM) all day, while another PEM was placed in the classroom (standing PEM) near the children. At the end of the workday, standing PEM was carried home by a parent.

Thesis

1. I developed a professional process for personal exposimetry in the radiofrequency range. [1]

2. Between September 2007 and June 2010, 100 measurements were performed with the help of 90 University students monitoring their exposure. [1]

3. These data got into an international comparison survey and a study which assessed SAR (Specific Absorption Rate). [2, 3]

4. In 2010 summer a survey was made among the residents who lived around mobile phone base stations. We aimed to find a relationship between the distance from base stations

and daily exposure of a person. Altogether 104 measurements were taken near 6 base stations in this survey. [4]

5. In 2009 and 2010, 31 elementary school teachers, 50 employees of kindergartens and day nurseries and 51 office workers were measured. In 2009 three districts of Budapest, in 2010 four big cities of Hungary were examined. The main aim of this study was to assess the RF exposure of children. [5]

In 2012, for our next study we selected volunteers from one of two groups: employees of kindergartens (n=25) and parents (n=25). The aim was the same: to approximate the exposure of children. [6]

Results

1. I proposed a procedure for defining personal RF exposure levels by using personal RF exposimeters combining the measurements with monitoring the activities. I tested and compared the instruments and developed an effective administration method for the measurements. Additionally, I tested the software was developed by a colleague of NIRR for data processing. Moreover, I elaborated a detailed procedure for statistical analysis.

2. I found that the daily mean of the RF exposure level of the students was far below the health exposure limits, in all cases. It also can be established that the highest exposure was detected during 'Travel' and the lowest during 'Sleep'. Much to our astonishment, we cannot state a significant difference between the residential groups, neither in the daily mean nor in any of the activities. Within frequency bands TV-VHF, TETRA and 3G were negligible, GSM 900 phones and base stations were considerable.

3. The comparison of countries opened to doubt since method was not entirely standardized. Sometimes there were significant differences but this could come from the different protocols. This points how important standardizing is. Nevertheless, it could be establish that the magnitude of exposure was the same in all countries. The radiation from mobile communication dominated in every environment, usually the exposure was the lowest in urban homes and the highest during traveling. The average exposure was calculated to whole-body SAR using a one-year child and an adult man for model. All the average and maximum SAR values were far below the ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines. Usually the SAR values well correlated to the exposure but it was affected by the microenvironment, frequency and the size of the phantom.

4. In the case of inhabitants lived near base stations it was established that there is no significant difference between activities according to mean exposures. Most of the exposure comes from base stations and broadcast antennae. In spite of misbelieves but in agreement with our theoretical physics knowledge, the most affected area is not directly under the base station but in the neighbourhood, 20-50 m from it. However, it is important to notice that in all the studies, all exposures were more orders of magnitude below the exposure limits.

5. Caretakers and teachers 5.7% of their time spent close to the children. For most frequency bands the majority (80%) of data points were below the detection limit. Derived child exposures were comparable to the worktime exposure of adults (control group). Compare to the control group pedagogues got less exposure from base stations but more from DECT.

Kindergarten microenvironment has less exposure than others probably because of a law which says that base station mustn't be settled in a 300 m area of kindergartens. So in this microenvironment mostly the mobile-usage of adults (maybe children) determines the exposure level. Important methodological result is that personal measurement can be substituted by microenvironment measurement if we can assess well the personal device-usage.

Summary

Due to my cooperation with NIRR Hungary could join to the world frontline of the research on RF and MW radiations. During our measurement campaigns we determined and compared the exposure of more groups. Beside this, I worked out an appropriate method for making and evaluating measurements.

Hopefully, my dissertation will be a useful basic in this field. I am planning to start a special course in this issue which is opened for all students of the University. I continue spreading knowledge in articles, conferences and other programs.

To summarize in my opinion the examination of radiofrequency radiations is one of the most important environmental problems and it is really necessary to measure the exposure and make epidemiological studies.

My research founded the improvement of this issue in Hungary and I hope so that these projects could also provide likely basis of systematic epidemiological studies.

Bibliography

References

Thuróczy Gy, Molnár F, Jánossy G, Nagy N, Kubinyi Gy, Bakos J, Szabó J (2008). Personal RF Exposimetry in Urban Area. *Annals of Telecommunication* 63: 87-96

http://www.nmhh.hu/index.php?id=hir&cid=15586

http://www.who.int/peh-emf/project/en/

http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

Thesis based on

[1] Finta V, Juhász P, Kiss Á, Thuróczy Gy (2011). Personal Measurements of RF Exposure on University Students in Hungary. *EBEA2011 poster*.

[2] Joseph W, Frei P, Röösli M, Thuróczy Gy, Gajsek P, Trcek T, Bolte J, Vermeeren G, Mohler E, Juhász P, Finta V, Martens L (2010). Comparison of Personal Radio Frequency Electromagnetic Field Exposure in Different Urban Areas Across Europe. *Environmental Research 110: 658-663*

[3] Joseph W, Frei P, Röösli M, Vermeeren G, Bolte J, Thuróczy G, Gajsek P, Trcek T, Mohler E, Juhász P, Finta V, Martens L (2012). Between-Country Comparison of Whole-Body SAR From Personal Exposure Data in Urban Areas. *Bioelectromagnetics online*

[4] Juhász P, Bakos J, Jánossy G, Nagy N, Finta V and Thuróczy Gy (2011). RF Exposimetry: Epidemiological Categorization by Distance from Base Stations. *EBEA2011 poster*

[5] Juhász P, Bakos J, Nagy N, Jánossy G, Finta V, Thuróczy Gy (2011). RF Personal Exposimetry on Employees of Elementary Schools, Kindergartens and Day Nurseries as a Proxy for Child Exposures. *Progress in Biophysics and Molecular Biology 107(3): 449–455*

[6] Finta V, Váradi L, Juhász P, Kiss Á, Thuróczy Gy (2012). A Method for Personal RF Exposure Assessment of Children. *„EMF Health Risk Research: Lessons Learned and Recommendations for the Future" workshop poster*

Other publications

Conferences

- Finta V, Kiss Á, Thuróczy Gy (2008). Személyi dozimetriai mérések módszere és első eredményei egyetemi hallgatók között a rádiófrekvenciás tartományban. *IV. Kárpát-medencei Környezettudományi Konferencia, Debrecen*
- Finta V, Juhász P, Sárközi E, Szolnoki M, Molnár F, Kiss Á, Thuróczy Gy (2010). Personal exposure measurements in the electromagnetic environment. *Spring Wind, Pécs*
- Finta V, Juhász P, Sárközi E, Szolnoki M, Molnár F, Kiss Á, Thuróczy Gy (2010). Személyi expozíció mérése módszere és első eredményei egyetemi hallgatók között a rádiófrekvenciás tartományban. *VI. Kárpát-medencei Környezettudományi Konferencia, Nyíregyháza*
- Sárközi E, Finta V (2010). Rádiófrekvenciás személyi expozimetria. *XII. Országos Felsőoktatási Környezettudományi Diákkonferencia, Sopron*
- Finta V, Kiss Á, Thuróczy Gy (2010). „Elektroszmog", a XXI. század környezeti kihívása. *Nyugat-Dunántúli Helyzetkép Konferencia, Szombathely*
- Finta V, Gresa L, Kiss Á (2011). Mobiltelefonok sugárzásának tudományos kérdései. *VII. Kárpát-medencei Környezettudományi Konferencia, Kolozsvár*
- Finta V, Koltay E (2011). „Elektroszmog", a XXI. század környezeti kihívása. *Baross Gábor Szakmai Konferencia, Széchenyi István Egyetem, Győr*
- Koltay E, Fülöp P, Finta V (2012). Bázisállomások közelében élőket érő elektromágneses sugárzás mértékének meghatározása. *XIII. Országos Felsőoktatási Környezettudományi Diákkonferencia, Veszprém*

Posters

- Finta V, Juhász P, Thuróczy Gy, Molnár F, Kiss Á (2009). Method for personal exposimetry in the radiofrequency range and first results for groups of students. *II. Települési Környezet Konferencia, Debrecen*
- Sárközi E, Finta V, Juhász P, Kiss Á, Thuróczy Gy (2010). Rádiófrekvenciás Személyi Expozimetria. *VI. Kárpát-medencei Környezettudományi Konferencia, Nyíregyháza*
- Fülöp P, Koltay E, Finta V, Kiss Á (2011). Bázisállomások közelében lakókat érő elektromágneses expozíció mértékének vizsgálata. *VII. Kárpát-medencei Környezettudományi Konferencia, Kolozsvár*

Popular articles

- Finta V (2007). Milyen hatásai vannak a környezetünkben lévő nem ionizáló elektromágneses sugárzásoknak? *Fizikai Szemle 57: 349-357*

Popular presentations

- Finta V (2010). Az „elektroszmog" vizsgálata. *Berze Tudományos Önképző Kör, Gyöngyös*
- Finta V, Koltay E (2011). Az „elektroszmog" tudományos háttere közérthetően. *4. Országos Alu-go találkozó és családi nap, Székesfehérvár*