ELF environmental exposure of the population A case study in a small city, south of Paris, France

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Abstract — **The environmental issues are a more and more important aspect of the life. Science and technology may be able to improve the knowledge of the exposure to various physical or chemical agents. This paper summarizes one aspect of a large environmental study dedicated to many factors. This specific part is dedicated to ELF exposure. A small town located in the south of Paris has been selected to conduct this study because it is at the border of many highways, close to the Paris-Orly airport runways and has a number of overhead powerlines crossing the area. This paper presents the results of the magnetic field exposure measurement that were carried out from january to may 2008, first on a sample of the population, second at some particular fixed points and finally, all around the town.**
Key words: 50 Hz ELF, overhead powerlines, exposure .

I. Introduction

The environmental issues are a more and more important aspect of the life and many studies have already been carried out to assess the influence of exposure to various physical or chemical agents often related to epidemiological studies. This paper summarizes a part of an environmental study dedicated to three main factors.

These factors are the acoustic noise levels, the air quality and the extremely low frequency (ELF) magnetic field. Additionally, it was added a sociological survey about the perception of any relationship between environment and health by the population.

This paper is only dedicated to the ELF exposure (mainly 50 Hz and harmonics) part of the study. A small town, Champlan located in the south of Paris (Fig.1) has been selected to conduct this study because it is at the border of many highways, close to the Paris-Orly airport runways and has a number of overhead power-lines crossing the area. This paper presents the results of the magnetic field exposure measurement survey that was carried out from january to may 2008 first on a sample of the population, second at some particular fixed points and finally, all around the town.

Champlan is a small town of 2500 inhabitants, located at about 15 km of the south of Paris. Only a small part of the population is directly exposed to the lines ELF magnetic fields as the overhead power lines stay mostly over highways but sometimes there are houses built directly or very close under the lines (Fig. 2)

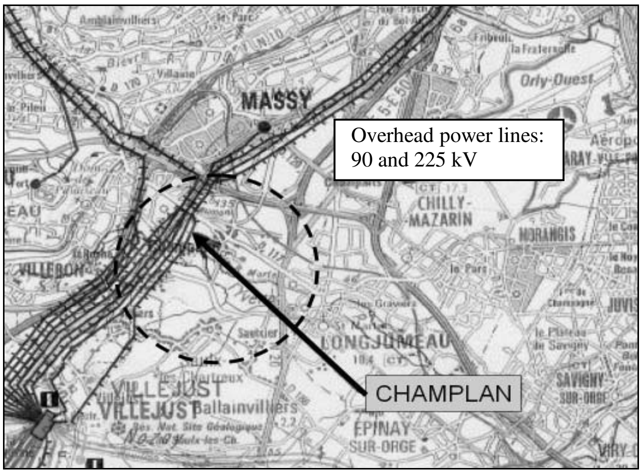

Fig.1. Map of the area of the survey

Fig.2. Google map picture of houses under the lines

II. Organization of the survey

A. Selection of the magnetic field meter

The selection of the magnetic field meter was not very simple. The technical specifications for the survey were that the meter should measure the magnetic flux density (MFD) on three axes, should have a good accuracy and a good dynamic range (0.01 to typically 200 µT), able to record the 50 Hz

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fundamental and harmonics as fast as possible during 24 hours, to be rugged and not too heavy as it had to be carried on workdays by the volunteers. It is important to have the information about harmonics as it allows to distinguish the influence of the power lines or transformers (with a low harmonics level) from appliances or electrical devices in general which produce a higher harmonics level (sometimes up to 30%).

After many tests on various meters, we finally have selected the Emdex II magnetic field meter (Fig.3). The Emdex II is manufactured by the Enertech Consultants company in California, under an EPRI license.

It is able to record during more than 24 hours at a 3seconds rate both the broadband magnetic field (50Hz and harmonics up to 800 Hz) and the harmonics (combination of harmonics up to 800 Hz with the fundamental). The accuracy is acceptable and the dynamic range is given from 0.01 to 300 µT. It is operated with a 9 V battery. An interesting data retrieving software Emcalc 2007 is delivered with the unit. This software allows to display the graph of the magnetic field versus time as well to compute many statistical data. It is also possible to export data to other software. The volunteers carried this meter in a protection pouch. The global weight was about 300 g.

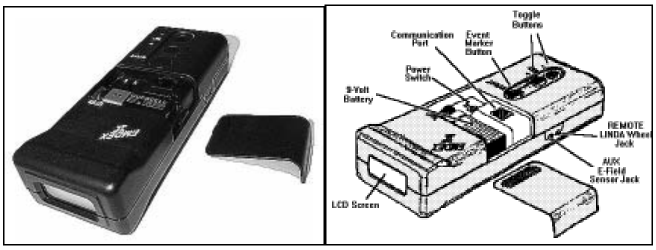

Fig.3. The ELF magnetic field meter (Emdex II)

B. *Selection of the GPS*

For the global city survey, a very simple and cheap GPS unit was selected from the Garmin company: the Garmin high sensitivity Etrex H (Fig.4). It has an serial interface output port and allows to record NMEA codes and to compute the coordinates on a laptop every second.

Fig.4. Garmin Etrex H GPS

C. *Survey protocol*

First, we have selected 17 volunteers, living or working in Champlan ready to carry during a full workday an Emdex II magnetic fieldstrength meter/data logger and to fill a timetable sheet describing their activity during these 24 hours with as many details as possible. A check list with instructions about handling the EmdexII meter was also given to the volunteer as for example, where to put the meter at night or for certain types of activities (sports etc.) in order to avoid as much as possible errors in the estimation of the exposure. The ELF meter was given at a certain time and day to the volunteer and returned the next day at or slightly after the same hour in order to get at least 24 hours recording.

The second part of this study was dedicated to a measurement in two houses directly located under the overhead 225 kV power-lines, one in the dining room, the other in a children bedroom with the EMF meters recording during 24 hours.

Finally, we have equipped a car with a GPS and an Emdex II meter connected to a laptop and we have recorded the magnetic flux density as well as the GPS localization coordinates. Then, we have plotted the results on a Google Earth map. This gave us an overview of the magnetic flux density in the city on a given day during one or two hours.

III. Main results of the study

A. *Results of the individual 24 h workday survey*

Fifteen of the 17 volunteers were inhabitants of Champlan, among them five live very close (less than 100 m) or under the overhead power-lines. The results are given here through samples of the magnetic field versus time curves as examples and all the statistical results are also tabulated afterwards.

Figure 5 shows the graph of the variation of the magnetic flux density (magnetic field) in microtesla (µT) versus the time for a volunteer who lives below an overhead power lines but works in the center of the village. We can notice that the survey starts at his work at 9 am, (low exposure), then he gets home for lunch, uses his microwave oven (peak at 6.6 µT) then stays in one room before changing to another room upstairs (closer to the lines), then back to work (very low exposure), then back home at night where we can notice the effect of the load current on the power lines at night.

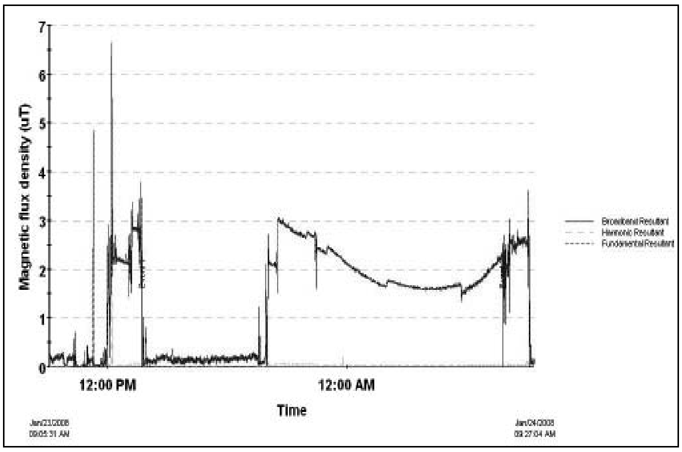

Fig.5. Graph of the record of a volunteer who lives under an overhead power line and works at more than 1 km of the line

Figure 6 shows the graph of the ELF magnetic flux density of another volunteer who lives in Champlan, but at around 150 m from an overhead power lines. We can notice that the

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effects of the lines are very low but when operating electrical appliances such as the electric oven or a kettle, the exposure level could be much higher than 5 µT. In fact, every part of the day has been well documented by the volunteers and it is possible to understand why there are peaks and why there is a residual noise.

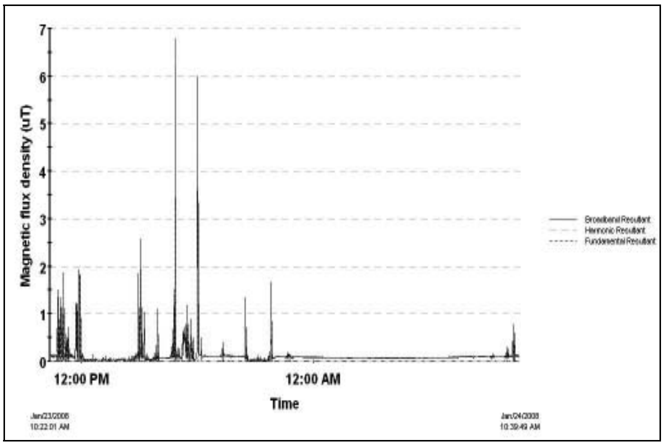

Fig.6. Graph of the record of a volunteer who lives at 150 m from an overhead power line

Next, in table I, we present the global results based on the average value on 24 hours and the peak value of magnetic flux density.

TABLE I - SUMMARY OF THE INDIVIDUAL EXPOSURE RESULTS

Volunteer	24h average exposure (µT)	Peak value (µT)	Comments
1	**0.67**	6.7	The maximum was found close to a microwave oven
2	0.08	6.8	The maximum was found close to an electric kettle
3	**0.70**	12	The maximum was found close to an anti-theft system in a department store
4	**2.00**	4.2	The maximum was found under the overhead power line in the garden
5	0.14	2.6	The maximum was found when driving under an overhead power line.
6	0.01	5.5	The maximum was found close to an electric tool.
7	0.06	19.5	The maximum was found close to a microwave oven
8	0.02	1.8	The maximum was found close to an electric appliance
9	0.08	3.4	The maximum was found close to an electric appliance
10	0.02	5.0	The maximum was found close to an electric appliance
11	0.05	1.7	The maximum was found close to an electric appliance
12	0.07	29.4	The maximum was found close to a microwave oven
13	0.21	10.6	The maximum was found close to an electric oven
14	0.07	2.6	The maximum was found close to an electric appliance
15	0.21	16.2	The maximum was found close to an electric oven
16	0.03	14.2	The maximum was found close to an electric appliance
17	0.06	2.2	The maximum was found close to an electric appliance

B. *Results of the two fixed points survey*

Two houses located directly under 225 kV overhead power lines have been selected as most exposed fixed points to do a 24 hours survey one in March 2008, the other in May 2008.

An Emdex II has been left recording in the dining room during 24 hours in one case (Fig.7), another Emdex II has been left in a child bedroom in the second case. Both houses are located at less than 10 meters of the overhead power lines.

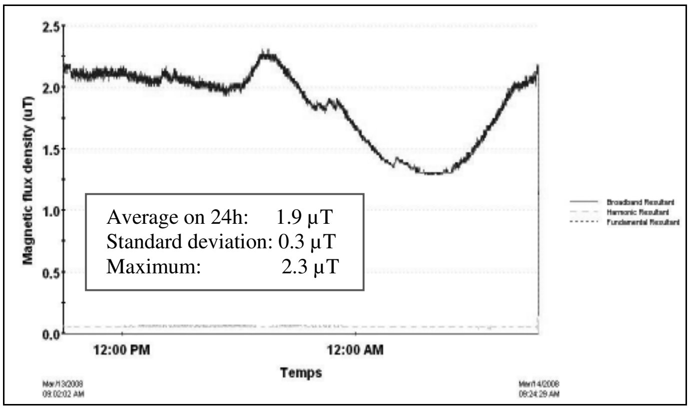

Fig.7. Graph of the record at the house #1 (dining room)

Fig.8. View from a window of house #2

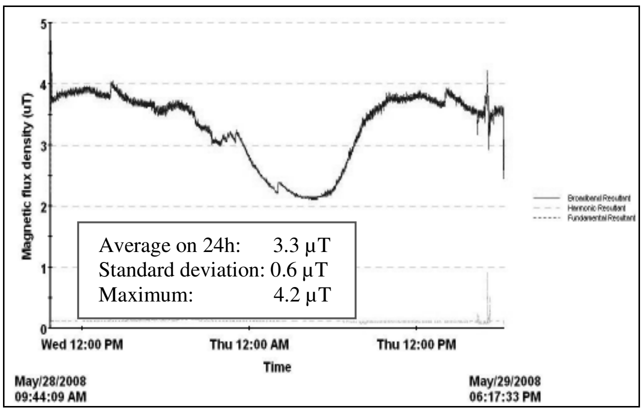

Fig.9. Graph of the record at the house #2 (children bedroom)

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In these two worst cases from the magnetic field exposure, the exposure from the overhead power lines is really predominant and almost constant with an average level always less than 4 µT. The variations of the magnetic flux density are directly in relationship with the power current load of the identified overhead power line. After completing this experiment, we have asked for the current load data to the utility company for the specific days that we conducted our measurements. So, we were able to compare our exposure measurement to the load current and found a perfect relation between both of them. Fig.10 shows the variations of the load current in the overhead power line above the house #1 during the magnetic field recording period.

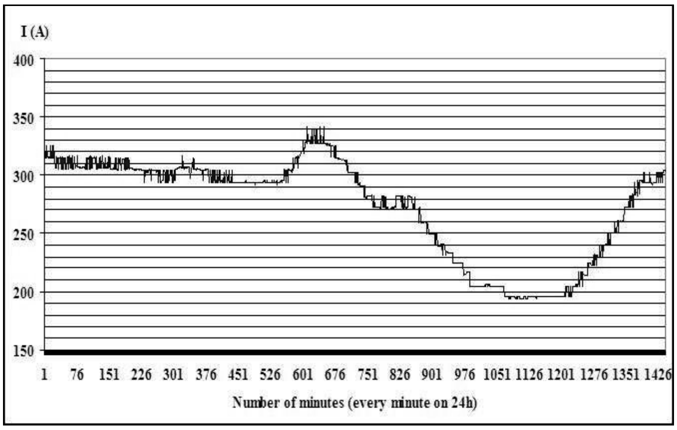

Fig.10. Variations of the load current on the 225 kV overhead power line above house #1 from 13 to 14 march 2008 (to be compared to Fig.7)

C. *Results of the overview on the Champlan city*

Finally, with a car equipped with an Emdex II and a GPS associated to a laptop computer, we have developed a software to acquire the GPS and Emdex II data and to transfer them on a Google Earth map system in order to have a representation of the exposure levels in many parts of the city, but mainly in the streets or the roads in the city.

The results showed a clear increase of the exposure very close (less than 30 meters) or under the overhead power lines, also an increase of the exposure levels close to local HV/LV transformers, a small increase when the car was above LV underground cables in the city.

The representation given in Fig. 11 shows small circles on the map, the diameter of these circles is directly proportional to the magnetic flux density, the color scale is blue for very low levels below 0.2 µT, green between 0.2 and 1µT and yellow / orange above up to 3 µT. On a Google Earth map, clicking on a circle pops up to show the magnetic flux density in µT.

Fig.11. Sample of a record through the city

IV. Conclusion

This study brought a clear confirmation that directly under overhead power lines, it is unusual to be exposed to more than 5 µT as we have shown in particular critical situations directly under overhead power lines. As soon as the distance to the line increases, the magnetic flux density decreases significantly and at 150 m, it is usually less than 0.2 µT. Many domestic appliances produce much higher magnetic flux density (MFD) at very close distance (10 to 20 cm) (such as 30 to 50 µT for some ovens) but the MFD decreases very fast when increasing the distance. Moreover, the exposure to appliances is not permanent as people use them temporarily.

The underground cables produce less significant MFD than overhead power lines and were sometimes difficult to identify when driving around the city.

All these results will be studied in a future paper, more in detail, particularly in order to compare the measurements to simulation software which are commercially available.

Acknowledgments

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