MODELLING THE STATIONARY ELF MAGNETIC FIELD FROM POWER LINES AND SOME CONSIDERATIONS ABOUT THE RISKS IN TERMS OF DYNAMIC EXPOSURE

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INTRODUCTION

The importance of the exposure assessment of the extreme low frequency (ELF) magnetic flux density (B-field) is mainly based on the epidemiological association between the stationary exposure (SE) to 0.4 µT and childhood leukaemia [1]. Since the 0.4 µT level is at present mostly accepted as the critical value of stationary B-field exposure for the possible induction of childhood leukaemia the first part of this paper deals with the modelling approach for estimating the additional risk of the stationary 0.4 µT exposure from power lines in Belgium. And, in order to get some knowledge about the dynamic exposure (DE) that should correspond with the 0.4 µT SE we introduce the concept of the relative exposure index (REI) [2]. By means of the REI we attempt to estimate that part of the B-field exposure that can be explained by man's mobility staying alternatively in poor and rich B-field areas.

MATERIAL AND METHODS

GIS-model for estimating the risk associated with the stationary 0.4 µT exposure

The analytical model we developed for calculating the 0.4 µT corridors for estimating the additional risk on childhood leukaemia by power lines was based on the Biot-Savart laws [3]. The model was calibrated by means of the Finite Elements Method (FEM) on the one hand and by means of *in situ* measurements of the B-field below and near to power lines on the other hand. We obtained all the input data for developing the model from ELIA which is the distributor of electrical energy in Belgium. The model was developed by order of the "Flemish Environmental Association (Vlaamse Milieumaatschappij; VMM)" and is entirely given on the website of VMM (www.VMM.be).
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Relative exposure index for the relation between the stationary and dynamic exposure

The relative exposure index (REI) is the ratio between the dynamic exposure (DE) and the stationary exposure (SE) and is aimed to give the relation between both variables:

$$REI = DE / SE \qquad (1)$$

The REI can have three different outcomes:

- REI = 1 meaning that the DE is equal to the SE
- REI < 1 meaning that the DE is smaller than the SE
- REI > 1 meaning that the DE is greater than the SE

For the determination of the REI, the SE and the DE were simultaneously recorded during one week with different EMDEX LITE meters. The SE was recorded by placing an EMDEX LITE during one week in houses below or near to a power line. For recording the DE one or more persons of the sampled houses carried an EMDEX LITE meter during the same week and recorded the activities in a log-book. After one week the data acquisition was stopped and analysed. Four different population estimators (the arithmetic and geometric mean respectively, the median and the exposure integral) of the B-field exposure were compared and used for computing the REI given in equation (1).

RESULTS

GIS-model for estimating the risk associated with the stationary 0.4 µT exposure

Fig. 1 shows an example of a 0.4 µT GIS-contour map of the 150 kV air power line net in Flanders (Belgium). The diameter of the 0.4 µT corridors was calculated for line current loads (CL) of 25, 50, 75 and 100% of the peak current from the line current which was recorded over a period of 1 year.

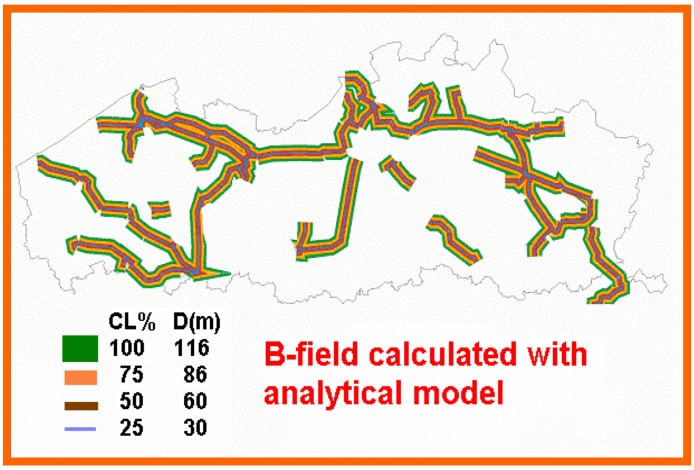

Figure 1**:** GIS-map of the 150 kV power line net in Flanders (Belgium)

The legend of the figure shows the current load (CL%) of the line and the corresponding radial diameter of the exposure corridor where the B-field strength is at least 0.4 µT. In the worst case situation (CL% = 100) the diameter of the 0.4 µT corridor is 116 m. In the other cases the corridor diameter decreases proportionally to the current load.
Table 1 shows the diameter of the 0.4 µT contour and the percentage of children (between 0 and 15 years old) exposed to 0.4 µT in average. The data were calculated at a line current load of 50% and 100% (worst case situation), an average height of the line conductors and a flat topography respectively.

Table 1: 0.4 µT corridor and percentage of children exposed to 0.4 µT in average

		Power line type			Total
Current		70 kV	150 kV	380 kV	
50%	∅ of 0.4 µT contour (m)	18	30	66	-
100%	∅ of 0.4 µT contour (m)	36	58	130	-
50%	% children exposed to 0.4 µT	0,25	0,31	0,13	0,7
100%	% children exposed to 0.4 µT	0,5	0,63	0,26	1,4

On base of the data of table 1, the cancer registration data of childhood leukaemia in Flanders, the relative risk of 2 for the association between stationary 0.4 µT exposure and childhood leukaemia, we calculated that every two years 1 additional childhood leukaemia is induced by the exposure to the B-field of power lines in Flanders. It has to be stressed out that this estimation is based on a stationary 0.4 µT B-field exposure calculated or measured in houses in the vicinity of power lines and that it doesn't tell anything about the dynamic exposure.

Relative exposure index for extrapolating the stationary to the dynamic exposure

Since the exposure to 0.4 µT isn't related to power lines only but also to other ELF sources of our daily life [4], we try to find out what would be the dynamic B-field exposure that corresponds to the stationary 0.4 µT stationary exposure inducing the same effect. Fig. 2 and 3 show an example of the profiles of the DE and the SE and the corresponding statistics respectively. The data were obtained by recording the B-field during 1 week in a house below a 70 kV power line (Fig. 2) on the one hand and by simultaneously recording the B-field of a person living in this house (Fig. 3) on the other hand.

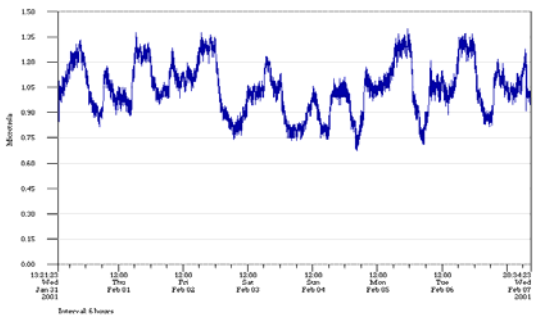

Fig. 2: Stationary Exposure Statistics (µT)

Min.: 0.68
Max.: 1.40
Arithmetic mean: 1.05
Geometric mean: 1.03
Median: 1.04
µT-h: 182

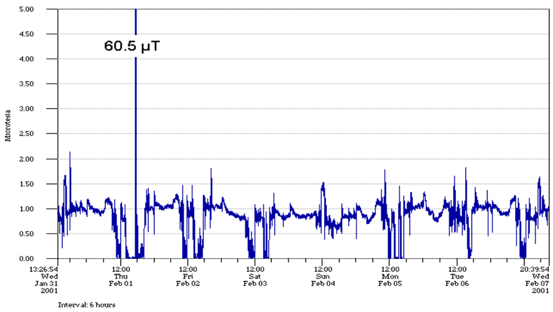

Fig. 3: Dynamic Exposure Statistics (µT)

Min.: 0.00
Max.: 60.5
Arithmetic mean: 0.85
Geometric mean: 0.61
Median: 0.90
µT-h: 145

By considering the location and dispersion exposure statistics we see that the minimum and maximum exposure of the SE and DE are quite different and that in the case of the SE the three estimation parameters (both means and the median) are equal whereas this isn't the case with the SE. These observations indicate that the SE data are quite normally distributed while the DE data are more distribution free like. This example serves only to illustrate that the distribution of the SE and DE might be quite different and that it isn't a good idea to consider the arithmetic mean as the best estimator of the real DE.

Table 2 summarizes the relative exposure index (REI) calculated on base of the estimators of the stationary (SE) and dynamic (DE) exposure of 8 houses below powers lines and 10 persons living in these houses.

Table 2: REI calculated on base of the estimators of the SE and DE

	Arithmetic Mean			Median			Geometric mean			Integral (µT-h)		
	SE	DE	REI	SE	DE	REI	SE	DE	REI	SE	DE	REI
Mean	0,76	0,43	0,62	0,77	0,47	0,65	0,74	0,29	0,44	122	71	0,64
St. dev	0,40	0,26	0,25	0,42	0,35	0,27	0,40	0,17	0,23	63	45	0,25

St. dev. = standard deviation

Though the sample size of this on-going study is quite small, the REI on base of the Arithmetic mean, the median and the exposure integral shows a tendency that the DE is somewhat more than 60% of the SE. If the Geometric mean is considered as the best estimator of both exposure forms, then the DE is only 44% of the SE. It has to be noticed that the REI-study is still running and that larger sample sizes and stratification techniques based on age, profession etc., would be necessary in order to get a deeper insight is this relationship.

CONCLUSION

The modelling approach showed that the stationary residential exposure to 0.4 µT by power lines induced 1 additional childhood leukaemia every two years. The REI-approach revealed that depending on the best exposure estimator, the dynamic or personal exposure of children living in the vicinity of power lines may be about 40% to 55% smaller than the residential stationary exposure. The combination of the results of both experiments suggests that one additional childhood leukaemia every two years may be induced by a dynamic exposure from 0.18 (0.45 x 4 µT) to 0.24 µT (0.6 x 0.4 µT). This implies that if a causal relationship between B-field exposure and childhood leukaemia exists the exposure assessment for the determination of a B-field threshold for this association should be based on a combination of the stationary and dynamic exposure. This should not only be done for ELF but also for other EMF frequency sources. In this respect personal dosimeters for the RF-radiation of the GSM family have been put on the market recently.

REFERENCES

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