The Medcross Group

A CASE-CONTROL STUDY.

Homepage
About Us
Contacts
Company Tour
Products

Non thermal studies
Our Research
Magnetotherapy
Electro Pollution
Endogenous Fields
Media File
The Coghill Challenge
The Natural World
Origins of Electricity
EMF Video Archives
TETRA
Photon Platinum
Review of 2003 NRPB Consultation Document

BIMT Prospectus

How to find us

Coghill Research Laboratories

Excellence in bioelectromagnetics

ELF ELECTRIC AND MAGNETIC FIELDS IN THE BEDPLACE OF CHILDREN DIAGNOSED WITH LEUKAEMIA:

Note

This is a simplified version of the study, peer-review published in Europ.J. Cancer Prev. 5: 3-10 (1996) and in Biophysics 41: 806-816 in the same year in Russian and English.

SUMMARY

At least nine epidemiological studies have found an association between childhood cancers and chronic exposure to ELF EM fields as indicated by a variety of mainly surrogate metrics. Few studies however have actually measured ELF EM fields in homes, and none in the child's habitual bedplace, arguably the principal place of domestic exposure. The three measured magnetic field studies so far reported have not generally confirmed the associations observed with surrogates, but no residential study has reported other than brief spot measurements of the electric component of the ELF EM field. The sole study reporting spot measurements of electric fields in homes of children with cancer found no correlation, but could not adequately address the issue of longer term exposure. Accordingly this retrospective case-control study of 56 cases and controls measured electric and magnetic fields over 24 hours in the bedplace of children with leukaemia. It found a significant dose-response relationship between electric field exposure and incidence. It is concluded that the importance of the electric field may have been overlooked in epidemiological studies todate.

Keywords:childhood leukaemia; extra low frequency electromagnetic fields; electric fields.

The possibility of there being a relationship between childhood cancer and chronic exposure to extra low frequency ("ELF") electromagnetic ("EM") fields such as those from powerlines have been extensively investigated by a number of authors, with conflicting results. Overall, nine out of eleven epidemiological studies have found correlations based on a variety of mainly surrogate metrics such as distance, wiring configuration, and historic measurements, and the quality of the remaining two (Fulton Cobb et al., 1980; Myers, Clayden et al., 1990) have been questioned. Though interactions between such weak fields and biological organisms are observed, their underlying mechanisms are not clearly established, partly because it is not easy to identify which parameter of many candidates (e.g. the electric component, magnetic component, power density, chronicity, frequency) is the active agonist. Measured magnetic field studies, of which to date only three have been reported, have not generally confirmed the associations observed with surrogate measures.

Occupational studies do not assist in identifying the active parameter, being prone to misclassification of job category. Furthermore, no residential study has reported other than brief spot measurements of the electric component of the ELF EM field, and since large variation in field strength is commonplace, even within the same room, the negative results of the single study reporting electric fields may simply reflect these variations. Against this background the present study measured electric and magnetic components of the ELF EM field over a continuous 24 hrs. period in or as near as possible to the beds of children diagnosed with leukaemia (mainly ALL), and compared the results with controls matched as well as possible for age and sex. Because childhood leukaemia, despite being an important cause of childhood mortality, is a comparatively rare disorder, only 56 cases and controls were available for study.

METHOD AND MATERIALS

Case selections and exclusions. Cases were obtained by media advertising, personal introduction, and courtesy of Wessex Health Authority, who were not however able to offer access to a large number of cases. In consequence, cases collected by self-help groups in the Bournemouth, London, and Home Counties known to a UK leukaemia research charity were added, and controls matched to these. Where possible, parents of the leukaemia cases were asked to identify a control child of the same sex and age living nearby, whose home could be similarly measured. Cases and controls were excluded if they had not normally slept for at least one year in the room being measured before diagnosis. Cases had to have been diagnosed within the decade to March 1995.

Table 1: The age and sex of cases by category

Age group (yrs)*	Male	Female	Total
10-15	5	6	11

5-9	11	7	18
0-4	12	10	22
n.a.	5	-	5
Total:	33	23	56

* at diagnosis

APPARATUS

Electric and Magnetic field probes (for magnetic fields three orthogonal components were recorded) were purpose-built, designed to IEEE recommended standards, and connected to dataloggers (Delta-T Devices, Burwell, Cambs, UK). Temperature, humidity and light intensity (Skye Instruments SKH2011, Digital Luxmeter) were also recorded during the measurement period, but have not been analysed for any significant differences. These standards, which are set out for the measurement and calibration of electric field instruments in the International Electrotechnical Commission publication IEC 833 (1987), and for magnetic fields in ANSI/IEEE Std 644/1987, were followed in designing the instruments' circuitry, described elsewhere (Philips, 1992).

Eight instruments were constructed for use in matched and calibrated pairs, so that a set of two instruments could be deployed in the home of case and control simultaneously in time (in 23 of the 56 pairs, case and control data were recorded simultaneously by research assistants trained to operate the instruments). In that way local effects from geomagnetic anomalies were to some extent controlled (and travel costs minimised). Using separate handheld instruments (Mersmann Kombitest, BPM 1003) readings were also taken sporadically at other locations in the home, and these preliminary observations suggested in an unquantified number of cases there were substantially different electric field levels even within the same room, for example emanating from the waterpoints, particularly in the region of the upstairs taps, suggestive of conductive plumbing.

For the most part evident sources of ELF EM fields were domestic wiring or appliances, rather than high voltage transmission/distribution lines. Data Collection Readings of all components were taken continuously each 30 seconds, averaged every 5 mins, for a period of 24 hours. Where the data collection period exceeded 24 hours only the first 24 hours data were analysed. There was no attempt to restrict analysis to matched time periods within 24 hrs (e.g. to night time only). A random selection of instruments was tested for accuracy by one researcher (L.R.) who took simultaneous 20 minutes readings in the same locations using Emdex II dosimeters supplied by National Grid Research Laboratories at Leatherhead. ELF magnetic field readings from the Emdex II instruments taken in case homes did not differ more than five percent on average (less than ten percent in control homes) from readings obtained by the study's dosimetric equipment, which gave slightly lower absolute values. Graphic comparison was also made of the rms magnetic field (see Table I). The captured data was downloaded into Supercalc5 spreadsheet software for statistical analysis.

RESULTS

Relative risk in the case and control homes by category of field strength are shown in Table 2.

Table 2: Relative risk by field strength category
a) 24 hour measured mean Magnetic fields (nT, rms)

Field Strength (nT)	Cases	Controls	Relative Risk
200+	3	-	-
150-199	2	1	2.20
100-149	3	8	0.41
100-200+	8	9	0.98
50-99	18	14	1.41
0-49	30	33	1.00
Totals:	56	56	

Though the overall relative risk is elevated above 150nT, there does not appear to be any consistent pattern of risk.

b) 24 hour measured mean Electric fields (V/m)

	Cases	Controls	Relative Risk
20+	13	5	4.59
15-19	5	3	2.94
10-14	8	5	2.82
5-9	13	13	1.76 <<5 17 30 1.00
Totals:	56	56	

There appears to be a consistent dose-response relationship between exposure to ELF electric fields and childhood leukaemia, with chronic night time exposure above 20 V/m leading to a nigh five fold risk.. Mean ELF magnetic field levels (nT, rms) in bedplaces of the 56 leukaemic children, (taken as close as practically possible to the bed habitually occupied by the child), were 70.18nT (SD 70.41) compared with 56.97nT (SD 37.78) in 56 control bedplaces. This difference is not significant (p=>>0.1).

Mean ELF electric fields (V/m, vertical component), by contrast, were 13.51 V/m (SD 13.39) and 7.26 V/m (SD 12.87) for cases and controls respectively. Here the case field strengths were significantly different from controls (t=3.51, p =<0.05).<<.01). Using a cut-off point of 10V/m, the relative risk for electric fields was 3.53 (unmatched). Matching yielded 27 discordant pairs, giving an Odds Ratio of 2.86 (for ELF electric fields). The 95% Confidence Interval was 1.37 2.34. A feature of the results particularly so far as electric fields are concerned, was the wide variation between individual homes, evidenced by the size of their standard deviations, and the overall range of the means. This was not so pronounced however when considering variations in the readings within each home during the measurement period (Table III):

Table 3: ELF EM field readings

Electric field (V/m):	**Cases (n=56)**	**Controls (n=56)**
Mean	13.51	7.26
Mean SD (between homes)	13.39	12.87
Mean SD (within homes)	3.12	1.90
Mean maxima	22.08	15.58
Mean minima	6.32	3.95
Range:	63.17-0.43	89.34-1.43

Table 4: Magnetic Field (nT, rms):

Mean:	70.18	56.97
Mean SD (between homes)	70.41	37.78
Mean SD (within homes)	22.33	17.80
Mean maxima	148.59	127.45
Mean minima	31.68	31.14
Range	447.92-13.33	173.26-12.44

VARIATION WITHIN AND BETWEEN HOMES

A feature of the results particularly so far as electric fields are concerned, was the wide variation between individual homes, evidenced by the size of their standard deviations, and the overall range of the means. This was not so pronounced however when considering variations in the readings within each home during the 24 hour period (Table Five):

Table 5: Variations in ELF EM field Readings

Electric field (V/m):	**Cases**	**Controls**
Mean (24 hrs)	13.51	7.26
Mean SD (between homes)	13.39	12.87
Mean SD (within homes)	3.12	1.90
Mean maxima	22.08	15.58
Mean minima	6.32	3.95
Range:	63.17-0.43	89.34-1.43
24 hrs mean measured Electric fields (V/m):	**CASES (n=56)**	**CONTROLS (n=56)**
Mean	13.51	7.26
SD	13.39	12.87
24 hrs mean Magnetic fields (nT)		
Mean	70.18	56.97
SD:	70.41	37.78

Table 6: Samples by Category of field strength
a) 24 Hrs Mean Measured Magnetic Field Strength (nT)

nT	**Cases**	**Controls**	**Total**

200+	3	-	3
150-199	2	1	3
100-149	3	8	11
50-99	18	14	32
0-49	30	33	63
Totals:	56	56	112

b) 24 Hrs Mean Measured Electric Fields (V/m)

V/m-1	Cases	Controls	Total
20+	13	5	18
15-19	5	3	8
10-14	8	5	13
5-9	13	13	26
Totals:	56	56	112

DISCUSSION

The only measured ELF electric field study todate (Savitz, Wachtel et al., 1988) relied on spot measurements of the electric component taken in the centre of several rooms and averaged. Spot measurements of the ELF electric field are a poor indicator of chronic exposure, because a) loads on nearby installations cause daily or seasonal fluctuations in AC magnetic field strength, and spot measurements will not take this into account b) though electric field spot measurements correlate somewhat better when taken and compared at different times, electric fields are extremely localised within any home, with variations upto tenfold even within one room. Thus measurements in the room centre say nothing about exposure levels in or around the bed, where a child may be sleeping for around eight hours each night c) the length of a 50Hz. EM wave is some 6000km. long, which means that all exposures are in its near field.

In consequence there is no correlation between electric and magnetic components of the wave in this situation. Since electric fields are generally related to voltage rather than to load, they tend to change little over time in any one part of a room. Separate (unpublished) studies failed to detect any major seasonal differences in electric field, unlike the magnetic component whose seasonal variations were well described by Renew, Male, et al., (1990). For the above reasons the present study recorded readings for 24 hr. periods and in the bedplace of the case or control, rather than single or multiple spot measurements at room centres. It is difficult to compare the results of this study with previous epidemiological studies of childhood cancers.

Only four residential studies todate have included actual ELF EM field measurements in homes of children with leukaemia and other cancer subtypes (Tomenius, 1986; Savitz, Wachtel et al., 1988, London, Thomas et al., 1991, and Feychting and Ahlbom, 1992). The remainder (Wertheimer & Leeper, 1979; Fulton, Cobb et al., 1980; Coleman, Bell et al.,, 1989; Myers, Clayden, 1990; etc.) used calculations or other surrogates such as distance from installations. These latter have been well reviewed elsewhere, and this discussion is therefore confined to measured field studies, and results of animal and cellular research.

Residential Measured Field Studies

Overall, epidemiological studies todate do not offer much data regarding electric field measurements. The Savitz study in the admission of its own authors was not able seriously to address the issue of electric field exposure, because of its study design. Feychting and Ahlbom did not calculate or collect electric field data at all, and the data collected on magnetic fields showed a poor correlation with the disorder of interest. Tomenius (1982, 1986) reported magnetic field measurements <169>near/outside the front door <170> of cancer homes as being nonsignificantly inverse to any association (mean levels, 68nT for cases, 68nT for controls). He did find an association between cancer incidence and measured magnetic fields, but none for leukaemia. In short the associations observed with surrogates are not in general confirmed by studies of measured magnetic fields.

One occupational study measuring electric field levels in the homes of 18 subjects in various electrical employments was also reported, but here too only the room centres were measured for electric fields, and the data reported was an amalgam of several different rooms (Bowman, Garabrant et al., 1988). The residential mean overall was reported as 2.46V/m. This mean appears low in relation to the results for controls presented here, and also when compared with levels reported by the NRPB Advisory Group (Doll et al., 1992). That the present study should find field levels much higher than this in the bedrooms of the cases gives support for the importance of the parameter. A puzzling feature of the results from these studies generally is that the association between measured magnetic fields and childhood cancer incidence is generally much weaker than the association with surrogate measures. The obvious implication is that the parameter present in the surrogates includes the electric component whereas studies simply reporting the magnetic component do not.

A closer evaluation suggests some support for this view. Savitz, Wachtel et al. (1988) measured ELF 60Hz. magnetic fields in 128 homes of various cancer subtypes, including 26 cases of ALL. They found a <169> modest <170> association between measured ELF magnetic fields under <169> low power use <170>: a cut-off score of 200nT resulted in an odds ratio of 1.4 (95% CI: 0.6-2.9) for total cancers, 1.9 for leukaemias, 2.2 for lymphomas, and 3.3 for soft tissue sarcomas. By low power use the authors meant that <169> home power was off to the extent needed to remove in-home field sources <170>, and in these conditions only a weak correlation between magnetic fields and cancer incidence was observed (ORs of 1.0 to 1.5).

They do not report the results of electric field associations in low power use conditions, but if to achieve low power use conditions the residential mains supply was turned off then ambient electric field levels would fall dramatically, since these are normally present independent of load when wiring is <169> live<170>. In high power use conditions Savitz found only 17 cases of the 129 measured with ELF electric fields exceeding 14V/m. when measured in the manner described above, which were compared with 30 controls. This gave rise to an OR of 0.9 (though the 41 cases between 9 and 14V/m gave an OR of 1.23 overall). As for subgroups only <169>miscellaneous cancers<170> gave rise to an elevated incidence (OR 1.7) in high use conditions. As with the Bowman, Garabrant study, these means reflect measuremnts from room centres and from several rooms, which may have masked higher readings from case bedrooms. The authors did not attempt any further analysis of the electric field data: <169> based on an inability to capture long-term electric field exposures through the measurement procedures <170>.

The authors comment that <169> the discrepancy between the strength of association for measured fields compared with wire codes is a cause for concern. The magnetic field measurements were originally expected to more directly reflect the exposure of interest compared with the wire codes, which are a surrogate for magnetic field levels <170>. Wiring configuration codes are of course, also a surrogate for electric field levels, as they admit: <169> electric fields (to a lesser degree) are also associated with wire codes <170>. They bring this out in a further table. However, to measure the fields the instrument was placed <169>in the centre of the room as far as possible away from appliances <170>. This can only be of little use in characterising exposure of the child asleep in bed, since field variations within any room can be enormous (Mader, Barrow et al., 1990; Armstrong, Deadman, et al., 1990).

In high power use conditions in any case the electric field would be little different from low power use since only the magnetic field varies with load. No low power use analysis was reported, because <169> Electric field measurements are thought to be dominated by such unstable characteristics as the location and grounding of appliances, which implies that the possible effects of long-term electric field exposure could not be addressed in this study, since an indicator of long-term exposure was lacking <170>. In short, the study did not adequately address the electric field's possible contribution to ill health. The study by London, Thomas et al., (1991) , which included Bowman among its authors, measured ELF magnetic fields for 24 hours or longer in the child's bedroom in 164 cases (144 controls). But nearly half of these measurements were made (between 1987 and 1989) in the most recent homes of leukaemic children diagnosed between three and nine years previously (1980-1984), and the authors admit that <169> for 63 percent of the cases and 53 percent of the controls our measurements covered at least half of the aetiologic period <170>

The corollary of this is that towards half of the homes measured were not those where exposure may have arisen. Moreover the measurements both of electric and magnetic fields were made <169> on a tripod made of non-conducting polycarbonate plastic and placed as close as possible to the centre of each room <170>. Whilst this protocol may be suitable for magnetic fields, it is clearly of little relevance in characterising night-time exposure to electric fields, since other studies (e.g. Mader, Barrow et al, 1990) show a tenfold electric field variation within rooms. Though the authors attempted to measure homes previously (but no longer) occupied by the cases, this limited the number which could be measured. and <169> when we could not gain access to the residence we made outdoor measurements <170>.

Finally the mean measurement in cases when two residences were involved was taken as the time-weighted average of the two. On the assumption that exposure if related to the disorder may well have originated in only one of the two homes, this has the effect of biasing the results towards the nul hypothesis. Unsurprisingly the authors report that the spot electric field measurements <169> were not materially associated with leukaemia risk <170>. Moreover, they found no association between measured magnetic fields and childhood leukaemia either: the associations which did emerge were all with surrogates such as wiring configuration or self-reported appliance use (mono TVs, electric blankets, electric space heaters, video games, hair dryers).

Indeed, higher general appliance use was a feature of case homes. The wide spread of measurements in the Bowman, Garabrant et al. study is evidenced by large standard deviations reported, but it is also evident from their results that bedroom exposures are more than three times those of the natural outdoor environment. In conclusion, this study, funded by the Electric Power Research Institute (EPRI), with further support from Southern California Edison, did not seriously address the question whether chronic exposure to ELF electric fields in the area of the bed is associated with childhood leukaemia. Feychting and Ahlbom's large scale 1992 Swedish study did not measure electric fields at all. The authors took 24-hour magnetic field measurements, assisted by Floderus who was also conducting an occupational measured field study, (where she took electric field measurements, but did not report them). Feychting and Ahlbom's sample population consisted of anyone in Sweden who had lived within 300 metres of a high voltage powerline between 1960 and 1985, and therefore did not include exposure to domestic electric wiring or domestic electric appliances, which arguably may be also an important contributor to total ambient EM fields.

Spot magnetic field measurements were first taken in homes, and the historic load calculated and translated into magnetic field strength, and finally for a sample of the subjects 24 hour measurements were obtained. The main analysis was based on historic calculated magnetic field exposures, where for childhood leukaemias a relative risk of 2.7 times was found for exposures over 200nT (95%CI: 1.0-6.0), and 3.8 for exposures above 300nT (95%CI: 1.4-9.3). This was confined to one-family homes, and no association was seen with brain tumours. Moreover it was based on only 5 cases. The study found no association with measured magnetic fields. Measurements for children were performed in 62 percent of homes, and most of those unmeasured were in Stockholm city, where one might expect measured fields to be higher.

The authors applied the low power use method developed by Savitz, and <169> for the purpose of analyses in their report each home was characterised by the mean value of of the low power use measurements across all rooms <170>, which must have diluted the levels of exposure in the bedrooms. It seems that the number of homes actually measured for 24 hrs was limited to 100 subjects, and though a total of 142 children with cancers were identified (of which 22 were ALL), spot measurements were only taken in 89 of these homes. Relative risk of ALL in relation to spot measurements was 4.1 and 3.1 if spot measurements exceeded 100 and 200nT respectively, but the numbers were too small for significance (6 in total). The authors did not report the relationship of 24 hour magnetic field measurements in relation to leukaemia risk, but offered one graphical representation of the relationship between spot and 24 hour measurements.

The reliance on historic calculated magnetic field exposures in the Feychting, Ahlbom study meant in effect that not only electric fields, but also 24 hrs measured magnetic fields were largely ignored, and the instruments used (Positrons) appear to have been worn by the subjects, not located in one fixed place (e.g. the bedroom). In conclusion this study tells us nothing about electric field exposure, and little about the magnetic field levels found in or around bedplaces of the children who sleep there for perhaps 8 hours each night. Finally, preliminary results of a 1994 study of 600 children in Los Angeles County (Preston-Martin et al., 1995, in press) also found no association between central nervous tumours and residential exposure to magnetic fields as assessed by spot and 24 hour measurements. On the other hand there is increasing evidence that transient magnetic fields, (particularly the third harmonic, 180Hz) are associated with ill health.

This view is supported by a 1994 occupational study from McGill University (Benedict, Armstrong et al., 1994), and by previous work by Kaune during the <169> Back to Denver <170> programme. Since an electric field arises whenever there is a change in the magnetic field strength, this is supporting evidence for the electric field's role as the active parameter. In short, research todate evaluating the environmental electric field exposure of leukaemic children is minimal. Since elevated associations have persistently been reported with surrogates such as wiring codes and distance, yet measured magnetic field have not confirmed or found any stronger association, it would appear logical to investigate this other indispensable component of the ELF electromagnetic field, namely the electric component,

Epidemiological attention since the mid-1980s appears to have focused on ELF magnetic in preference to electric fields partly by historic accident, and partly by a poor understanding of the physical action of the separate components of an electromagnetic energy wave. In their 1979 epidemiological study (which used wiring configurations as a surrogate measure) Wertheimer and Leeper argued that <169> because our findings appeared to related to high current rather than voltage we looked into the magnetic fields induced by current flow. Magnetic fields penetrate the human body (and buildings etc.) readily. They are not easily shielded...<170>

The physics of interaction is not so simple as this, however. Some physical considerations The conclusion is often drawn that because electric fields are easily shielded by materials they are not likely to be a factor in the aetiology of childhood leukaemia, if powerlines are implicated. This view is not shared by eastern bloc researchers, who argued that (unlike the magnetic component): <169> The electric component significantly exceeds the natural level of the Earth's electric field, thereby altering the electromagnetic environment in places of human habitation, and necessitating the need for measurement and control <170> (Shandala, Dumanskiy et al., 1988).

Inside a home under high voltage cables the ELF electric field is still quite likely to be as high as 100V/m, (many times the norm) even though this is 100 times less than the field strength outside. It is also argued that electric fields do not penetrate human tissue, and therefore are not likely to cause bio-effects. This is not strictly true when only the surfaces of a body (e.g. membrane surfaces) are considered, since external electric fields attract (opposite) electric charges to the interior surface of the exposed object, and though the space inside the object may itself have have a zero field in accordance with Gauss law, its inner membrane surface will carry charges of opposite sign to the exterior field. If a number of such bodies are involved, each within the other, the charges on the inner surface of the inmost body could be very high.

Since cellular interior space (cytosol) is largely aqueous and conductive these inner surfaces will remain charged (Cross, Electricity and Magnetism, 1976, p36). One basic physical distinction between magnetic fields and electric fields is that magnetic fields influence the spin orbits of electrons, whereas the electric field influences the flow of electrons. Moreover, whereas the magnetic field is entirely dependent on load, (and disappears when the current ceases to flow) the electric field in domestic wiring and powerlines alike is present continuously even when current is not flowing. To that extent exposure to electric fields is more chronic. Moreover any alternating magnetic field will induce an electric field in the tissues exposed to it.

Finally, some argue that electric field measurements are of little use because the operator perturbs the field. This is certainly true while the instrument is being held. However, in this study the instruments were left in an undisturbed position for some 24 hours, and being of a standard shape if anything the field was uniformly perturbed in all measurements, which would cancel out artefactual differences. For these reasons more attention to the electric component in epidemiological studies would seem justified, especially since the 1960s and 1970s research into electric field effects both in the eastern bloc and the West (e.g. Korubkova, Morozov et al., 1972; Kouenhoven,. Langworthy et al., 1967), the latter of which led the utilities largely to disregard the electric component, included serious deficiencies such as lack of controls and measurement uncertainties.

Other studies From a biological viewpoint, whereas few if any studies show adverse effects from static magnetic fields below 1000 Gauss, many cell and live animal studies implicate the electric component in sequelae as diverse as altered haematological indices (Morris, Kimball, et al.,1989), efflux of Ca2+ from brain tissue (Bawin and Adey, 1976), inhibition of NK lymphocyte competence (Lyle, Ayotte, et al., 1988), and disturbance of cellular respiration (Blank & Soo, 1992). Several known vital biological mechanisms (e.g cellular respiration via oxidative phosphorylation in the synthesis of ATP) rely fundamentally on electron transport along biological membranes, and are disturbed by exogenous electric fields which influence or uncouple them (Abood, 1954).

Moreover, the majority of hypotheses constructed to explain the interaction between weak EM fields and organisms implicate the electric component (Adey, 1993; Tsong & Astumian, 1984; Blank, 1992, etc.), whereas those implicating the magnetic field (Liboff, 1985; Edmonds and Male, 1991; Lednev, 1990; Kirschvinck, 1990 etc.) have proved to have serious deficiencies. In short, the electric component appears to be a plausible biological candidate for mechanisms of interaction with organic life.

CONCLUSIONS

Though epidemiological data on human electric field exposure is sparse, with virtually no studies reporting this parameter, cellular and live animal studies have implicated the electric component of the ELF EM field, as have proposed mechanisms of interaction That this study, the first collecting electric field data in the actual bedplace of leukaemic children, should also find significant differences in field levels, suggests that the importance of the electric component may have been overlooked in epidemiological studies todate, and points to a useful new direction for research.

PRINCIPAL REFERENCES (also see our main references file)

F.A. Barnes, H Wachtel, D.A. Savitz, and J.A. Fuller (1989) Use of wiring codes for estimating externally generated electric and magnetic fields. Bioelectromagnetics J. 10: 13-21

D.L. Mader, D.A. Barrow, K.E. Donnelly, R.R. Scher, and M.D. Sherar (1990). A simple model for calculating Residential 60-Hz. magnetic fields Bioelectromagnetics J. 11(4): 283-296

M.D. Morris, K.T. Kimball, T.E. Aldrich, and C.E. Easterley (1989) Statistical approach to combining the results of similar experiments, with application to the haematological effects of extremely low frequency electric field exposures. Bioelectromagnetics J. 10(1): 23-34

A. Philips (1992) Measuring magnetic fields in your own home. Electronics World, April 1992, pp281-283

D.C. Renew, J.C. Male, and B.J. Maddock (1990) Power frequency magnetic fields: measurement and exposure assessment. CIGRE 1990 Session, 36-105, 26 August -1st September.

D.A. Savitz, H. Wachtel, F.A. Barnes, E.M. John, and J.G. Tvrdik (1988) Case-control Study of childhood cancer and exposure to 60Hz. magnetic fields. Am. J. Epidemiol. 128: 21-38