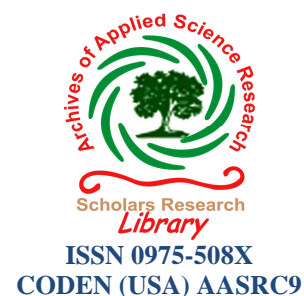




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Archives of Applied Science Research, 2013, 5 (5):100-104  
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## A pioneer study on residential electric and magnetic fields: The case of a house at Fumesua, Ashanti Region, Ghana

Koranteng Christian<sup>1</sup>, Essel Charles<sup>1</sup> and Nkrumah Jimmy<sup>2</sup>

<sup>1</sup>Department of Architecture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

<sup>2</sup>Development Office, KNUST, Kumasi, Ghana

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### ABSTRACT

Nowadays, very little attention is given to the effects of high electromagnetic fields (EMF) on the environment and mankind. Numerous studies have associated long-term exposure of high EMF to childhood leukaemia and other serious illnesses such as Alzheimer and brain cancer. On the other hand, associations between high EMF and illnesses have not been very strong. Conversely, current studies have found associations between exposure to EMF and for instance, Alzheimer disease to be very likely. The aim of the study is to assess EMF values in a residential building. The field measurement approach using an EMF tester and comparing the measurements to the recommended range (3 - 4 milligauss) revealed interesting clues. Walls containing fuse boxes resulted in high EMF values (195% more than the recommended range). Various equipment and gadgets (fan switches, laptops, microwave, extension boards, etc.) in daily use were found to have 125% to 1925% more EMF when in operation. The study concludes by urging architects and services engineers to champion the course of an improved and healthy built environment.

**Keywords:** Electromagnetic Field, Health, Architecture, Building Ecology

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### INTRODUCTION

Humans have evolved within a specific range and characteristics of electromagnetic energies. The energies originate from the sun and the earth. All living organisms have adapted themselves to this very unique radiation climate prevalent on planet earth. However, the prevailing natural balance is being threatened now, because over the last 100 years, humans have been very busy adding their own versions of electromagnetic energies without giving due considerations to the biological implications [1].

National and international guideline-setting organizations specify limits for occupational and public exposure to electric fields, magnetic fields, and contact current (current that flows through the body when it is in simultaneous contact with two conductive surfaces carrying different voltages) [2]. Exposure limits are also set for radio frequency electromagnetic fields (they deposit thermal energy in the bodies of exposed persons) from sources such as radio and television broadcast towers, and mobile telecommunications antennas [3]. Furthermore, studies on utility workers found that the highest exposure to electromagnetic fields (EMF) occurred when working near electrical equipment [4].

As humans keep on being exposed to electromagnetic fields through development, there is the need to monitor possible health effects and ensure that guidelines are strictly followed.

The objective of this pioneer study is to document and contribute to the creation of a database of electromagnetic field levels in and around residential buildings in Ghana. The paper looks at spot measured electromagnetic field levels and compares the measurements to recommended exposure limits.

Research work on apartment buildings with built-in electricity transformer stations at the basement or ground level in Hungary showed that spaces located above transformer rooms had a higher power-frequency (50 hertz [Hz]) [5]. Another study in Finland [6] came to a similar conclusion as that of [5]. Both studies concluded that spaces located near transformer rooms reliably predict magnetic field exposures. A survey of 2214 homes in Taiwan with children showed that exposure levels were above the norm of 3 – 4 milligauss (0.3 – 0.4 microtesla) [7]. The authors also concluded that Taiwanese children have a higher exposure to EMF than children in Europe and North America. Moreover, a study on magnetic field exposure and long-term survival among children with leukaemia yielded alarming results [8]. The authors purported that children whose homes had high measured magnetic fields (above 0.3 microtesla), experienced more complications during the follow-up period after diagnosis, but this finding was not statistically significant. These children also experienced poorer survival; this finding was statistically significant. The authors further cautioned on the small sample size and that further confirmation may be needed by other researchers.

Currently, some studies [9 and 6] have associated electromagnetic fields with for example brain cancer, leukaemia, and Alzheimer. They have not yet proved causality to electromagnetic fields. For instance, a study on childhood brain cancer found an association with exposure levels above 3 - 4 milligauss [9]. Their results were not statistically significant but could not exclude moderate risk increase at higher exposure levels. Similarly, [6] could also not establish a causal relationship in their study but noted that the association they found could be a variable (confounding variable) present along with magnetic fields or from inadvertent error in the selection of study participants. Moreover, the selection of participants has been a subject of debate in epidemiological studies as noted by other researchers [7] that most studies are undertaken in the developed world where exposure to high EMF may not be as drastic as in developing countries. Inconsistent associations between occupational exposure to EMF and negative health effects have been reported [10, 9, 7, and 2].

A recent study published by an independent expert group on electromagnetic fields alleged that there were no associations between EMF and Alzheimer disease in the 1980's and early 1990's, but now, an association has been reported in current studies [11].

The outlined discussions connote the changing knowledge and health implications of electromagnetic fields on humans. As the world waits for results on long-term studies with improved methodology on exposure to EMF's, there is the need for humans to live cautiously as our quest for development increases.

## APPROACH

The investigation of prevailing electromagnetic fields in a residential building at Fumesua in the Ashanti Region of Ghana adopted the field measurements approach. The method has been propagated by [9] as the best in studying and interpreting exposure limits. The EMF limit (3 - 4 milligauss or 0.3 - 0.4 microtesla) proposed by national and international bodies such as the World Health Organization has been the comparative basis of research work [10, 12, 7, 8, and 2]. In addition, a study showed that guideline basic restrictions provide adequate protection [3].



**Fig1 Image of the studied building showing the high-tension power lines and the unprotected transformer**

The conveniently chosen residential building has a number of characteristics making it important for the study. The main features of interest are the high voltage lines (11,000 volts) running on the boundary line (fence wall) and about 6m – 8m above ground. Additionally, 240 volts power lines (5m off ground) run opposite the high voltage lines on one side of the street. The building occupants use the street in accessing their facility. An unprotected step-

down transformer is situated at the corner of the rectangular plot (5m off the fence wall) and multiple electric poles take off from here (see Fig. 1). This unplanned situation is a common sight in Ghana where utility providers cannot pull alongside with developments at peri-urban sites.

To measure the EMF levels around and in the residential building, a grid of 2m x 2m was laid over the building plan including the surroundings. Situations where a grid passed through a wall were solved by shifting the grid and readings were taken 5cm off the wall. The spot-measured average magnetic fields taken 1m off the ground were computed and compared to the standard of 3 – 4 milligauss. Subsequently, measurements around installed gadgets were recorded. The measurements took place under two conditions. The first was during a blackout (no power from the Electricity Company of Ghana (ECG)) and the second was when the power was installed. The conditions made it possible to analyse the differences in EMF levels. The accuracy of the EMF tester is shown in Table 1.

**Table 1- Accuracy of the EMF tester (PCE-EMF 823)**

Range [microtesla – milligauss]	Accuracy [%]
20 – 200	+/- 4
200 – 2000	+/- 5
2000 – 20 000	+/- 10

*Source: PCE [13]*

At the end of the field measurements, the building occupants were interviewed on possible health complaints.

## RESULTS

The results of the measurements of spaces and equipment are presented below.

**Table 2- Measured EMF levels of spaces**

Space	Condition 1* EMF [mg]	Condition 2** EMF [mg]
Bedrooms	0.3 - 0.4	0.3 - 0.5
Living area	0.3 - 0.35	0.3 - 0.5
Dining area	0.4 - 0.5	0.4 - 0.5
Circulation spaces	0.3 - 0.35	0.3 - 0.35
Washrooms	0.3 - 0.4	0.3 - 0.4
Outdoor space (around the house)	0.3 - 0.5	0.3 - 0.6
Terrace	0.3 - 0.4	0.5 - 0.6
Area under the High Voltage lines	0.3 - 0.4	0.7 - 0.8

\* Blackout (no electrical power from ECG)

\*\* Power restored

The space around the installed transformer recorded 0.3 - 0.4 milligauss (mg) during condition 1 whereas high values were measured when the power was restored. Table 3 illustrates the measured values at different distances from the Transformer.

**Table 3- Measured EMF levels at various distances from the Transformer**

Distance [m]	EMF [mg]
0.05	17-60
1	4-5
2	3-3.3
3	1.6-1.8

Moreover, the electrical cables hanging around the electric poles recorded 14mg (measured at 5cm off the cables). The EMF levels of installed systems and gadgets in operation were measured. Table 4 demonstrates the recorded values of the various installations (measurements taken at 5cm around the installations).

Furthermore, electrical wiring leading to sockets in the studied building was found to have EMF values of 4 - 5 milligauss. High values were recorded on walls containing wiring to and from the main switch and fuse boxes (3.5 - 78 milligauss). The meter recorded a value of 50 - 108 milligauss (5cm off the meter to about 0.5cm, (close proximity)).

The interview of the occupants on adverse health complaints revealed no serious illness. Occasional headache and malaria related illnesses were voiced out.

**Table 4- Measured EMF levels of installations and equipment**

Item	EMF [mg]	Percentage above the norm (3-4mg)
Iron	23	575
Radio set	50	1250
Light switch	5	125
Water heater switch	13-63	1575
Fan switch (single)	10	250
Fan switch (double)	30	750
Standing fan	57	1425
Fridge (frontage)	6	150
Fridge (back)	55	1375
Micro wave	11	275
Television (frontage)	25	625
Television (back)	50	1250
Table top freezer	7-15	375
Music player (system)	17-40	1000
Laptop (keypad area)	4.3-5.6	140
Laptop (power button and battery area)	28-78	1950
Laptop adaptor	5	125
Extension boards	10-60	1500

## DISCUSSION

The measured EMF levels of the spaces inside and around the building revealed low values in both conditions (no power and when power was restored). A maximum value of 0.8mg is depicted in Table 2. The value is far less than the recommended range of 3 - 4mg [10, 12, 7, 8, and 2]. The position of the high voltage power lines and various spaces of the building positioned 5m away from the threat seems to provide adequate protection. Protection for the building occupants is further enhanced through the deciduous trees positioned between the high voltage power lines and the building. The result proves that when guidelines are followed, building occupants can be guaranteed adequate protection as depicted by a study [3].

Alarming results have been demonstrated in Table 3. High values were recorded (4-60mg) in close proximity to the transformer. The unprotected nature of the transformer is a threat to children who get as close as 1 meter to it. On one occasion, children were seen trying to close the transformer door which had been left opened. The danger (leukaemia) and effects of high EMF values to children have been demonstrated in numerous epidemiological studies [5, 14, and 7]. There is the need for the electricity company of Ghana to protect all transformers, as such a measure would avoid children being exposed to high EMF. The highest value recorded was 60mg at 5cm off the casing of the transformer. The level shows that workers who may need to perform maintenance services get exposed (highest exposure) each time they interact with transformers [4]. Research on occupational EMF exposure has not been able to prove a very strong association between brain cancer, leukaemia and subtypes of leukaemia [10]. It is however known that continuous exposure to high EMF levels could result in serious illness. A small risk increase (10-13%) has been reported by [10].

Table 4 illustrated measured EMF levels of equipment in operation mode at the residential building. All the recorded values are beyond the recommended range of 3 - 4 mg. Values as high as 60mg have been recorded. For instance, the radio set, water heater switch, standing fan, fridge (back), television (back) and the power button area of laptops were found to be 1250% to 1950% higher than the accepted norm (3 - 4 mg). The high levels when operating installed systems and gadgets in buildings imply that each time an electrical appliance is operated, a health price is possibly paid which could lead to serious illness. Another study looked at physical activity and EMF exposure in pregnancy [15]. The main result was that women with high activity levels were more likely to encounter high peak EMF (household appliances, office equipment, electric power lines, etc.) which could lead to miscarriage [15]. Children are known to be susceptible to leukaemia and that is why epidemiological studies have had their attention to date [9]. A researcher [16] proposes a lower range (0.2 to 0.5 milligauss) for babies. Electrical wiring and the position of fuse boxes ought to be considered in the design of buildings by architects and services engineers. Walls harbouring electrical cables constantly have high EMF values. It is prudent to conduct surveys of houses before occupants move into their buildings. Areas of threat could be shielded with wardrobes, which calls for expert advice in dealing with building ecology and interior design.

There was no alarm regarding the results of the interview with the occupants on prevailing adverse health effects. The building occupants were advised to be cautious when handling electrical gadgets and to be mindful of children operating and playing close to installed equipment. The occupants were advised to change the swing direction of a door leading to one of the bedrooms. The access to the bedroom was alongside a partition wall which houses the fuse box of the dwelling.

Generally, most published research works on exposure to EMF and negative health effects have not been conclusive as have been reported [2, 12, 7, 17, and 2]. It is however paramount to note that current studies have found an association between EMF and Alzheimer disease [11]. One ought to be cautious when dealing with electromagnetic fields.

### CONCLUSION

The study presented had the aim of assessing EMF levels in residential buildings. The method used was a field survey where measurements were recorded and compared with an accepted range of EMF. The results showed that the occupants in the studied building are safe. Nevertheless, exposure to high EMF (5 - 78mg) could be experienced when operating electrical gadgets. The walls containing the fuse box were found to have a high EMF value, double the recommended range of 3 - 4mg. Building designers and services engineers are to champion the course leading to healthy environments. More detailed studies on EMF levels in buildings have to be of interest to researchers.

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