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Measurement of Magnetic Fields Emitted By Household Appliances

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ABSTRACT

Increasing the number of electrical devices in our homes causes an increasing in the presence of electric and magnetic fields which result in increasing the degree of exposure to such fields . There is an increasing concern that exposure to EMF may be associated with biological and health effects .The aim of this study is to provide measurements of the magnetic field emitted by some home electrical devices in the range of very low frequency (50 Hz). Measurements were carried out by the EMF TESTER (827). The obtaining results shows that the practical measurements are consistent with the mathematical calculations results .Comparison of these results with the safety standard guideline limits shows that they are within the acceptable exposure limits recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and that means there is no health risk from exposure to these fields if the exposure is within the acceptable limits.

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INTRODUCTION

The generation, transmission, and use of electric energy is associated with the production of electric and magnetic fields (EMF) which emitted by power lines, transformers, service wires, and electrical panels as well as by home appliances. So, In our everyday life, we expose to electromagnetic fields from different sources all the time (Jackson JD. 1992). Many researchers have already embraced the enormous and wonderful effects of these fields on human health because of the association of electromagnetic fields with increased behavioral changes and health problems such as epilepsy, leukemia, cancer, brain tumors, and other serious disorders, (Allen, S. G.; Bernhardt. 1991) and (Feychting M, Jonsson. 2003).

EMF radiations come from both natural sources such as the sun or atmospheric and solar disturbances and from man-made sources including anything that generates, distributes or uses electricity create electromagnetic field (ICIRP. 2009). Electric and magnetic fields are invisible lines of force that surround all electrical devices, home wiring, power lines in the street and high voltage transmission lines. They are invisible lines of force created by electric charges, which produce two kinds of fields: electric and magnetic. EMFs exist almost everywhere. and the intensity of magnetic and electric fields minimizes as you move away from the source (Tenforde, T. S.1991). Residential exposure was associated with miscarriages while occupational exposure was linked to various reproductive problems as well as adult cancers including primary brain tumors, leukemia, and breast cancer (Wertheimer, N. and E. Leeper. 1989).

In this research we will try to investigate the human exposure to electromagnetic field in home at low frequency (50 Hz) and we will focus on the magnetic field and not on electric field by calculating and measuring the magnetic field density (B) in the (living room, bed room and kitchen) and identify possible mechanisms to reduce the EMF exposure levels in order to avoid its negative health effects.

1.1. Previous work:

Some epidemiological studies have suggested increasing cancer risk associated with estimates of magnetic field exposure, in the other hand there is no adverse physiological or psychological effects were observed in laboratory studies of people exposed to50-Hz fields (Sander, R.; Brinkmann, J.; Ku¨hne, B. 1982) and (Ruppe, I.; 1995).

The following studies are conducted to determine the risk assessment:

- Sander *et al.* (1982) and Graham *et al.* (1994) fond that there were no observed changes in blood chemistry, blood cell counts, blood gases, lactate levels, electroencephalogram, skin temperature, or circulating hormone (Selmaoui, B.1996).

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-Two studies are conducted by Wertheimer and Leeper, one examining the use of electric blankets and heated waterbeds (1986) and the other examining ceiling cable electric heat (1989), showed that fetal loss increased when conception occurred during the months of increasing cold (October to January) for parents exposed to an EMF source during the night. Homes in which electric blankets and ceiling cables were not used did not show a seasonal pattern of fetal loss. Electric blankets can generate magnetic fields as high as 4 mT at a distance of 5 cm, and ceiling cable heating produces ambient magnetic fields of approximately 10 mT and electric fields of 10-50 V/m. Ambient fields in most homes, even those with baseboard heaters, tend to be less than 0.1 mT and 10 V/m (Wertheimer and Leeper 1989).
- (Goldhaber *et al*. 1988) conducted a case control study of 1583 pregnant women who attended one of three gynecology clinics in Northern California during 1981 and 1982. They found a significantly elevated risk of miscarriages for the working-women who reported using video display units for more than 20 hr each week during the first trimester of pregnancy compared to other working women who reported not using video display units (J.Schuz and A.Ahlbom.2008).
-Sandström *et al*. (1993) measured magnetic fields from video units in 150 offices and found that rms values measured at 50 cm from the screen ranged up to 1.2 μT (mean: 0.21 μT) in the ELF range (0–3 kHz) and up to 142 nT (mean: 23 nT) in the VLF range (3–30 kHz).
- Liburdy *et al*. (1993) reported that women sleeping under electric blankets had disrupted melatonin production. The threshold for effect was between 0.2 and 2 uT, well within the range of the Wertheimer and Leeper (1986, 1989) studies. Melatonin has many functions one of which is the regulation of sex hormones, estrogen and progesterone, which are critical for full term pregnancies.
- Goldhaber *et al*. (1988) conducted a case control study of 1583 pregnant women who attended one of three gynecology clinics in Northern California during 1981 and 1982. They found a significantly elevated risk of miscarriages for the working-women who reported using video display units for more than 20 hr each week during the first trimester of pregnancy compared to other working women who reported not using video display units (London, S.J., D.C, 1991).

1.2. Biological effect of EMF radiation:

Low-frequency MF induces current within the human body. The strength of these currents depends on the intensity of the outside magnetic field. If the amount of current is large then it can effects biological processes and could simulate the nerves and muscles**.** Some of these biological effects are (ICINRP. 2001):
1. Contribute to miscarriage or birth defects.
2. Promote the growth of cancer cells.
3. Interfere with the cell processes and functions.
4. Affect the function of the pineal gland and its hormone, melatonin.
5. Influence the dopamine, opiate, and pineal systems, which in turn interact with the immune system.

Many organizations have been established and issued guidelines for limiting EMF exposure that will provide protection against adverse health effects The major of these organizations is the International Commission on Non-Ionizing Radiation Protection(ICNIR) which established in1998 and issued its guidelines exposure limits (Huuskonen, H.1996) shown in table (1).

Table 1: EMF Exposure Standards Applicable in Europe and Elsewhere (Huuskonen, H. 1996).

(EMF)	E(V/m)	B (μT)
Occupational Exposure	10KV/m	500 μT
General public Exposure	5KV/m	100 μT

2. Methodology:

For determining the magnetic field levels. We will go through the following steps:
1- Mathematically calculating the electromagnetic flux density (B) for some house hold appliances at three ranges (5cm , 25cm and 75cm).
2-Practically Measuring the electromagnetic flux density (B) for some house hold appliances at three ranges (5cm , 25cm and 75cm).
3-Practically Measuring the electromagnetic field levels at four points in three samples of (living room, kitchen and bedroom)

2.1. Mathematical Calculation:

The magnetic flux density(B) can mathematically calculating using Amperes law which gives the magnetic flux density (B) when a current (**I**) flow through the very long conductor (Matthew N.O. Sadiku. 2009).

$$B = \frac{I.\,\mu 0}{2\pi .r} \qquad (1)$$

Australian Journal of Basic and Applied Sciences, 7(13) November 2013, Pages: 292-298

Where:
B : Magnetic field (magnetic flux density), measured in *Tesla (T)*
I : Electrical current , measured in *ampere (A)*
r : distance from the source of EMF , measured in *meter (m)*
μ_0 : Permeability of free space, measured in *Tesla .meter/ampere* ($T . m / A$)

$\mu_0 = 4 \pi x 10^{-7}$ ($T . m / A$)

Basing on Maxwell's equations, The magnetic field in any point at home or work place can be calculated by superimposing the individual contribution of the current of each conductor : as in the following equation (Matthew N.O. Sadiku. 2009):

$$B = \frac{\mu_0}{4\pi} \int_{k_i} \frac{I \mathrm{d}\mathbf{l} \times (\mathbf{r})}{|\mathbf{r}|} \quad (2)$$

Where:
I : Electric current
r : distance between the observed point and the original conductor [m]
ε – Permittivity of space in which the field is calculated

2.2. Practical measurement:

We will use the EMF exposure level tester (EMF-827) shown in figure (1) for measuring the magnetic fields. This portable instrument is an exposure level meter for measuring magnetic fields in homes and workplaces at a frequency of (50 HZ).

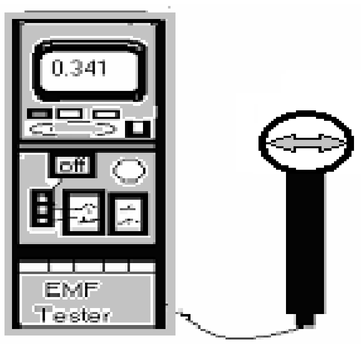

Fig. 1: The electromagnetic field tester: (EMF-827) wit\h wireless probe.

The practical measurements are carried out as follows:
1 - Measuring the electromagnetic field levels at three ranges (5cm, 25cm and 75 cm) from each of the household appliances.
2-Measuring the electromagnetic field levels at four corners inside the living room beginning from point (p_1), point (p_2) which is at a distance of (0.75 m) from the air-condition in, then point (p3) and finally point (p4) which is at a distance of (6.5 m) from the air-condition but it is close to TV and desktop computer as shown in fig.(2).

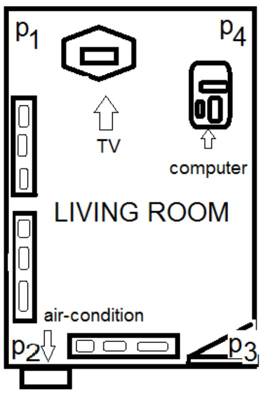

Fig. 2: Top view of the living room.

3- Measuring the electromagnetic field levels at four corners in bedroom that contains air-condition beginning from (p1), (p2) ,(p3) and (p4).as shown in fig.(3).

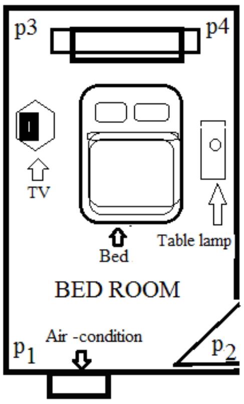

Fig. 3: Top view of the bed room.

4- Measuring the electromagnetic field level in the kitchen contains (refrigerator, electric oven, electric fan and electric mixer) at four points beginning from (p1),(p2) , (p3) and (p4).as shown in fig. (4).

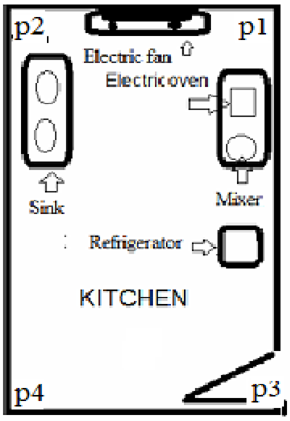

Fig. 4: Top view of the kitchen.

RESULTS AND DISCUSSION

By applying equations (1,2), the magnetic field density (B) emitted by some household appliances can be mathematically calculated at thee ranges from the sources as illustrated in table (2).

Table 2: Mathematical calculations results of magnetic field density emitted by some household appliances in (microTesla).

Device	B(µT) atr = 5cm	B (µT) at r = 25 cm	B (µT) at r = 75 cm
Air-condition	1.104	0.776	0.548
Electric mixer	1.507	0.413	0.028
Electric Oven	1.719	0.876	0.183
desktop Computer	0.965	0.216	----
Refrigerator	0.843	0.312	0.062
Color television	0.932	0.440	0.081

Results of magnetic field measurement for household appliances in (µT) are shown in table (3).

Table 3: Practical measurement of magnetic fields emitted by household appliances in (µT).

Equipment	r = 5 cm	r = 25 cm	r = 75 cm
air-condition	4.206	0.873	0.523
electric mixer	3.433	0.778	0.225
Electric Oven	2.621	0. 508	0.041
desktop Computer	1.875	0.125	———
Refrigerator	1.729	0.233	0.032
Color television	2.872	0.426	0.071

Practical measurements of (B) in living room in four points for three living room samples are shown in table (4)and the graphical representation of these measurements are illustrated in figure (4).

Table 4: Practical measurements of (B) in thee samples of living rooms.

Living room contains TV, desktop computer and air-condition	Magnetic flux density (B) at some points in the living room in micro Tesla (µT)			
	P1	P2	P3	P4
Living room No.1	0.172	0.631	0.198	0.187
Living room No.2	0.165	0.548	0.164	0.197
Living room No.3	0.208	0.534	0.157	0.212
Average values	0.181	0.571	0.173	0.198

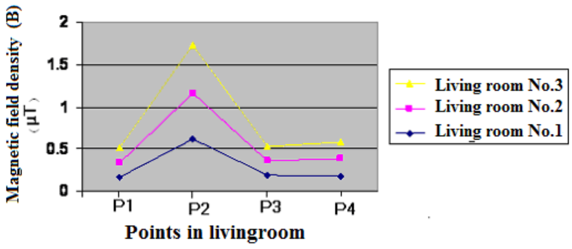

Fig. 5: Graphical representation for magnetic field levels in the three samples of the living room.

Practical measurements of (B) in living room in four points for three samples of bedroom are shown in table (5) and the graphical representation of these measurements are illustrated in figure (6).

Table 5: Practical measurements of magnetic field levels in three samples of bedrooms.

bedroom contains air-condition	Magnetic field (B) at some points in the bedroom in micro Tesla (µT)			
	P1	P2	P3	P4
Bedroom No. 1	0.581	0.314	0. 144	0.112
Bedroom No.2	0.493	0.283	0. 176	0.116
Bedroom No.3	0.572	0.352	0. 169	0.111
Average values	0.548	0.316	0. 163	0.113

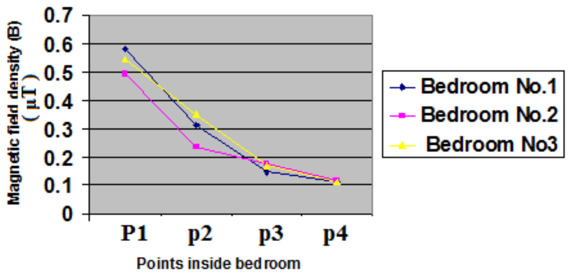

Fig. 6: Graphical representation for magnetic field strength (B) in the three samples of the bed room.

Practical measurements of (B) in living room in four points for three samples of kitchen are shown in table (6)and the graphical representation of these measurements are illustrated in figure (7).

Table 6: Practical measurements for magnetic field strength (B) in three samples of kitchen

kitchen contain refrigerator, electric fan , electric mixer, electric oven	Magnetic flux density (B) in the kitchen in micro Tesla (µT)			
	P1	P2	P3	P4
kitchen No.1	0. 980	0.909	0.578	0.185
kitchen No.2	0.761	0.864	0.615	0.196
kitchen No.3	0.846	0 .790	0.597	0.207
Average values	0. 862	0.854	0.596	0.196

Australian Journal of Basic and Applied Sciences, 7(13) November 2013, Pages: 292-298

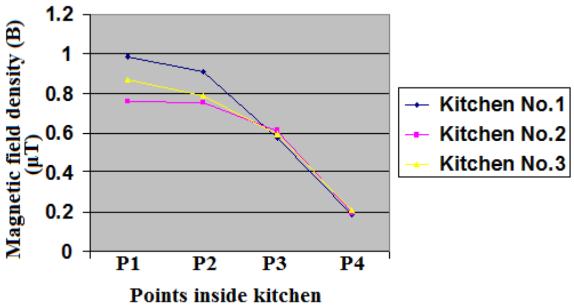

Fig. 7: Graphical representation for magnetic field strength (B) in the three samples of kitchen.

According to the standard limitation set by the ICINRP shown in table (1), the mathematical and practical measurements have been shown quite normal exposure to magnetic field (< 100 µT). the average of exposure level in (living room ,kitchen and bedroom) are illustrated in tables (4,5,6) and graphical representation of measurement levels illustrated in figures (5,6,7). It is observed that the highest exposure to magnetic field is found in kitchen (point p_1= 0.862 <100 µT). The lowest exposure is found in the bed room at point (p_4=0.12< 100 µT). The reason of high magnetic field exposure in kitchen is because it contains many electric equipments such as refrigerator, electric fan, electric mixer, electric oven. However, the measuring levels are within the exposure limits set by ICNIRP (< 100 µT), and they don't pose any risk to health. From the results and discussion, we can conclude the following:
a- The magnetic field in the points closer to the electric oven and refrigerator in the kitchen were higher than fields in the other points. So it is strongly recommended to be away as possible from these appliances when working with them in kitchen to avoid the negative health effect of the exposure.
b- The magnetic field in the points closer to the air-condition in the living room and in the bed room was higher than fields in the other points. Accordingly, the magnetic fields rose up to the levels that threaten health conditions when moved towards the air-condition and decreased when moved away from it. So it is strongly recommended to be away from the air-condition at least for (2m) to avoid the negative health effect of MF exposure.

4. Recommendations:

To reduce EMF levels in our vicinity the first thing that must be taken into account is the distance from the source of the field and how much time we spend in the field. So, expanding the distance between our self and the sources of EMF is the easiest way to reduce EMF exposure level .
The following simple recommendations will help us to reduce EMF exposure levels at our homes:
•Move as possible any electrical devices away from your bed.
•Stand away from operating appliances that use a lot of electricity especially those with motors .
•Sit a few metes away from the TV and at least an half meter from the computer screen.

5. Conclusion:

Human beings are affected by interior and exterior electromagnetic fields that exist in nature, as well as the electromagnetic field pollution created by themselves, The devices that create electromagnetic fields have become a part of our lives. Therefore, we have to take possible precautions against the adverse effects of these devices. Because it is not possible to see the electromagnetic fields with the naked eye and their effects cannot be felt directly, people can not attach adequate importance. So, it is important to spot the sources of magnetic field pollution in our homes to take necessary precautions to reduce its effect on our health.

In this work the magnetic field measurements are carried out in two parts: mathematical calculation and practical measurement. The results are considered and studied individually. The comparison of these results with the standard exposure limits that set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) shows that the measurements levels are within the standard levels(<100 µT) ,so they may be don't cause any risk to human health if the exposure is for intermittent periods. However, a risk does exist if the humans exposure is being for a long and continuous periods.

Abbreviations:

EMF : Electromagnetic Field
ICNIRP: International Commission on Non-Ionizing Radiation Protection
WHO : World Health Organization

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