

Measurement of Low Frequency Electromagnetic Radiation Emitted from Overhead Power Lines in the State of Kuwait

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Abstract — We aim to measure the ELF-magnetic field radiation levels emitted from power transmission lines in Kuwait. Many areas were scanned especially close to the transmission lines. The areas were monitored over a 12 month period with repeated visits to each location. Some have shown safely low levels, while few locations close to power stations exhibited high levels. However, since the locations with high levels are not inhabited, we can confirm that the power transmission lines in Kuwait do not pose any health threat to the public.

Key Words - Electromagnetic radiation, Gauss, Leukemia, Power transmission, .

1. Introduction

We are exposed to EMF from many sources, including high voltage transmission lines (usually on metal towers) carrying electricity from generating plants to communities, and distribution lines (usually underground) that bring electricity to our homes, schools and workplaces. We are also exposed to magnetic fields from wiring in buildings and from all our electric appliances like TV sets, radios, hair dryers, electric blankets and electric tools.

The strength of magnetic fields varies depending on many different factors, including the magnitude of the current and the proximity to an EMF source. Because magnetic fields decrease with distance from the source, the magnitude of the magnetic field is higher in homes near a power line than those further away. Commercial and residential power distribution systems can be a more significant source of magnetic field exposure than transmission lines, but they are usually not a very significant source of large electric fields.

One of the main sources of high magnetic radiation is the electric power system transmission lines. The magnetic field produced around the power lines has always been an important issue and concern for the people working in the environmental sector and those who are interested in the health matters. In this paper, we present measurement results of magnetic fields around power transmission lines

in the state of Kuwait. The results will provide information for health authorities and regulatory agencies on the possible effects of electromagnetic field exposure on human health, and to give guidance on the assessment of risks from occupational and general population exposure. The results presented in this paper cover the period from March 2005 to February 2006.

In the next section we will present information on the power system in Kuwait. In section 3 we will assess the outcome of research on the health effects of electromagnetic radiation. The measurement methodology and results will be presented in section 4 while the discussion is given in section 5. Finally comes the recommendations and conclusions in section 6.

2. The Electrical Network of Kuwait

The complete electric power system is a complex mix of generation, transmission lines, and distribution lines, interspersed with substations and transformers that adjust the voltages between the various lines and the end user.

Kuwait, at present, is covered by a vast electric power network consisting of overhead lines and underground cables in addition to the primary, secondary and distribution transformer stations. Currently there are 6 major power stations in Kuwait as follows;

1. Doha east and Doha West

2. Sabbia
3. South Shuaiba
4. Zoor east and Zoor West

These supply power to the sixteen “275Kvoltage” substations, which are usually called 300Kvoltage substations. It is these stations and the lines connected to them that may raise health concerns. There are more than 200 132Kvoltage substations which feed power to the 33Kvoltage stations and the 4Kvoltage stations. Following is the status of Electrical Networks by the end of 2003:

1. Extreme High Voltage Network:
 - a- 203km of underground 300 KV Cables.
 - b- 638km Overhead 300 KV Lines.
 - c- 16 Sub-Stations of 300 KV.
2. High Voltage Network:
 - a- 237 Sub-Stations of 132 KV.
 - b- 116 Sub-Stations of 33 KV.
 - c- 169 Spur Sub- Stations of 33 KV.
 - d- 2824km of underground 132 KV Cables.
 - e- 1517km of underground 33 KV Cables.
 - f- 1510km of Overhead 132 KV Lines.
 - g- 1718km of Overhead 33 KV Lines.

3. Survey of Research on ELF-EMF Health Effects

Research on the health effects of EMF began in the late 1960.s and was originally focused on electric fields. In 1979 Wertheimer et al, [1] reported a statistical association between magnetic field exposure and distance between a power line and someone’s home, and two- to three-fold increases in leukemia risk among U.S. children. In 1988 a second study by Savitz et al. [2], found similar results. This early research brought the issue of magnetic field-related health risks to the attention of scientists and the public. Some recent studies have reported no statistically significant association (Linnet et al., 1997; Dockerty et al., 1998; McBride et al., 1999) while others have reported an association (Green et al., 1999; Schuz et al., 2001). The strongest evidence that ELF-EMF exposures pose health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. The epidemiological studies demonstrate a fairly consistent pattern of small increased risk with increasing exposure that is somewhat

weaker for chronic lymphocytic leukemia than for childhood leukemia. The mechanistic studies and the animal toxicology literature report sporadic findings of biological effects (including increased cancers in animals). No indication of increased leukemia in experimental animals has been observed. The lack of connection between the human data and the experimental data (animal and mechanistic) severely complicates the interpretation of these results. The human data are tied to real life exposures and show some consistency that is difficult to ignore. Epidemiological studies have serious limitation in their ability to demonstrate a cause and effect relationship whereas laboratory studies, by design, can clearly show that cause and effect are possible. Accordingly some advisory groups and scientific review committees like NIHS and the British NRPB, Advisory Group on Non-Ionizing Radiation have concluded that ELF-EMF exposure cannot be recognized at this time as entirely safe because of scientific evidence that exposure may pose a leukemia hazard.

In 1999 the Institute of Electrical and Electronics Engineers, Engineering in Medicine and Biology Society convened the Committee on Man and Radiation (COMAR) concluded that it is highly unlikely that health problems can be associated with average 24-hour field exposure to power frequency magnetic fields of less than 1 microT (10 mG).

In September 2000 researchers published a pooled analysis of EMF studies in the British Journal of Cancer (Ahlbom et al., 2000). The analysis included data from nine studies that had been conducted in Europe, Canada, New Zealand, and the U.S., including data from the 1999 McBride et al. study. The study reported a weak association between exposure to power frequency magnetic fields greater than 4 milligauss and childhood leukemia. Specifically, the study found that children with residential exposures to magnetic fields greater than 4 milligauss had a statistically significant relative risk estimate of two for childhood leukemia.

A committee chaired by Sir Richard Doll, reported in March 2001 for the National Radiological Protection Board in the UK, that there is a possible cancer risk from magnetic field exposure. In particular, it is possible that a

child exposed to prolonged and higher-than-normal magnetic fields might develop leukemia.

4. Measuring the Low Frequency Electromagnetic Radiation

4.1. Measurement Methodology

To assess the effects of the electromagnetic radiation from power transmission lines, a professional Gauss meter was used. We have made more than 100 field trips during the project period, with an average of approximately 12 trips per month. We aimed at measuring different areas all over the inhabitant areas of the state of Kuwait, trying to cover as much area as possible.

We have measured radiation levels both in a *wide* and in a *detailed (focused)* survey. By wide we mean a large coverage area with distant measurement locations. While detailed refers to the condensed measurements taken over a small area close to a specific transmission line. The team has taken many readings for the targeted area to increase the reliability of the measurements and to obtain readings that cover different potential load conditions at different times and dates. In addition, the team surveyed areas that did not include transmission lines, to confirm the safety of these locations.

An overview of the results is presented in the color coded images. Tables of detailed measurement levels are available but were omitted due to space restrictions. Satellite images available from Google Earth and map images from Map Source were used to display the color coded results.

4.2. Measurement Results

In this section we present the measurement results of the magnetic fields over wide areas. The purpose of this analysis is to give a general vision of radiation levels in the State of Kuwait. The measurement technique implemented in this analysis relied basically on taking few readings (at least five readings every 10 seconds) at each location. The locations were separated by a distance of approximately 1 km. Then, at each location these readings were averaged and consequently this average value represents the level at the corresponding position. The level of

radiation exposure is categorized into four different classes as shown in table 1.

Table 1 Legend of the color used in categorizing the radiation levels.

Colour	Range of Radiation (mG)
Green	$X < 15$
Yellow	$15 < X < 40$
Orange	$40 < X < 80$
Red	$X > 80$

The *Green* colour represents the safe level of exposure. On the other hand, the *Yellow*, *Orange*, and *Red* range colours represent undesirable range of exposure. Although there are no overhead transmission lines on the First, Second and Third Ring Roads, in addition to Arabian Gulf Street we measured the magnetic field radiation in order to confirm the safety of these regions. Four different trips were made to take readings according to the procedure explained above. As anticipated, the radiation levels were within the Green category. The average magnetic field was less than 5mG, indicating safe levels of exposure.

We also measured the radiation level along the coastline moving towards the south from AlBeda' to AlMessila then along the Fahahel highway. The level of magnetic radiation was less than 15mG, i.e. in the green category. With an average value for the four trips equaling 6.3 mG.

The Fifth Ring Road has many transmission lines and towers that run parallel to the road. Fourteen different trips conducted on this road, between the Bayan Palace and AlQairawan, passing through the National Control Center (NCC) and the areas of South Surra, Khaitan, Omariya, Rabya. Ardiya, Firdous, Sulaibiya, and Qairawan.

There are many substations that are built along the 5th RR and consequently the distribution of the line is condensed in this area. The trips were divided in two groups: (i) Westbound From Bayan Palace towards Jahra, and (ii) Eastbound from Jahra towards Bayan Palace. The transmission lines are on the eastbound side of the 5th ring roads. Therefore, the first group of trips concentrated on the areas that were away from the lines, whereas the second group

represents the areas close to the transmission line. As will be shown in the coming maps the effects of the level of the magnetic radiation on the areas belonging to the second group is higher than those belonging to the first group, which is an expected result.

As can be seen in Fig. 1 which represents one of the trips from group 1, the overall level of radiation is in the *Green* category, i.e. the safe class. However, there are some locations that fall in the *Yellow* region. These *Yellow* locations are mainly within a distance of 50 meters from the transmission lines. Since houses are further than 50 meters from these lines, we can confirm the lines do not pose any danger to residents of these houses.

Figures 2 and 3 represent trips from group 2 that concentrates on the areas close to the transmission lines distributed along the 5th RR. We can see that the distribution along this side of the road varies. Although the major parts belong to the *Green* category, there are some areas that are categorized as *Yellow*, *Orange*, or *Red*. Moreover, most of the areas with colours other than Green were found at locations close to the power substations. For example, at some locations in Khaitan and Ardiya, where substations exist, the radiation level increases above the green limit.

In addition, the magnetic radiation of the power lines at many locations near the Qairawan area is categorized as Red. Although the houses built there are far from these lines, people need to be advised to keep away from the lines (especially children that may use these open spaces to play). Figure 4 indicate that the inhabited areas of Al-Jahra have safe radiation levels except for a small area.

King Fahad road (or Al-Maghreb road) probably hosts the largest number of the power towers, and power distribution lines. The 300-kV lines are mainly distributed along this road. Therefore, we have split the road into two main segments: (i) from the National Control Center (NCC) to Al-Qosour, and (ii) from Al-Qosour to Mina Al-Shuaiba area. From several trips we found that the readings do not reflect a radiation hazard. Rather, the levels fall generally in the *Green* category. Figures 5 and 6 demonstrate a summary of the results.

In the detailed survey we aim to investigate the suspected areas in more detail relative to the

wide area measurements. In the detailed study we made more than 40 field trips over a six month period, from April to October 2005. The measurement procedure included taking at least 30 readings at locations surrounding each tower. These locations were few meters apart. Several towers were investigated at each area, where the distance between these towers is approximately 200 meters. At each tower the readings were averaged to represent the exposure level at the corresponding tower location. The surveyed locations were; *Exhibition Area at Mishrif*, *Khaitan*, *Al-Omariya*, *Al-Rabia*, *Al-Salam (South Surra)*, *Al-Ardiya*, *Al-Qairawan*, *Al-Jahra*, and South of Kuwait on route 40. Most of these areas have some radiation levels that reach the red mark. Figure belonging to this part of the study were omitted due to space restrictions.



Figure 1. Radiation level on the Fifth Ring Road from Bayan Palace to Jahra for trip 2, (west bound).

5. Discussion

Many researchers have determined that important elements to confirm causality are currently lacking for EMF and human disease, including strength of association, consistency and specificity of observations, appropriate temporal relationship, dose response relationship, biological plausibility, and experimental verification.

However, we believe there are many parameters that affect the cause and effect relationship, and since we are dealing with the human being some of these factors are unknown or complex. Therefore, and since ignoring the threat could be fatal, epidemiological studies

must be taken into consideration even if lab studies can not establish a cause and effect relationship.

Before judging on the risk of power lines in Kuwait, given the measured values, we need to know the exact relation between degree of radiation and time of exposure. The literature indicates that scientists related the health concerns with two parameters, the radiation levels and the amount of time of exposure.

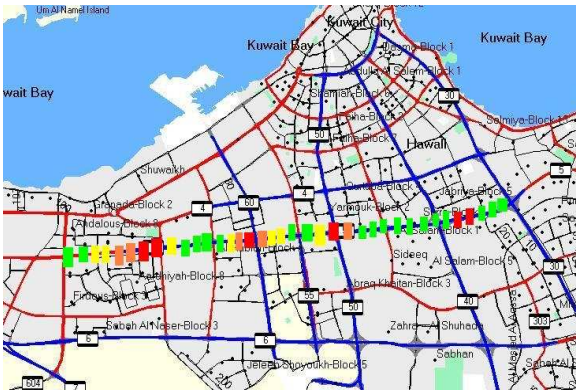


Figure 2. Radiation level on the Fifth Ring Road from Jahra to Bayan Palace for trip 1, (east bound).

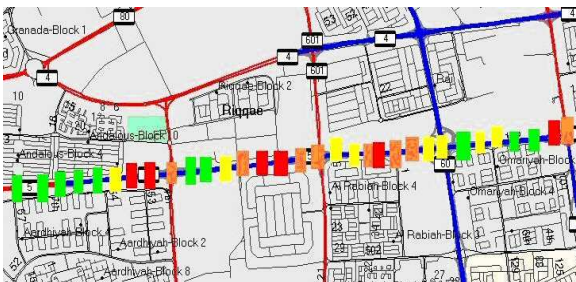


Figure 3. Radiation level on the Fifth Ring Road from Jahra to Bayan Palace for trip 12, (east bound).

As was explained in section 3, the red areas shown in our maps may not cause any health risks if a person is not exposed for long periods of time. Based on our research we did not find any formula that shows how the two parameters are related when a health risk exists. Therefore, for health concerns to be raised, we do not know if increasing one parameter would be followed linearly by a decrease in the second parameter. For example, for a 40mG radiation, what is the amount of time needed before a health warning is raised. And how much would this time frame become for a 4mG radiation. We believe that an investigation along this line is needed.



Figure 4. Magnetic radiation level along the road toward Al-Jahra for trip 4.



Figure 5. Magnetic radiation level along the King Fahad road from NCC to Qosour for trip 4.

It is obvious that moderate levels of radiation exist around the power transmission lines. It is also established that radiation may increase the risk of cancer among other health problems. Given these two facts we emphasize that no one should stay in the radiation zones for prolonged periods of time.

Fortunately, none of the areas of high radiation were close to the inhabited areas. The lines run next to highways, which we do not consider as inhabited, because no person stays there for prolonged periods of time and drivers pass through the radiation fields briefly. Therefore, we do not think this should raise any concerns. However, the public should be advised not to camp under the power transmission lines. They need to camp at least 50 meters away from

these lines since the radiation level drops to safe levels at such a distance.

6. Conclusion

The aim of this paper is to record radiation levels, and compare them with the international limits. We have scanned large areas of Kuwait, especially close to the power lines, to record the ELF radiation levels. We covered the 5 ring roads in addition to the coastal line and highway 40. Additionally we have surveyed targeted areas in Aljahra, the Mishrif exhibition area and some routes next to highway 40 in the south.

We have noticed high levels reaching the red mark on the fifth ring road, on route 8, on route 40 and in Aljahra. The Mishrif exhibition area produced radiation levels just above the green marker, i.e. the yellow marker. Since none of the high radiation level areas are inhabited, we conclude that the radiation in the State of Kuwait does not pose any threat to the public.

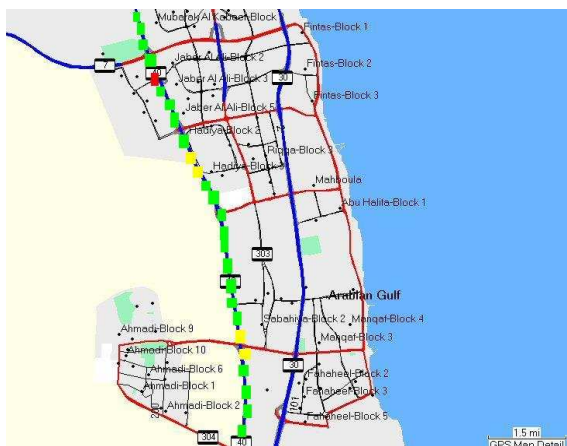


Figure 6. Magnetic radiation level along the King Fahad road from Qosour to Mina Shuaiba for trip 4.

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References

[1] Wertheimer, N., and E. Leeper (1979), Electrical wiring configurations and childhood cancer. *Am. J. Epidemiol.* 109:273-284.

[2] Savitz, D.A., Wachtel, H., Barnes, F.A., John, E.M., Tvrdik, J.G. (1988), Case Control Study of Childhood Cancer and Exposure to 60-Hz Magnetic Fields. *Am. J. Epidemiol.*,128:21-38.

[3] Dockerty, J.D., Elwood, J.M., Skegg, D.G., Herbison, G.P. (1998), Electromagnetic Field Exposures and Childhood Cancers in New Zealand. *Cancer Causes Control*, 9 (3): 299-309.

[4] Green, Lois M., Miller, Anthony B., Agnew, David A., Greenberg, Mark L., Li, Jiehui, Villeneuve, Paul J., Tibshirani, Robert (1999), Childhood leukemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada, *Cancer Causes and Control* 10: 233-243.

[5] Schuz, J., Grigat, J., Brinkmann, K., Michaelis, J. (2001), Residential Magnetic Fields as a Risk Factor for Childhood Acute Leukaemia: Results from a German Population-Based Case-Control Study. *International Journal of Cancer*, 91: 728-735.

[6] IEEE 1999. C95.1-1999, IEEE Standard for Safety Levels with Respect to Human Exposure to RF Electromagnetic Fields, 3 kHz - 300 GHz, IEEE Inc.

[7] National Radiological Protection Board (2001), Statement on Childhood Leukemia and Residential Exposure to Magnetic Fields, web: http://www.nrp.org/press/response_statement/response_statement_5_01.ht