# Electromagnetic Energy in the Environment and Human Disease

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**Abstract**

Environmental electromagnetic energy from high-voltage powerlines, microwave ovens, radio and TV towers, and other similar sources, is pervasively present in the environment. Numerous laboratory studies with animals and human beings have shown that such energy is a biological stressor in the sense that it can elicit an adaptive response from the exposed organism. As with any stressor, chronic application is inimical to the organism's well being and ultimately may lead to disease. Electromagnetic energy does not produce a signature disease, rather it is associated with an elevation of mortality and morbidity levels in the exposed population. The link with human disease has been shown in appropriately controlled epidemiological studies in which exposure was associated with cancer and suicide.

Keywords: electromagnetic energy, electromagnetic fields, electric fields, magnetic fields, environment.

## Introduction

The emerging perception of man in relation to the environment is that of an adaptable — but not infinitely so — animal attempting to cope with myriad factors, each of which has potential physiological significance.[1] These factors may be internal such as a genetic predisposition, or external such as chemical substances in the air or water. Clinical disease may be viewed as a manifestation of the cumulative impact of these factors. It develops when the total load exceeds the individual's adaptive capacity.[2]

The total-load concept applies to any factor that is inherently capable of eliciting an adaptive response.[3] Electromagnetic energy present in the environment from such devices as high-voltage powerlines, microwave ovens, or electric blankets is such a factor. Consequently, chronic exposure to these and similar devices has significance for the public health and for the clinical status of particularly sensitive individuals. My aim here is to broadly sketch the nature of environmental electromagnetic energy, and its clinical consequences.

## Electromagnetic Energy in the Environment

The Earth has a natural electromagnetic background that arises from the sun and other cosmic sources, and from the Earth itself in the form of the geomagnetic field and electrical disturbances produced by weather patterns. Until recently the natural electromagnetic background was relatively constant, but the situation changed markedly and precipitously with the development of modern communications and electrical power systems. The environment is now heavily laden with man-made electromagnetic fields from radio, TV, microwave relay, CB, and many similar sources that propagate through space with the speed of light (measured in units of microwatts/cm$^2$). Typical values of environmental electromagnetic fields are shown in Table 1. Because the antenna for a hand-held walkie-talkie is near the user's head area, fields up to 12,000 microwatts/cm$^2$ can occur. Microwave ovens are permitted in commerce with leakage levels as high as 5,000 microwatts/cm$^2$. Aging ovens with worn hinges or door seals may leak still higher levels. In large cities, antennas are frequently mounted on top of tall buildings to increase broadcast efficiency and range. This procedure results in relatively high levels inside adjacent buildings. Antenna farms consist of groupings of antennas at a relatively high elevation in the vicinity of the intended audience. Energy levels up to 28,000 microwattslcm$^2$ have been measured at the Mount Wilson antenna farm near Los Angeles. The Sentinel Heights area south of Syracuse, New York, contains about a dozen transmitters that produce about 1 microwatt/cm$^2$ throughout an area of several square miles. The Environmental Protection Agency has conservatively estimated that about 1% of the United States population is exposed to more than 1 microwatt/cm$^2$ at any given moment.[8] The permissible safety level in the USSR for exposure to electromagnetic fields is 5 microwatts/cm$^2$ (recently raised from 1 microwart/cm$^2$). There is no official safety level in the United States.

In addition to electromagnetic fields, electric fields and magnetic fields arising from powerlines and the devices that they energize are also present in the environment. As with electromagnetic fields, the strength of the elec

tric and magnetic fields (units, volts/meter and gauss respectively) actually experienced depends strongly on location. The average man-made background electric field is probably on the order of 1 volt/meter[9] and the average background magnetic field is about 80() microgauss (1 gauss = $10^6$ microgauss).[9] These fields are pervasively present, and cannot be uniquely identified with any par ticular device. Significantly stronger fields can be measured in the immediate vicinity of specific kinds of hardware. 'The high-voltage powerline is one example. Typical ground-level values of the electric and magnetic field directly under powerlines are 10,000 volts/meter and 0.5 gauss respectively. The intensity of both fields decreases as one moves laterally away from the line on either side. I)espirc this, the actual zone of influence of high-voltage powerlines (the distance from the powerline within which the electric field is greater than I volt/ meter) is surprisingly wide (Table 2).[9]

Reported values for the electric[10] and magnetic field[11] near ordinary household devices are listed in Table 3.

**Table 1**
**Electromagnetic Fields in the Environment**

| Source | Electromagnetic Field (microwatts/cm$^2$) | Reference |
|---|---|---|
| Walkie-Talkie | 12,000 | (4) |
| Microwave Oven | 5,000 | — |
| 102nd Floor, Empire State Building | 32.5 | (5) |
| Mt. Wilson, California | 28,000 | (6) |
| Sentinel Heights, NY | 1 | *(7)* |

**Table 2**
**Zone of Influence of High-Voltage Powerlines**

| Powerline Voltage (volts) | Lateral Distance From Centerline (feet) |
|---|---|
| 765,000 | 2500 |
| 500,000 | 1700 |
| 345,000 | 1300 |
| 230,000 | 800 |
| 115,000 | 400 |

**Table 3**
**Electric and Magnetic Fields**
**Near Typical Household Appliances**

| Appliance | Electric Field (volts/meter) | Magnetic Field (microgauss) |
|---|---|---|
| Broiler | 130 | 500 |
| Hair Dryer | 40 | 500 |
| Color TV | 30 | 800 |
| Vacuum Cleaner | 16 | |
| Electric Range | 4 | |
| Light Bulb | *2* | |

**Health Significance of Environmental Electromagnetic Energy**

**1. Biological Stress.** Many reports have shown that electromagnetic energy (electromagnetic, electric and magnetic fields) can alter the metabolism of the nervous, endocrine, cardiovascular, hematological, immune-re sponse, and reproductive systems.[9] The effects on each tissue or system are largely independent of the specific electrical characteristics of the applied signal. For exam ple, Fischer found that 5300 volts/meter resulted in an initial rise of norepinephrine in rat brain and a subsequent decline below the control level;[12] Grin[13] observed the same change at 500 microwatts/cm$^2$. The organism's re sponse to electromagnetic energy is partially determined by its physiological history and genetic predisposition. Thus, individual animals even in an apparently homogen eous population may exhibit changes in opposite direc tions in the biological parameter being measured. For ex ample, when the EEG response was measured in 24 rab- bits (100 microwarts/cm$^2$), 14 rabbits exhibited elevated activity, 6 exhibited depressed activity, and 4 rabbits did not respond to the electromagnetic field.[14] Biological in dividuality is the hallmark of an organism's response to external electromagnetic energy. The responses are generally adaptive or compensatory.

**2. Human Epidemiology.** If electromagnetic energy is simply a nonspecific biological stressor that can elicit a systemic adaptive response in the exposed organism, what kinds of clinical signs will occur in exposed human beings? If an organism is subjected to, for example, a cold stress, adaptive changes occur. If the stress is main tained, the animal's defenses may break down resulting in a diagnosible disease. But there is no signature disease for a cold stress. The animal could exhibit any of several diseases; infection (if a viral or bacterial agent were pres ent in the environment) and pneumonia (if its respiratory system were already weakened for other reasons) are ex amples. The effects produced by environmental electro magnetic energy also depend on diverse factors, and therefore will be manifested by an increase in all diseases in the chronically exposed population.

In the example of the animal undergoing a cold stress, suppose that a second stress is applied (for example, that the animal is forced to live in cramped quarters). The ex pected result in an animal undergoing two stresses is that, whatever disease it is fated to develop when stressed be vond its limit, it will manifest that disease more quickly than if it experienced only one stressor. Thus, in general, electromagnetic energy will be a contributing factor, but not a strict cause, of disease.

One of the first documented links between en vironmental electromagnetic energy and human disease was provided by Becker[15] who reported on an apparent association between such energy (from radio and TV

antennas and high-voltage powerlines) and the incidence of cancer in Sentinel Heights, New York. The cancer in cidence in the electromagneticallv-contaminated study was twice the expected level based on mortality figures for the county as a whole. Subsequently, a more con clusive link with cancer was reported by Wertheimer and Leeper; in separate controlled studies, they found a cor relation between exposure to electromagnetic energy and increased incidence of cancer.[11,16] In 1982, a similar association was made in the context of occupational ex posure.[17] When the incidence of death from cancer among occupationally exposed individuals (electrical engineers, power workers, etc.) was compared to the ex pected incidence, it was found that the exposed popula tion exhibited approximately a l50% greater chance of cancer. Milham's report has been confirmed in three in dependent studies.[18-20]

In the late 1970s, Perry observed what appeared to be an excessively large number of patients with depressive mental illnesses who lived in the vicinity of high-voltage powerlines. These observations led to a detailed epidemi ological study of the possible relationship between suicide (for which accurate public-health records were available) and the strength of the powerline magnetic field at the home of the suicide victim. We found that there was an apparent association between suicide and the strength of the magnetic field;[2]i the suicide victims tended to live in regions of high magnetic field as compared to non-suicide controls.

**High Risk Factors**

Because of its etiological role in human disease — the true dimensions of which are presently only dimly per ceivable – it is prudent to minimize environmental ex posure to electromagnetic energy, particularly among in dividuals exhibiting known sensitivities to chemical agents. Which devices result in the greatest risks? High-voltage powerlines contribute relatively high electric and magnetic fields into the environment, and they are usual ly associated with long-term human exposure of the population that lives or works in the vicinity. Personnel operating airport metal detectors are at risk because the magnetic field employed in such detectors is efficient (compared to powerlines) at coupling electrical energy in to the human body. Because of the liberal leakage levels permitted by federal law, microwave ovens are a concern — more so the older oven and the oven mounted at eye level and subjected to heavy use, such as in fastfood restaurants. Electric blankets expose the user to both relatively high electric and magnetic fields and are associated with relatively long exposure times. Walkie ralkies and CB's result in relatively high exposure levels for the operator because of the proximity of the radiating antenna. Finally, some radar detectors, designed to mount on a car dashboard or sun visor to detect police radar, themselves emit microwaves thereby irradiating the driver.

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