A STUDY OF ELECTROMAGNETIC RADIATION EFFECTS FROM MOBILE PHONE BASE STATIONS ON HUMAN HEALTH

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ABSTRACT

Nowadays, several electrical appliances such as the radio, television, computer, microwave oven, mobile phone are inevitably involved with events in our lives. All of them commonly generate electromagnetic radiation of different frequencies, especially mobile phones, the fifth basic necessity which has recently become part of our everyday lives. During the last decade, the rate of mobile phone subscription has extensively increased to 6.8 million people in 2012 and tends to further increase to 9.7 million people worldwide by 2017. Therefore, it is required that the number of base stations for signal transmission through radiofrequency electromagnetic radiation be expanded by 1.4 so as to support the increasing consumption needs of the present. Such rise in the number of base stations may make people living nearby concerned about electromagnetic radiation effects on both short- and long-term health problems. In order to explain the previous studies of electromagnetic radiation effects on human body, this research focuses on the effects of electromagnetic radiation on various health aspects, i.e. an increase in body temperature, cancer incidence, and abnormalities at cellular and DNA levels. All the contents in this paper can enable us to understand the overall picture of study and research methodologies from the past up to the present. This will lead to development of Thailand’s research in the future.

Key words: Electromagnetic, Effect, Mobile, Base Station, Human, Health


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1. INTRODUCTION

Non-specific health symptoms (NSHS) are subjective to sufferers’ feeling and cannot be measured, for example, headache, dizziness, giddiness, and amnesia. These symptoms are regularly used in health evaluation regarding occupational and environmental syndromes of which the disease mechanism has not yet been able to be explained. However, the study of A. Spurgeon, D. Gompertz, and J. M. Harrington on “Modifiers of Non-specific Symptoms in Occupational and Environmental Syndromes” reveals that such NSHS may result from psychosocial factors as presented in Figure 1 [1].

![Diagram](https://via.placeholder.com/150)

**Figure 1** Relationships between health hazards and social terms and conditions leading to symptoms [1]

From the study of Wongsakorn Angkhakhummool et al [2], undertaken in a village of complaints, it is found that most of the sample groups had an intermediate level of stress and the interview carried out with the villagers and leaders reveals some social conflicts arisen from this particular issue. Furthermore, the villagers also got the information from independent academics and their descendants about the case where a university complained about health effects which eventually leaded to demolition of the mobile phone towers nearby. These stimulate the incidence of NSHS, especially in case where valid scientific information concerning health effects is not available.

The study undertaken in the areas of complaints in a southern province of Thailand by Wongsakorn Angkhakhummool et al [3], was based on the hypothesis made from the population’s concern that people living near cell phone transmission towers will experience NSHS. However, from the analysis of relationships between the distance from towers and NSHS carried out on a group of people living within the radius of 300 meters from towers and another living farther than 300 meters away, it is found that most of NSHS are not subjected to the distance from cell phone transmission towers.

However, according to the literature review of Martin Roosli and Kertin Hug on “Wireless communication Fields and Non-specific of Ill Health” conducted in 2010, there are not any relationship between NSHS and exposure to electromagnetic radiation found [4].
The studies about health effects from electromagnetic radiation or from mobile phone base stations are abundant, including the experiment undertaken in animals and the epidemiological study. However, the article of Martin Roosli et al. entitled “Systematic Review on the Health Effects of Exposure to Radiofrequency Electromagnetic Fields from Mobile Phone Base Stations” published in the Bulletin of the World Health Organization 2010 [5] reveals no health effect involving receiving electromagnetic radiation at daily life exposure doses. However, there are very few study results concerning long-term health effects and effects on children and adolescents found.

In regard to effects of electromagnetic radiation, the term “Electromagnetic Hypersensitivity Syndrome” (EHS) is used to describe the syndrome characterized by non-specific symptoms, in the absence of visible symptoms or physiological mechanisms. Such EHS lacks distinct diagnostic criteria and scientific relations with electromagnetic radiation exposure. Furthermore, it has never been revealed before that people with EHS are more sensitive to electromagnetic radiation [6] and that EHS is a medical diagnosis.

The ICNIRP has summarized a few relationships between electroencephalogram (EEG) and electromagnetic radiation exposure, especially with alpha EEG-bands [7]. However, it is neither believed to have an apparent effect on health nor a clear relationship in relation to electromagnetic radiation. Moreover, the relationships with quantitative responses are still unidentified.

For the non-specific symptoms including headache, fatigue, and bodily itching, there has never been any distinct relationship with electromagnetic radiation exposure found. It is possible that the symptoms are the consequence of expectations of the conscious mind.

This paper organizes the content as follows. Section 2 describes the effects of electromagnetic radiation in body temperature and neurobehavioral. Section 3 explains the effect of electromagnetic radiation on cancer incidence. The effects of electromagnetic radiation on abnormalities at cellular and DNA levels are introduced in Section 4. The last section is the conclusion.

2. A STUDY OF EFFECTS OF ELECTROMAGNETIC RADIATION IN BODY TEMPERATURE AND NEUROBEHAVIORAL DISORDERS

From the report of the World Health Organization (WHO) surveyed in several countries, it is found that levels of exposure to electromagnetic radiation depend on several variables such as energy density of electromagnetic waves, distances from the antenna, and surroundings. Such values are generally in the range between 0.002 – 2 percent, determined by the international standard level of ICNIRP [8].

In 2005, the WHO collected the researches on effects of electromagnetic radiation on the rise in body temperature. Several survey researches carried out in both humans and animals reveal no apparent effect of the increasing body temperature stemmed from base station exposure on the health of humans and animals [9].

In 2006, Cooper et al [10]. undertook the study on effects of exposure to electromagnetic radiation on the increase in human body temperature (>1°C) and found that the increase in body temperature from exposure to electromagnetic radiation will be specifically found in the industry with high-frequency electromagnetic radiators such as electromagnetic induction heaters.
Malfunction of the nervous system affecting behaviors or neurobehavioral effects/disorders refers to the disorder of the central nervous system (CNS). It results in changing behaviors such as a headache, insomnia, fatigue, depression, affective disorders, shiver, movement disorders, amnesia, and attention deficit disorders [11]. Such disorders stemming from several causes such as brain diseases (stroke, memory disorder, etc.), severe brain concussion [12], or poisonous environmental chemicals are the factors that lead to neurobehavioral disorders [13].

The effects of electromagnetic radiation on nearby inhabitants have been extensively studied and researched for almost a decade. During 2002-2003, Santini et al [14][15]. were the first to study the health effects through taking the 2 factors into account: distance from base stations and gender/age. The questionnaire research carried out among 530 French citizens (270 males and 260 females) living at different distances away from base stations: 10, 100, 200, 300 meters or farther for extensive periods of 1 year and longer than 5 years (number of surveyed base stations was unidentified) reveals some neurobehavioral effects among people living near base stations. These may stem from the following 2 factors:

2.1. Factor 1: Distance from base stations

Some reports on neurobehavioral effects in people living near base stations are significantly found (p<0.05) compared with the control group. The symptoms are different depending on the distance between residences and base stations as follows:

- At the distance of 10 meters: nausea, visual disturbances, and loss of appetite
- At any distance between 10 – 100 meters: irritability, depression, loss of memory, dizziness, and libido decrease
- At any distance between 100 – 200 meters: headache, sleep disruption, and discomfort
- At any distance between 200 – 300 meters: tiredness and fatigue
- Farther than 300 meters: no symptom found

Statistically, it has never been significantly found that such symptoms are related to the period of stay, within the radius of 300 meters.

2.2. Factor 2: gender and age

Being compared with males, a greater number of females (p<0.05) were reported to develop several symptoms, i.e. headache, nausea, loss of appetite, sleep disruption, depression, discomfort, and poor eyesight when living within the radius of 300 meters from base stations. Such symptoms tend to be significantly easily found among people aged above 20 years old and over.

Nevertheless, this study was undertaken through questionnaires and the samples had been informed in advance about the objective concerning effects of exposure to electromagnetic radiation from base stations on health. Therefore, there were some influencing factors from anxiety leading to malingering effects involved. Based on this, women tended to express greater anxiety than men and the level of anxiety was proportional to the increasing age.

From such survey, the researcher proposed that any base stations should be constructed at least 300 meters away from residences so as to avoid neurobehavioral effects on people living nearby.

In 2005, the World Health Organization (WHO) [16] collected the study results of electromagnetic radiation effects on the brain, nervous system, and behaviors. They
revealed no effect posing on the nervous system, hearing, short-term memory loss, dizziness, dysarthric speech, etc.

Later in 2007, Abdel-Rassoul et al [17]. carried the study on neurobehavioral effects among 85 Egyptian samples living near a base station: 37 samples lived in the building where the base station was installed while another 48 samples lived in the opposite building which was 10 meters away from the base station. By comparing the control group of 80 people with corresponding ages, genders, occupations, and educational backgrounds to the sample group, the volunteers were asked to fill up psychological questionnaires without any research study objectives having been informed in advance. The results of this research study showed that a greater number of people living near the base station experienced neurological symptoms than people in the control group (p<0.05). Several reported symptoms include:

- Headache: 23.5 percent (10 percent of people in the control group)
- Memory change: 28.2 percent (5 percent of people in the control group)
- Dizziness: 18.8 percent (5 percent of people in the control group)
- Tremor: 9.4 percent (0 percent of people in the control group)
- Depression: 21.7 percent (8.8 percent of people in the control group)
- Sleep disturbance: 23.5 percent (10 percent of people in the control group)

Moreover, it was found that the sample group living opposite to the base station had weaker performance in problem solving than the sample group living in the building with a base station installed on the roof. Nevertheless, this particular research was focused only on the aggregate population living in a small area where only one base station was located.

In 2009, Kundi and Hutter [18] compiled and analyzed several researches epidemiologically and experimentally. They found no research evidence definitely proving that electromagnetic radiation emitted from base stations (in the frequency used in previous experimental researches) had posed bad effects on the well-being and health of inhabitants living nearby. This corresponds to the research findings of Otitolouju et al [19]. revealing the study results carried out in Nigeria during 2013.

In 2010, Danker-Hopfe et al [20], studied the effects of electromagnetic radiation from base stations, specifically on the sleep of residents, among the sample group of 397 Germans aged between 18 - 81 years old (50.9 percent of this amount accounts for females) who lived in 10 villages lacking mobile phone network services. The sample group itself had to complete questionnaires concerning sleep efficiency while the experimental data was collected at the same time. Besides, the level of exposure to electromagnetic radiation had been measured from the sample group while they were sleeping (frequencies in the 900 and 1800 MHz ranges were emitted from GSM base stations while the sample group was sleeping) for 12 nights before the sleep efficiency was analyzed through the data collected. From the research findings, there was not any direct abnormality in sleep caused from base-station radiation significantly found, but the sample group who was anxious about the effects of base-station radiation tended to have poorer sleep efficiency than those who were not. This indicates that the poorer sleep efficiency found in the previous researches may stem from several factors, especially the anxiety over health effects which may influence the residents of nearby base stations to have poorer sleep efficiency.
3. A STUDY OF EFFECTS OF ELECTROMAGNETIC RADIATION ON CANCER INCIDENCE

3.1 CARCINOGENS

The term “cancer” refers to the malignant tumor that has been developed from cells and gone beyond control. Therefore, it becomes large in size enough to press on nearby tissues, causing gangrene and bad effects on other organs nearby.

The International Agency for Research on Cancer or IARC, an organization founded by the WHO, set up the committee for studying individual chemicals, some environmental conditions, rays, and electromagnetic radiation. Later on, the document called the “Monograph” was published to sort out carcinogens which are also known as “carcinogenic agents” in this particular article, since electromagnetic radiation and several conditions are not categorized as substances. In this regard, the IARC classified carcinogenic agents into 4 groups (as shown in figure 2-2) which are presented in every issue of Monograph as follows:

3.1.1 Group 1

The agent (mixture) is carcinogenic to humans according to the following 2 cases:

- Firstly, there is efficient evidence proving that it causes cancer in humans.
- Secondly, there is sufficient evidence that it causes cancer in animals and also the strong evidence supporting that it affects humans in the way that generally leads to cancer.

3.1.2 Group 2

The agent (mixture) that probably causes cancer in humans can be classified as:

A. Group 2A: The agent (mixture) is probably carcinogenic to humans according to the following 3 cases:

- Firstly, that particular agent has limited evidence proving that it causes cancer in humans but sufficient evidence proving that it causes cancer in animals.
- Secondly, there is inadequate evidence proving that it causes cancer in humans but sufficient evidence proving that it causes cancer in animals, and strong evidence supporting that the particular mechanism which leads to cancer incidence in animals also exists in humans.
- Thirdly, it is rarely found or merely little limited evidence revealing that it causes cancer only in humans can be referred to.

B. Group 2B: The agent (mixture) is possibly carcinogenic to humans according to the following cases:

- Firstly, there is limited evidence supporting that it causes cancer in humans and less than sufficient evidence supporting that it causes cancer in animals.
- Secondly, there is inadequate evidence proving that it causes cancer in humans and sufficient evidence proving that it causes cancer in animals.
- Thirdly, there is inadequate evidence proving that it causes cancer in humans but limited evidence proving that it causes cancer in animals.
3.1.3 **Group 3**
The agent (mixture or exposure circumstance) is not classifiable as to its carcinogenicity to humans according to the following cases:

- Firstly, the evidence is inadequate to prove that the agent causes cancer in humans and is also inadequate or limited to prove that it causes cancer in animals.
- Secondly, the evidence is inadequate to prove that the agent causes cancer in humans. However, the evidence is sufficient to prove that it causes cancer in animals, but there is strong evidence proving that the mechanism of cancer incidence does not appear in humans.
- Thirdly, any substances apart from members of the other groups

3.1.4 **Group 4**
The agent (mixture) is probably not carcinogenic to humans according to the following 3 cases:

- Firstly, there is the evidence suggesting the lack of carcinogenicity in humans and animals.
- Secondly, there is inadequate evidence proving that the agent causes cancer in humans, but there is evidence suggesting the lack of carcinogenicity in animals.

Some examples of chemicals, touch or the aforementioned conditions presented in Table 1 are excerpted from “Agents Classified by the IARC Monographs”, volumes 1-109, but some in the parentheses are taken out from other articles.

**Table 1** Examples of different groups of carcinogens

<table>
<thead>
<tr>
<th>Group</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>The agent (mixture) carcinogenic to humans</td>
<td>Benz[a]pyrene (found in grilled foods*), fine sand, formalin, asbestos, fumes from diesel engines, dried salted fish, flukes (found in uncooked pickled fish), cigarette smoke, sunlight, cork dust</td>
</tr>
<tr>
<td>Group 2A</td>
<td>The agent (mixture) probably carcinogenic to humans</td>
<td>Smoke from wood burning, Chloramphenicol, a hairdresser, on-call jobs, lead</td>
</tr>
<tr>
<td>Group 2B</td>
<td>The agent (mixture) possibly carcinogenic to humans</td>
<td>Coffee, smoke from weld, electromagnetic radiation, dichlovos (herbicide used as cockroach bait*) benzyl (gasoline), and fumes from the engine that uses benzyls</td>
</tr>
<tr>
<td>Group 3</td>
<td>The agent (mixture or exposure circumstance) not classified as to its carcinogenicity to humans</td>
<td>Caffeine (not coffee*), coal dust, crude oil, sedative such as Diazepam</td>
</tr>
<tr>
<td>Group 4</td>
<td>The agent (mixture) probably not carcinogenic to humans</td>
<td>Water, salt, sugar*</td>
</tr>
</tbody>
</table>
3.2. Electromagnetic Radiation and Electromagnetic Fields are Possibly Carcinogenic. (Group 2B)

3.2.1 Electromagnetic Radiation from High-voltage Electric Lines

They are the AC fields that have a very low frequency of 3-300 Hz or known as Extremely Low-Frequency Electric and Magnetic Fields (ELF). Meanwhile, the one with a higher frequency between 30 kHz – 300 GH used in mobile phones is generally known as Radiofrequency (RF), Electromagnetic Radiation or briefly called Electromagnetic Field (EMF).

The committee established by the U.S. National Academy of Sciences (1996) used to deduce that “Children living close to high-voltage electric lines run the higher risk of leukemia”. Since there were very few patients found, the value of reliability was highly variable subjecting to various researches, but the relative risk was still at 1.5 overall. However, in some research work where the value of electromagnetic fields was measured, there was no relationship between electromagnetic fields and leukemia or other types of cancers shown.

It can be said that living close to high-voltage electric lines leads to childhood leukemia, regardless of the relationship to other types of cancers. The incidence of cancers may not stem from electromagnetic radiation but other factors, for example, the location of high-voltage power towers is commonly near streets/ traffic congestion areas or the living standard of residents is low in quality. However, there are some documents revealing that the ions generated around high-voltage electric lines are the cause of cancers.

The IARC Monographs, volume 80, classified “Extremely Low-frequency Magnetic Fields” as possibly carcinogenic to humans (Group 2B).

3.2.2 Electromagnetic Radiation in the form of Radio and Mobile Phone Waves

-Electromagnetic Radiation from Mobile Phones

Several previous studies generally reveal that electromagnetic radiation has no relationship with cancer incidence. In most studies, if the odds ratio between the accumulative number of calls and brain tumors (Glioma) is determined, it will always be less than 1. This implies that both of them have no relationship between each other.
The study of Vrijheid et al. (2009) reveals that if the patients were divided into smaller groups, the ratio for glioma of the group having the maximum number of telephone calls or using mobile phone for longer than 1,640 hours would stand at 1.40 (95% CL, 1.03-1.89). In this group, the patient who used the telephone for longer than 5 hours a day would take extraordinarily high risks. That is, the odds ratio would decrease from 1.40 to 1.27 if the patients who used the telephone for longer than 5 hours a day were excluded from calculation. (IARC Monograph Volume 102, page 215) (Since the results of several researches are the same, they are considered the limited evidence of human carcinogenicity.)

Furthermore, it was found during 1992-2006 that the ratio of brain tumor incidence in USA was lower but was statistically significantly higher in women aged 20-29 years old. However, there was no relationship with electromagnetic radiation reported. (IARC Monograph Volume 102, page 192.)

The most principal and reliable study undertaken in 13 countries: Scandinavian and others, such as Greece and Japan, is considered the case control study of relationships between mobile phone utilization and brain tumors or acoustic neuroma called “Interphone Study” which focuses mainly on mobile phones. The findings reveal both the countries with and without any relationship at all. The weakness of this particular study is that the increasing odds ratio would not be found if the period of mobile phone utilization was longer, and there was no relationship shown in some countries as shown in table 2-2.

It can be seen that the odds ratio for cancer incidence among people using mobile phones revealed by the study of Auvinen et al. stood high at 2.1, but less than 1 as revealed by the study of Inskip et al.

In addition, the IARC also took notice of brain tumor incidence on the side of the brain where the phone is used. That is to say, the ratio of the odds ratios for ipsilateral phone use to those for contralateral use increased steadily with the increasing accumulative number of calls.” (IARC Monograph 102, page 215). However, the study had several limitations that obstructed its progress.

The best summary of IARC is “In summary, there was no increased risk of glioma associated with having ever been a regular use of mobile phones in INTERPHONE study. When divided into 10 groups, there were suggestions of an increased risk of glioma in the group in the highest decile of exposure. Besides, it was found that tumors may develop in the brain hemisphere with ipsilateral exposures, occasionally in the temporal lobe (the part most heavily exposed to electromagnetic waves from mobile phones), although chance, bias or confounding may explain this increased risk.” (IARC Monograph 102, page 216)

For the incidence rate of other cancers, apart from tumors and acoustic neuroma such as lung cancer, urinary bladder cancer, esophageal cancer, liver cancer, urethral cancer, cervical cancer, gastric cancer, kidney cancer, and pancreatic cancer, there was a study among mobile phone users undertaken in Denmark during 1982 – 2002 (cited in IARC Monograph). However, its result did not show the increasing rate of such cancer incidence among mobile phone users compared with the cancer incidence rate of the total population of Denmark [21].
Table 2 Examples of researches with the odds ratios of related researches shown (only two groups were selected here), excerpted from IARC Monograph Volume 102, page 205

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Number of patients</th>
<th>Number of controls</th>
<th>Data source of the controls</th>
<th>Measurement of exposures</th>
<th>Site in which cancer develop</th>
<th>Type of exposures</th>
<th>Number of exposed people</th>
<th>Odds ratio (95% CI)</th>
<th>Component variable</th>
<th>Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inskip et al. (2001), USA, 1994-1998</td>
<td>489</td>
<td>799</td>
<td>Patients receiving treatment from the same hospital but do not have cancers</td>
<td>From conducting interviews with the aid of computers</td>
<td>Glioma</td>
<td>Accumulative hours:- Never or barely used</td>
<td>398</td>
<td>1.0</td>
<td>Hospital, age, gender, nationality</td>
<td>There are several other variables and consequences excluded from the consideration such as acoustic neuroma</td>
</tr>
<tr>
<td>Auvinen et al. (2002), Finland, 1996</td>
<td>398 (198 glioma patients)</td>
<td>1990</td>
<td>Finnish population Register Center</td>
<td>The information gained from 2 network service providers</td>
<td>Glioma (191)</td>
<td>Analogue: - Ever used</td>
<td>26</td>
<td>(1.3-3.4)</td>
<td>Age, gender</td>
<td></td>
</tr>
</tbody>
</table>
Electromagnetic Radiation from Radio and Mobile Phone Towers

There were interesting studies revised by the IARC. Several of them were undertaken to find the relationship between various diseases and radio towers, whereas the relationship with mobile phone towers was barely emphasized.

Dolk et al. (1997) (cited in IARC Monograph, Volume 102, page 165) undertook the study among UK populations living close to radio towers. The prominent feature of this particular study is that the total value of energy emitted from various sources, i.e. 0.013 W/m² from television towers and 0.057 W/m² from radio towers. The morbidity rate of the residents living within the radius of 0-2 kilometers and 0-10 kilometers from the antenna was compared to the country’s statistics. Here, the morbidity rate was adjusted to be in line with the age, gender, year of exposure, and living conditions. It was found among the population aged over 15 years old that the Standardized Incidence Ratio [22] (SIR) for all types of brain tumors stood at 1.29 (95% CI, 0.80-2.06) for the residents living within a radius of 0-2 kilometers and 1.04 (95% CI, 0.94-1.16) for the residents living within a radius of 0-10 kilometers. For brain tumors, the SRI stood at 1.31 (95% CI, 0.75-2.29) and 0.98 (95% CI, 0.86-1.11), respectively.

Ha et al. (cited in IARC Monograph, Volume 102, page 165) studied the cancer incidence rate of the Korean population aged over 1 year old living within a radius of 2 kilometers from an AM radio base station that has high transmission power in comparison with the population living close to a low-transmission power base station. The data obtained from documents issued by insurance companies revealed that the age-standardized incidence rate ratios for brain tumor incidence in both males and females stood totally at 2.27 (95% CI, 1.30-3.67) for a 100 kW base station, 0.86 (95% CI, 0.41-1.59) for a 250 kW base station, 1.47 (95% CI, 0.84-2.38) for a 500 kW base station, and 2.19 (95% CI, 0.45-6.39) for a 1500 kW base station.

An interesting large-scale sampling study undertaken among the residents living near mobile phone towers is of Elliott et al. (2010-0 (cited in IARC Monograph, Volume 102, page 186) which reveals that the odds ratios of risk groups did not increase to the level expected.

Based on this, the IARC deduced that “electromagnetic waves are possibly carcinogenic to humans (Group 2B)” and most of the evidence was included in the research on mobile phones.

In 2009, Sumet Wongphanitloet interestingly publicized the document on “Health Effects from Electromagnetic Radiation”, especially on the issue concerning cancer incidence which may be caused from electromagnetic radiation emitted from mobile phone base stations. Up to this time, there have been very few epidemiological study reports which clearly and conformingly indicate that the electromagnetic radiation from mobile phone base stations is carcinogenic. Based on several researches surveyed by the WHO, most of them still cannot clearly identify whether the electromagnetic radiation from base stations are carcinogenic, but there are some identifying that electromagnetic radiation is a cause of cancers. This reflects that most of the researches are still in different directions, obstructing the WHO from affirming or guaranteeing that electromagnetic radiation emitted from mobile base stations are carcinogenic to humans. It has been, therefore, like a “suspect” contributing to cancers and is classified in the Group 2B: the agents (mixtures) possibly carcinogenic to humans.
4. A STUDY OF EFFECTS OF ELECTROMAGNETIC RADIATION ON ABNORMALITIES AT CELLULAR AND DNA LEVELS

Nowadays, several researchers and scientists in several areas pay attention on studying the effects of radiofrequency electromagnetic radiation in more diversified contexts, especially the effects on abnormalities at cellular and DNA levels. In 2006, Guler et al [23] undertook the study on electromagnetic radiation effects among the group sensitive to radiofrequency electromagnetic radiation, such as pregnant women and unborn children, through laboratory studies and experiments. This was to analyze the destruction of DNA and lipid in the brain of pregnant rats compared with non-pregnant rats exposed and unexposed to radiofrequency electromagnetic radiation (GSM 1800 MHz) for 15 minutes per day, for the duration of 15 days. From the laboratory test results, there existed the DNA and lipid damage in brain tissues of the pregnant rats exposed to radiofrequency electromagnetic radiation but the embryo. This may be the result of wave attenuation stemmed from electromagnetic absorption by tissues varying in the depth. That is, the embryo generally implants in the womb covered by tissues which protect them from damages to brain tissues. However, this particular research is only fundamental and still requires additional researches and experiments among the increasing number of sample groups so as to bring about guidelines for the prevention of such illnesses in humans.

In 2013, Miyakosh et al [24] gathered the researches related to effects of radiofrequency electromagnetic radiation at the cellular level. They found no obvious conclusion specifying that radiofrequency electromagnetic radiation contributes to the alteration in genetic material, mutation, has effects on immunity, yeast, protein, brings about changes in signal transduction within the cell, etc. Anyway, the researches that focus on explaining the effects of radiofrequency electromagnetic radiation at the cellular level are still in the very limited scale and cannot properly account for effects at the cellular level. The comprehension of effects of radiofrequency electromagnetic radiation at the cellular level is, therefore, challenging and necessary for the future study.

5. CONCLUSION

Mobile phones are now an integral part of human society. In many countries, over half the population use mobile phones. Given the large number of mobile phones users, it is important to investigate, understand and monitor any potential public health impact. This paper aims to review the previous studies of electromagnetic radiation effects on human body. For the future work of this paper, we will investigate electromagnetic radiation levels from mobile base stations in Thailand.

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http://www.iaeme.com/IJARET/index.asp
A Study of Electromagnetic Radiation Effects From Mobile Phone Base Stations on Human Health


[22] The comparative ratio is obtained from dividing the actual number of illnesses or deaths out of the population by the number of illnesses and deaths calculated in case the morbidity or mortality rate equals general population.


