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Electromagnetic Pollution: A Primer

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Abstract Due to industrialization and rapid advances in technology, the use electrical and electronic devices has been increasing more and more in the modern society. These devices produce electromagnetic radiation. Consequently, the environment has been subjected to electromagnetic pollution. Electromagnetic fields are invisible and omnipresent in our environment. Long term exposure of humans to high levels of radiation can lead to serious health problems or even death. This paper discusses the characteristics and effects of electromagnetic pollution of the environment.

Keywords electromagnetic pollution, electromagnetic radiation, electromagnetic interference

1. Introduction

In the modern life, extensive use of electrical energy has some harmful effects on nature. In the 20th century, environmental exposure to man-made electromagnetic fields has been steadily increasing due to growing electricity demand, ever-advancing technologies, and changes in social behavior. Cellphones, microwaves, Wi-Fi routers, computers, the power lines, and other devices create electromagnetic fields or radiation that some experts are concerned about.

The electromagnetic (EM) spectrum, depicted in Figure 1, is the wide range of all electromagnetic radiation frequencies [1]. It is increasingly used for innumerable applications such as wireless communication technologies, terrestrial and satellite communications, radio and television broadcasting, radar, industrial processing, medical applications and consumer products. Although everyone is aware of the benefits derived from electromagnetic systems and devices, only few users are aware of the real dangers associated with them. Long-term exposure to EM fields and it related electromagnetic radiation may be harmful to human beings.

This is increasingly establishing a new phenomenon of pollution, which is often known as electromagnetic pollution (EMP) or electrosmog. Electromagnetic waves are radiated from many sources, both natural and man-made, that produce electromagnetic pollution.

Figure 2 shows a typical electromagnetic pollution [2]. To some degree, all living creatures are exposed to electromagnetic pollution. It is increasing severe these days because it can incur harm to human health. The terrestrial electromagnetic environment has been rapidly affected by humans as a result of technological advancements. It has become part of the global ecological problem on Earth and part of the general and workplace environments early in the 20th century.

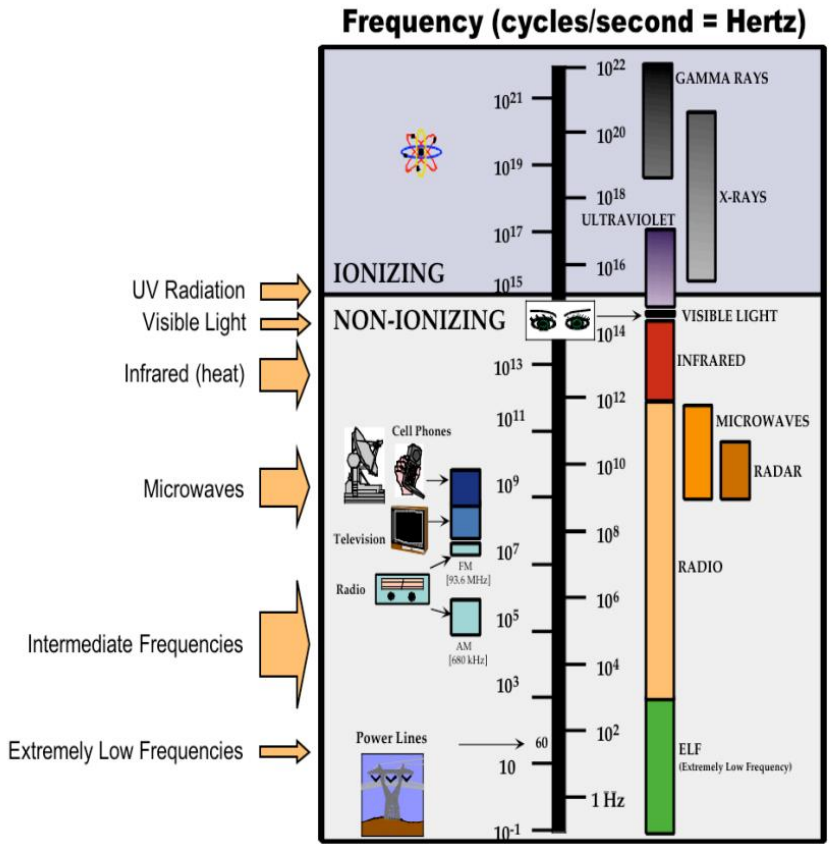

Figure 1: Electromagnetic spectrum [1]

Figure 2: A typical electromagnetic pollution [2]

Electromagnetic Radiation

Electromagnetic radiation (EMR) is a form of environmental pollution which may hurt humans as well as wildlife. Classically, electromagnetic radiation consists of electromagnetic waves, which are made of electric and magnetic fields. EM waves are emitted by electrically charged accelerating particles. They carry energy away from their source and can impart the energy to matter with which they interact. EM waves

radiate into infinite space and decrease in intensity by an inverse-square law of power. These waves in space can be predicted by the classical laws of electricity and magnetism, known as Maxwell's equations [3].

EMR is often categorized as either ionizing or non-ionizing depending on the energy of the radiated particles. EMR of visible or lower frequencies (i.e., visible light, infrared, microwaves, and radio waves) is called non-ionizing radiation, because its photons do not individually have enough energy to break chemical bonds. The main effect of non-ionizing radiation on living tissue has only recently been investigated and found to the rise of body tissue temperature.

In contrast, high frequency ultraviolet, X-rays and gamma rays are called ionizing radiation, since individual photons of such high frequency have enough energy to break chemical bonds. In other words, ionizing radiation creates high-speed electrons in a material and breaks chemical bonds. This radiation can be a health hazard [4].

After 30 years of extensive study the World Health Organization (WHO) is yet to confirm a health risk from exposure to low-level fields. International Electrotechnical Commission (IEC) sets international standards for radiated and conducted electromagnetic interference. In the United States, the Federal Communications Commission (FCC) regulates the susceptibility of consumer electronic equipment.

EMR exposure limits to prevent health effects have been derived for the level of heating or the strength of the electric field generated inside the body. No known health effects are expected if your exposure to EMR falls below the levels in the following guidelines [5]:

- natural electromagnetic fields (like those created by the sun): 200 V/m
- power mains (not close to power lines): 100 V/m
- power mains (close to power lines): 10,000 V/m
- electric trains and trams: 300 V/m
- TV and computer screens: 10 V/m
- TV and radio transmitters: 6 V/m
- mobile phone base stations: 6 V/m
- radars: 9 V/m
- microwave ovens: 14 V/m

Causes of EM Pollution

Electromagnetic pollution is mostly caused by increasing human activity involving a variety of wireless devices that we use today. It is generated by emissions from one or more sources operating at same or different frequencies. As an example, Figure 3 shows the emission of the magnetic fields from a computer [6]. The term "electrosmog" is often used to refer to all electromagnetic fields artificially generated by man-made technologies. It is classified as non-ionizing radiation. Some common potential sources of EM radiation include mobile/cell phones, cordless phones, microwave ovens, computers, house energy meters, wireless (Wi-Fi) routers, cellphones, bluetooth devices, power lines, MRIs, doorbell transformers, toaster ovens, electric blankets, ultrasonic pest control devices, electric bug zappers, heating pads, touch controlled lamps, electric trains, electric arc furnace, transformers, medical devices, and signals such as radio, television, and telephone waves. These sources emit electromagnetic fields at different frequencies and cause electromagnetic pollution. Some of these sources are elaborated as follows [7-12].

Figure 3: Emission of the magnetic fields from the computer [6]

1. *Cell Phone:* Cell phones have become an indispensable part of daily life because they allow us to be always in touch with others. Use of cellphones has increased rapidly since they were introduced in the 1980s. These modern devices transmit and receive signals from a network of stable low power base stations. Electromagnetic radiation emitted by cell phone towers is a form of environmental pollution, which can case a new health hazard. Experimental results have shown that the exposure levels in a city were below the international exposure limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), but much above the biological limit. Teenagers spend much time using the cell phone, which correlates with an increased prevalence of headaches. The possible impact of EM radiation from cell phone on male fertility is a hot topic.
2. *Wi-Fi equipment:* Wi-Fi is an acronym for "wireless fidelity" and Wi-Fi equipment uses radio frequency signals to communicate. Just like other electronics devices, Wi-Fi equipment radiates electromagnetic wave and causes electromagnetic pollution. With the development of wireless technologies, Wi-Fi has become more popular in the world today. Wi-Fi equipment is used in different places such as home, work, shopping center, airport, cafe, etc. The rapid deployment of Wi-Fi technologies makes their electromagnetic pollution important today. Thus, assessing EMP radiated by Wi-Fi equipment is crucial for human health.
3. *Power Lines:* The transmission power lines are a major source of extremely low frequency radiation. Long term exposure to the field from the power line may result in health risk. The International Radiation Protection Association (IRPA) recommends measuring the electric field and the magnetic field strength for evaluation of electromagnetic pollution from power lines. This is implemented for general public and occupational exposure using ICNIRP reference levels. Some people build their homes or workplace close to transmission power lines. This exposes human body to EMR caused by overhead power lines, as illustrated in Figure 4 [13].

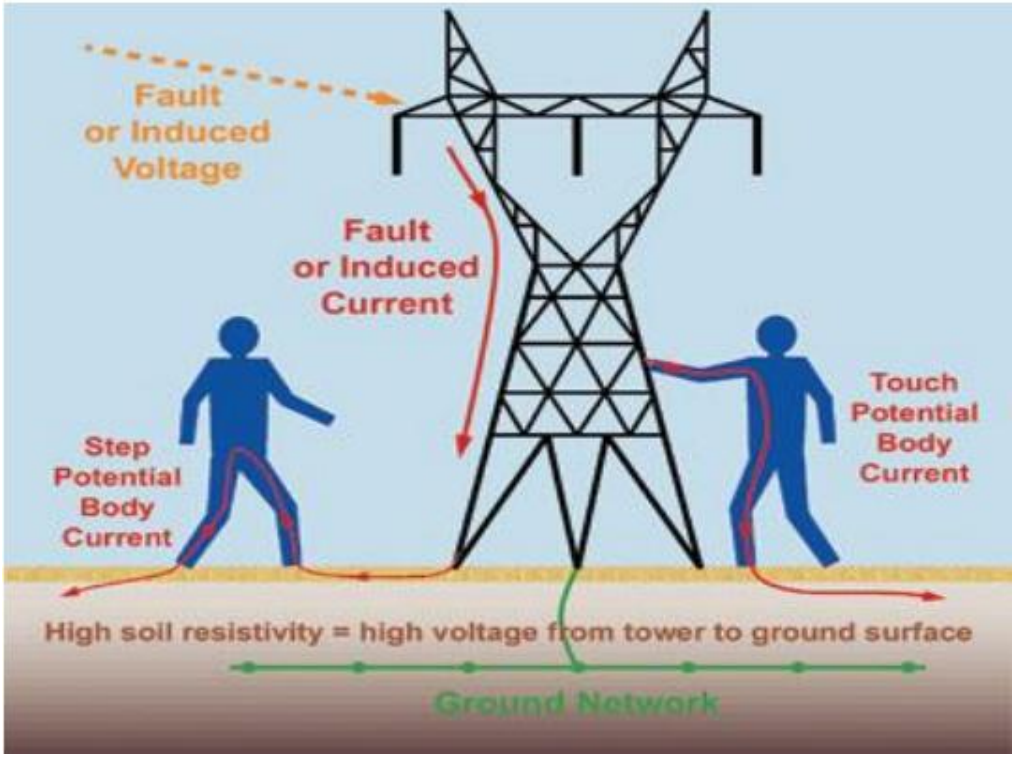

Figure 4: Interference between human body and the power lines [13]

4. *Smart Meters:* Throughout the United States and other parts of the world, electric power utilities have been implementing advanced metering infrastructure, also known as smart meters. To bill a customer for utilities such as electricity, natural gas, or water, the amount the customer uses must be measured. This is usually done with a meter. Current technologies such as smart meters (also called Advanced Metering Infrastructure) have become a source of electromagnetic pollution from generated electromagnetic radiation.
5. *TV and radio:* The transmission of the radio AM is via large arrays of antennas which are often installed on the roof of buildings. The antennas of television and FM radio stations are much smaller than AM radio

antennas and are placed in arrays on top of tall towers. Radio amateurs must operate in accordance with the radio communication rules from International Union of Telecommunication (ITU).

6. *Microwave Radiation:* Microwaves are the second-lowest frequency waves in the EM spectrum. Due to their higher frequency, microwaves can carry information through obstacles that interfere with radio waves such as clouds, smoke, rain, and snow. Microwaves are used in microwave ovens, radar, landline phone calls, and the transmission of computer data. Microwave is the main cause of electromagnetic pollution which threatens human beings. Recently, wildlife has been chronically exposed to microwaves.

7. *Radar:* The radar is often used for navigation, weather forecasting, and military applications, etc. They emit pulsed microwave signals. For example, high power military radars reduce exposure to levels below the limits of directives when they are in locations accessible to the public.

8. *Security Systems:* These devices are used in shops against theft and are based on labels attached to goods. When the customer purchases something, the label on it is removed or deactivated permanently. Metal detectors and security systems at airports generate a strong magnetic field.

Eliminating EM Pollution

Electromagnetic pollution can be reduced or eliminated using applying the following measures.

1. *Paper-based metasurfaces*: These are employed to shield the electromagnetic interference. Waste paper-based metasurface exhibits remarkable electromagnetic shielding properties with small thickness. This creates new opportunities in turning waste paper into a solution for eliminating electromagnetic pollution [14].

2. *Metalloplastics:* The addition of a few percent of metal and/or metallized glass fibers to plastics leads to a family of materials known as "metalloplastics." They show electrical resistivities as low as 0.01 ohm-cm, and so combine excellent conductivity and shielding capability with the light weight and moldability of plastics [15].

3. *Protect Yourselves*: To minimize the effects of electromagnetic pollution on yourself, do some homework. Determine whether your electronic devices generate EMR on you or your family member. Increase your distances from radiation sources. Obtain electromagnetic field protectors to reduce the impacts [16].

4. *Other Measures:* Here are some other ways that can reduce EMP [17]:

- Avoid directly answering your phone, use headsets or place the call on speaker mode.
- Avoid having your phones/tablets/ laptops/etc near you during the night.
- Where we have poor network reception, avoid using your devices.
- If it's not an emergency, avoid answering your calls in moving vehicles or trains.
- Wi-Fi may be stronger the closer you are to the router, but so are the strong radiation. Keep a safe distance.
- Find another way to track our wildlife, but collaring them should stop.

Considering the map of electromagnetic pollution, facilities such as schools, hospitals, stores, etc. and settlements should be established in areas far away from energy transmission lines, base stations, and substations.

Conclusion

Electromagnetic fields are ubiquitous in our modern society. The rapid diffusion of wireless technologies makes the electromagnetic pollution crucial for today society. Electromagnetic pollution is getting more and more serious with each passing day at local, national, and international levels. EMP and its hazards have been observed by the international scientific committees and the standard institutes. The effects of EMP have been investigated by many scientists worldwide. Although the importance of EMP is noticed worldwide, the conclusion of various investigators is controversial because some studies are contradictory. More information about electromagnetic pollution can be found in books in [18,19] and a related journal: *Journal Electromagnetic Analysis & Applications*,

References

[1]. M. Havas, "Health concerns associated with energy efficient lighting and their electromagnetic emissions," June 2008,

https://www.electricalpollution.com/documents/08_Havas_CFL_SCENIHR.pdf
[2]. "Beware of electromagnetic pollution," https://www.parentcircle.com/clipbook/beware-of-electromagnetic-pollution/
[3]. M. N. O. Sadiku, Elements of Electromagnetics. New York: Oxford University Press, 7th edition, 2018.
[4]. "Electromagnetic radiation," Wikipedia, the free encyclopedia, https://en.wikipedia.org/wiki/Electromagnetic_radiation
[5]. "Should you be worried about emf exposure?" https://www.healthline.com/health/emf
[6]. Y. Erdogan, "Electromagnetic pollution in the computer labs: The effects on the learning environment," Essays in Education, vol. 22, Fall 2007.
[7]. M. N. O. Sadiku, S.M. Musa, A. Omotoso, and A.E. Shadare, "A primer on smart meters," International Journal of Trend in Research and Development, vol. 5, no. 4, 2018, pp. 65-67.
[8]. A. K. Dhami, "Study of electromagnetic radiation pollution in an Indian city," Environmental Monitoring and Assessment, vol. 184, 2012, pp. 6507–6512.
[9]. O. Velentza, "Electromagnetic pollution - Pathological effects of electromagnetic fields in man," AASCIT Journal of Health, vol. 2, no. 6, 2015, pp. 74-79.
[10]. A. Ozovehe, M. Ibrahim, and A. Hamdallah, "Analysis of electromagnetic pollution due to high voltage transmission lines," Journal of Energy Technologies and Policy, vol. 2, no. 7, 2012.
[11]. K. Eraydın, Ç. Kurnaz, and B. K. Engiz, " Investigation of electromagnetic pollution radiated due to Wi-Fi equipment on Samsun light rail system," Conference paper, September 2015, https://www.researchgate.net/profile/Cetin_Kurnaz/publication/283541487_Investigation_of_Electromagnetic_Pollution_Radiated_due_to_Wi-Fi_Equipment_on_Samsun_Light_Rail_System/links/563ddb8308aec6f17dda265d/Investigation-of-Electromagnetic-Pollution-Radiated-due-to-Wi-Fi-Equipment-on-Samsun-Light-Rail-System.pdf
[12]. A.B. Khalifa and A. B. A. Alnabi, "Electromagnetic pollution emitted from base station Tahani," International Journal of Science and Research, vol. 6, no. 14, 2013, pp. 1125-1132.
[13]. A. Elgayar et al., "Power transmission lines electromagnetic pollution with consideration of soil resistivity," TELKOMNIKA, vol. 17, no. 4, August 2019, pp.1985-1991.
[14]. Z. Wang et al., "Paper-based metasurface: Turning waste-paper into a solution for electromagnetic pollution," Journal of Cleaner Production, vol. 234, October 2019, pp. 588-596.
[15]. D. E. Davenport, "Metalloplastics: An answer to electromagnetic pollution," Polymer-Plastics Technology and Engineering, vol. 17, no. 2, December 2006, pp. 211-223.
[16]. A. Kumar, "Electromagnetic pollution: Invisible, but the most detrimental threat," January 2017, https://techstory.in/electromagnetic-pollution/
[17]. C. Winnie, "Let's talk about electromagnetic pollution," https://chechewinnie.com/lets-talk-about-electromagnetic-pollution/
[18]. L. McLean, The Force: Living Safely in s World of Electromagnetic Pollution. Scribe US, 2011.
[19]. G. Swartwout, Electromagnetic Pollution Solutions. Create Space Independent Publishing, 3rd edition, 2012.

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