Study of Electromagnetic Radiation at Extremely Low Frequency (ELF) in Universitas PGRI Yogyakarta

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ABSTRACT.
Public concern about the new health implications of exposure to electromagnetic radiation emitted from several sources of electromagnetic fields, especially at extremely low frequencies, is a very interesting phenomenon to be investigated further. The negative impact caused by exposure to electromagnetic radiation is still being studied today. Therefore, it is very necessary to conduct a research study to measure and map the level of electromagnetic radiation with the aim of analyzing the potential risks that occur. This study was conducted to estimate the level of exposure to electromagnetic radiation at extremely low frequencies by measuring the value of the magnetic field that has the potential to become radiation power in the environment around the Yogyakarta PGRI University. Exposure to electromagnetic radiation is measured using an electromagnetic field tester, then the results are compared with the safety guidelines issued by ICNIRP and WHO, namely the measured magnetic field value must be less than $2x10^{-4}$ Tesla or 200 μT. The results obtained that the level of radiation exposure in terms of the value of the magnetic field measured in microtesla units at 29 location points at PGRI Yogyakarta University is far below the ICNIRP guidelines for the educational and work environment. The highest measured magnetic field value is 132.46 μT, while the lowest measured magnetic field value is 1.436 μT. Even so, several studies have stated that magnetic fields above 0.3 to 0.4 T can increase the risk of leukemia in the long term. This research has produced useful information as a basis for health policy making in the PGRI Yogyakarta University.

Keywords: *Electromedic, ELF, Electromagnetic Radiation*

1. INTRODUCTION

Exposure to electromagnetic field radiation is always present in the environment around us. Since the 20th century, exposure to electromagnetic radiation has increased along with the increasing demand for electricity, increasingly sophisticated technology, and changes in social behavior that have created more sources of electromagnetic radiation [1]. Electromagnetic radiation is the emission of energy created by a combination of electric and magnetic fields. Electromagnetic radiation from an electric current of 30-300 Hz is called extremely low frequency electromagnetic wave radiation (ELF). ELF radiation is included in the category of non-ionizing radiation, this is because the radiation emitted at the ELF cannot ionize any material in its path [3, 4]. Nevertheless, electromagnetic radiation has a significant influence on the behavior of all living things. system, therefore the use of electronic devices that emit electromagnetic radiation needs to use the optimization principle [2].

ELF radiation is generated by electrical devices, high-voltage power distribution networks, and power line sources. ELF electromagnetic radiation is often found in today's modern society, especially in the educational environment [5]. The educational environment is very close to exposure to electromagnetic radiation at this very low frequency. Learning support facilities such as media originating from various electronic devices, high-voltage electrical panels, internet network supporting devices and so on, have contributed to exposure to electromagnetic field radiation. All of these infrastructure facilities are also available on the PGRI Yogyakarta University campus [6].

The electric power system is one source of exposure to ELF electromagnetic radiation that has a major contribution. Meanwhile, sources of exposure to electromagnetic radiation with a high contribution

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coming from outside are electricity distribution lines and transportation systems. Other electronic devices also contribute to the ELF electromagnetic field radiation exposure, although not too much [7, 8].

ELF electromagnetic radiation is a field consisting of a magnetic field and an electric field. The electric field generated from the ELF is a field that is easily attenuated by all types of materials, including building materials. The contribution of exposure to ELF electromagnetic radiation from outdoor sources is greater than that of indoor electromagnetic radiation because most of the indoor exposure comes from indoor wiring systems and other electrical equipment [9]. The magnitude of the electric field originating from the source of radiation exposure decreases with increasing distance from the source. The farther the point of view from the source of exposure, the lower the value of the electric field. The electric field appears when the device is off or on. This shows that there is always an electric field in every corner of the place even though its strength varies greatly in each location

Unlike the electric field, the ELF magnetic field is difficult to attenuate by building materials or other materials. ELF magnetic fields can penetrate walls almost without interference [10]. This indicates that external ELF magnetic field sources such as power lines and electrical voltage sources in the vicinity of humans may have a significant influence on biological systems. Previous studies have revealed that transmission lines at ground level have a maximum magnetic flux density of up to tens of microtesla, whereas in general the average flux density level does not reach more than a few microtesla [11, 12].

Exposure to ELF electromagnetic fields has been considered carcinogenic based on several studies in the last ten years. The existence of an increased risk of leukemia in children and brain tumors in adults after receiving regular exposure to ELF electromagnetic field radiation has been reported by several epidemiological studies [15]. The risk of leukemia in children increases due to periodic exposure to ELF electromagnetic radiation of more than 0.4 μT [16]. In another study, it has also been shown that there is an increased risk of leukemia in the community due to exposure to ELF electromagnetic fields emitted by power transmission lines at the residential level. In addition, studies related to the impact of ELF electromagnetic field radiation exposure on the histology of thyroid gland follicles showed a change in cell volume after exposure to ELF radiation [17]. Changes in cell volume as evidenced by a decrease in the diameter of the thyroid follicle can affect the absorption of iodine in the thyroid gland and increase the effect of temperature on the thyroid gland [16, 18].

The interactions that occur between biological materials and ELF electromagnetic fields can have harmful effects, which are influenced by factors of frequency and wavelength, field density and exposure time [19, 20]. Other important factors that also influence the adverse effects of these interactions, namely functional status, sensitivity of the exposed biological material [4, 24–26], distance from the radiation source and vascularity of the irradiated part also need to be considered [6, 21, 22]. The amount of exposure to ELF electromagnetic fields that we receive up to now on a regular basis, has become an important factor that contributes to the risk of cancer, especially leukemia and brain cancer [2, 23]. Therefore, the IARC concludes that the ELF electromagnetic field is considered a carcinogenic exposure to humans [29–32].

2. METHOD

ELF electromagnetic radiation in the era of modern education is very possible to be measured with a high value. The ELF electromagnetic field generated is sourced from electrical equipment used as a medium for learning and research, both in the laboratory as well as in classrooms and lecturer rooms. PGRI Yogyakarta University is a university that has experienced rapid development in recent years. Several new laboratories were built to improve the quality of learning and research, therefore many electrical equipment and resources and channels have the potential to generate electromagnetic radiation in the campus environment. So it is necessary to measure the level of ELF electromagnetic radiation as scientific information that can be useful as a basis for making health policies for the entire academic community of Universitas PGRI Yogyakarta.

This research on pollution exposure to extremely low frequency electromagnetic wave radiation was carried out in the Yogyakarta PGRI University campus. This research was conducted by measuring the value of the magnetic field (microtesla (μT)) in the campus zone. The magnitude of the electromagnetic radiation is proportional to the value of the magnetic field according to the following equation:

$$S = E\,.H = E^2/377 = 377\,H^2$$

$$B = \mu\,.H$$

Where S is the electromagnetic radiation power density, E is the electric field and H is the magnetic field flux density. The strength of the magnetic field is symbolized by B with units of Tesla (T) while magnetic permeability whose value is constant when in the air is $4\,\pi\,x\,10^7$ [27, 28].

Measurement of the magnetic field at low frequencies is considered more effective because the electric field emitted by sources of electromagnetic

radiation at low frequencies is easy to experience attenuation/decrease in value due to barrier materials.

Measurements were carried out at 29 location points spread out over the Yogyakarta PGRI University campus. Each measurement at the location point is repeated five times to minimize measurement errors. The tool used in this research is a Portable Electromagnetic Field Tester with the following specifications:

TABLE 1. EMF Tester Specification

Electromagnetic Field Tester	Specification
	Frequency range: $0.3x10^2$ Hz – $0.3x10^3$ Hz
	The EMF Tester is a portable device designed to be easy and fast to use to measure electromagnetic field radiation at a bandwidth of 60Hz/50Hz originating from power lines, household appliances and industrial equipment.
	The units of measurement displayed are µT and mG
	Measurements with the EMF Tester must be carried out without interference from other devices so that the results are accurate.

3. RESULT AND DISCUSSION

This research has produced data on the measurement of electromagnetic field radiation which can be useful information as a basis for making policies related to health, security and safety in the PGRI Yogyakarta University campus. Although there is still a need for further studies on the impact of exposure to ELF electromagnetic field radiation on human health. Regular exposure to electromagnetic field ELF radiation can result in the perception of electrical charges on surfaces, stimulation of electrically excited nerves and muscle tissue.

The results of magnetic field measurements that have been carried out at 29 location points in the PGRI Yogyakarta University campus environment show that at 29 points the location is still within the safe threshold according to ICNIRP and WHO regulations, which is below $0.2x10^{-4}$ T or 200 µT. The following is a graph of the data from the magnetic field measurements that have been carried out:

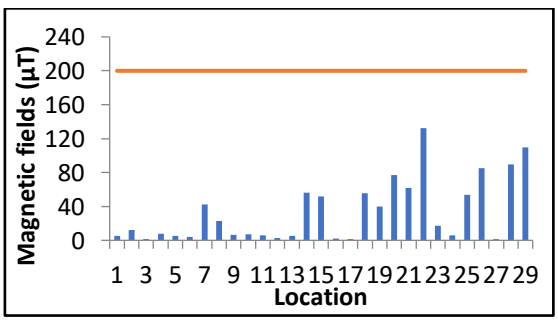

FIGURE 1. Representation of magnetic field radiation level at 29 point locations

Measurements of the ELF-EMF magnetic field were carried out in all work units at PGRI Yogyakarta University, both unit 1, unit 2 and unit 3. Based on the graph in Figure 1, it can be seen that the highest measured value of the ELF-EMF magnetic field is at location point 22, namely reached 132.46 µT. The location point is in unit 1 of building A on the 2nd floor. This value is quite high because at location point 22 there is a high-power source of electrical voltage and power lines, causing a fairly high ELF-EMF magnetic field radiation as well. While the lowest value of the measured ELF-EMF magnetic field is at location 27 which is 1,436 µT. The location point is in unit 2 on the 3rd floor. This value is very far from the safe threshold based on ICNIRP regulations, so it can be said that at that point the location is safe from ELF-EMF electromagnetic field radiation pollution that can endanger health.

This bioelectromagnetic research has a weakness in interpreting an understanding of the experimental data produced, which is related to the interaction mechanism of ELF electromagnetic field radiation exposure to biological material. In general, exposure to electromagnetic field radiation can affect all systems that have charged particles such as the human body. In the human body that is exposed to electromagnetic field radiation, of course there will be disturbances in chemical reactions. Free radicals that are formed in cells can cause mutations or DNA damage.

Damage to macromolecules, such as DNA, membrane lipids and proteins caused by the presence of free radicals in the body that can affect these cells. Other studies have shown that exposure to electromagnetic field radiation can increase the activity of free radicals in cells, mainly through the Fenton reaction. The Fenton reaction is a process that catalyzes iron into free radicals, in which iron molecules in the body such as hydrogen peroxide and products of oxidative respiration in the mitochondria are converted into hydroxyl, a cytotoxic and very strong molecule. Chronic

exposure to ELF electromagnetic field radiation has been reported in several studies to damage DNA, via free radicals in cells by indirect secondary processes. The low energy of the electromagnetic field causes the DNA damage process that occurs secondarily in the long term.

Cancer induction is the negative impact of non-ionizing radiation from the ELF electromagnetic field which is one of the cases in the main focus of several studies. Damage to the cell genome that can lead to the emergence of cancer cells, has become the focus of several studies on the interaction of exposure to electromagnetic field radiation with the structure of chromosomes and DNA in biological tissues.

Several studies report different experimental results. This is because there are many factors that contribute to the experimental results of the interaction of ELF electromagnetic field radiation exposure with biological materials. The factors that affect the ELF electromagnetic field depend on the energy absorbed by biological organisms and how that energy is transmitted in space and time. These factors can also influence each other, giving rise to different new impacts, such as duration of exposure, intensity, number of exposures and frequency. As for the biological consequences that need to be understood regarding the cumulative effect of exposure to ELF electromagnetic fields, the response generated by biological systems and when the homeostasis of the exposed material will begin to be disturbed.

The energy level resulting from exposure to the ELF electromagnetic field is low enough to cause damage to chemical bonds in molecules directly. However, there are secondary effects that can be indirectly induced in the induced biochemical changes in body cells. The most likely consequence of this secondary effect is DNA damage caused by the abundance of free radicals in healthy cells. The results of measurements of magnetic field exposure measured at 29 location points in the PGRI Yogyakarta University campus environment, although still below the ICNIRP standard value (< 200 μT), but there are still long-term effects that can be caused by exposure to ELF electromagnetic field radiation if the magnetic field value is above 0.4 μT.

4. CONCLUSION

This study shows that the value of electromagnetic radiation at extremely low frequency (ELF) at PGRI Yogyakarta University is still far below the threshold value set by ICNIRP. However, several studies have shown that exposure to extremely low-frequency electromagnetic radiation with a magnetic field of 0.3 to 0.4 microtesla in the long term can increase the risk of leukemia. This research has produced useful information as a basis for making health policies within the PGRI Yogyakarta University campus. Although there are a number of uncertainties that still need to be resolved, especially regarding the consequences of exposure to extremely low frequency electromagnetic field levels.

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