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FOREWORD

I am pleased to put into the hands of readers Volume-5; Issue-7: 2018 (July, 2018) of **"International Journal of Advanced Engineering Research and Science (IJAERS) (ISSN: 2349-6495(P) | 2456-1908(O)" ,** an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to Science, Technology, Management and Humanities. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release print issue also, but this decision the journal issue will be available in various library also in print and online version. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind. This journal has DOI (Digital Object Identifier) also, this will improve citation of research papers. Now journal has also been indexed in **Qualis (Interdisciplinary Area) (Brazilian system for the evaluation of periodicals, maintained by CAPES).**

I thank all the authors of the research papers for contributing their scholarly articles. Despite many challenges, the entire editorial board has worked tirelessly and helped me to bring out this issue of the journal well in time. They all deserve my heartfelt thanks.

Finally, I hope the readers will make good use of this valuable research material and continue to contribute their research finding for publication in this journal. Constructive comments and suggestions from our readers are welcome for further improvement of the quality and usefulness of the journal.

With warm regards.

Dr. Swapnesh Taterh
Editor-in-Chief
Date: Aug, 2018

Editorial/ Reviewer Board

International Journal of Advanced Engineering Research and Science (IJAERS) *[Vol-5, Issue-7, July- 2018]*
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The Analysis of Extremely Low Frequency (ELF) Electric and Magnetic Field Exposure Biological Effects around Medical Equipments

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Abstract— *Naturally, we have been exposed to electric fields and natural magnetic fields emitted by the Sun, Earth and objects in nature. The process of life will proceed normally in conditions exposed to electric fields and natural magnetic fields. However, the intensity of electric field and magnetic field Extremely Low Frequency (ELF) in the environment always increases along with the development of the electric-powered equipment utilization. This study will describe the increase of electric field and ELF magnetic field around the medical equipment in the hospital. The results of measuring the intensity of the electric field and the ELF magnetic field at a distance of more than 100 cm are not significantly different than the natural intensity. The exposure to the electric field and the ELF magnetic field at the operator position (more than 40 cm) of medical equipment, the ELF electric field is in the range of intensity (2.75 - 166) V / m and the ELF magnetic field is in the range of intensity (0.021 - 3.26) T. Until now, there has been no reference results of research that proves exposure to the intensity of the ELF electric field and the ELF magnetic field resulted in a real biological impact. The results conclusion of this study is that the exposure to electric fields and magnetic fields ELF by medical equipment does not have the potential to cause biological effects.*

Keywords—Extremely Low Frequency (ELF), Electric and Magnetic Field, Biological effect.

I. INTRODUCTION

The need of electric energy in life is always growing rapidly along the development of electric power equipment technology. The utilization of electric-powered equipment especially medical equipment is proven to improve service quality and healing of patient. However there are fears of possible biological effects by exposure to electric fields and magnetic fields around these medical devices. Based on Hans Christian Oersted's experiments in 1820, it is proved that in the vicinity of the wire that the electric currents will generate magnetic fields (Halliday and Resnick, 1997: 296).While Maxwell has proven that in the vicinity of the wire flowing by AC will arise electric fields and magnetic fields that propagate to form electromagnetic waves (Young, 2012: 762). The exposure of electromagnetic waves that arise around electrical devices is classified as the spectrum of Extremely Low Frequency (ELF) electromagnetic waves. ELF Electromagnetic wave is a spectrum of electromagnetic waves with a frequency of 0 - 300 Hz. Considering that the source of electrical energy in Indonesia comes from the power plant by the State Electricity Company (PLN) with a frequency of 50 Hz, then the electric field and magnetic field exposed is ELF electromagnetic wave component.

Therefore, the electric field and magnetic field in the exposure of electric powered equipment with the source of PLN is the electric field and ELF magnetic field.

The main source of exposure to electric fields and natural magnetic fields comes from the radiation of electromagnetic waves emitted by the Sun and by the Earth's surface. Yet, the intensity of electric fields and magnetic fields in the environment is increasing as the use of electric-powered equipment in human life increases. Electromagnetic waves consist of different spectrum of different wave types according to λ wavelength and frequency (*f*).

Figure. 01 provides an overview of the type of spectrum of electromagnetic waves based on their frequency.

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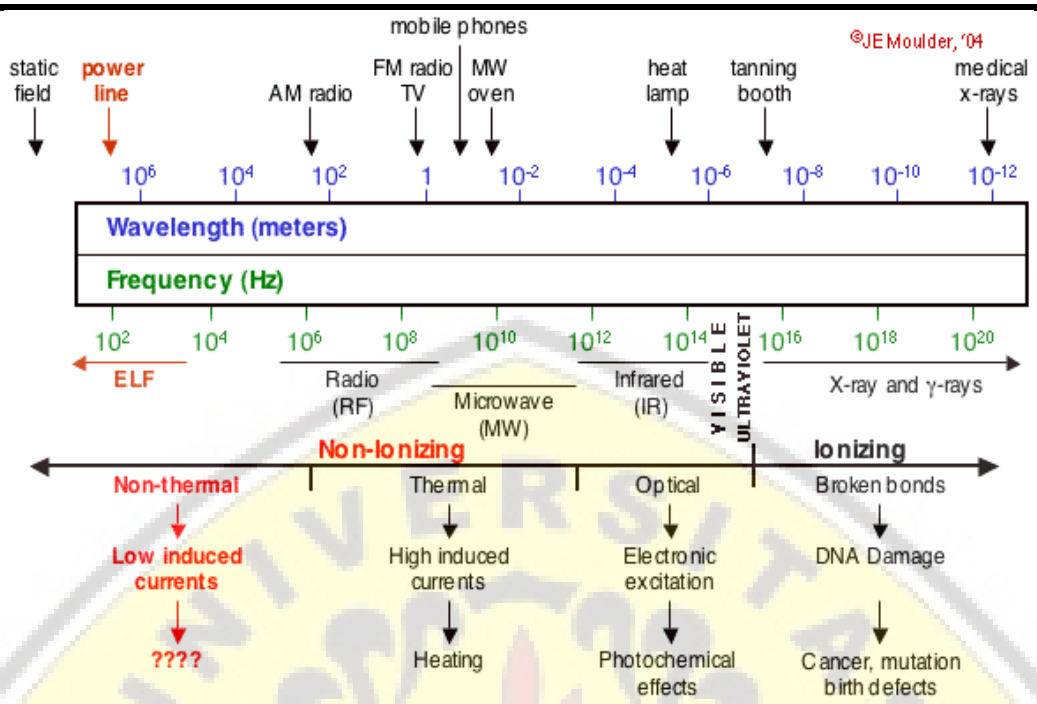

Fig.1: The spectrum of electromagnetic waves (Source: Moulder, 2006)

Based on the figure, it shows that ELF electromagnetic wave spectrum is at the lowest frequency (0 - 300) Hz. The energy contained is also weak, so the effect is non ionizing radiation and non thermal. This means that ELF electromagnetic wave radiation does not cause ionization effects on the atoms of a material, and does not cause a rise in temperature when interacting or inducing a material.

Naturally we subconsciously immersed in a place full of electric fields and magnetic fields, both by radiation exposure to the magnetic field by Earth and by the Sun. At the intensity of the electric field and the natural magnetic field, the process of life takes place normally. The presence of electric energy equipment will have an impact on increasing the intensity of exposure to the electric field and the surrounding ELF magnetic field.

The results of Sudarti's measurements, 2002, prove that the intensity of the electric field and the ELF magnetic field in the residential population about 500 kV High Voltage Transmission Line increased significantly compared to the natural intensity. The intensity of the ELF magnetic field increased 21 times compared to the intensity of the natural electric field, while the intensity of the ELF magnetic field increases 9 times compared to the intensity of the natural magneticfield. However, the exposure to electric field and magnetic field ELF by 500 kV High Voltage Transmission Line is still far below the exposure value recommended by INIRC.

The characteristics of the electric field and magnetic field are very different. The electric field is obstructed, which means that the intensity of the electric field will decrease by the presence of a barrier. However, the magnetic field is unhindered, which means that the intensity of the magnetic field is relatively not decreased by the barrier or is capable of penetrating various barriers including biological materials such as the human body and animals (Grotel 1992).

The exposure to the ELF's magnetic field from the environment in the body directly interacts with the cell through the cell membrane (Shimizu, 1995), therefore it is suspected that the magnetic field as the dominant factor that can cause biological effects.

Normal cells are microcosms containing ions and nonstop molecules undergoing geophysical processes while constantly changing their structure and function to react to their environmental conditions. The exposure to the ELF's magnetic field in the environment can force the ion and molecules in the cell resulting in a change in cell membrane potential, which may cause cellular alterations, either beneficial or detrimental changes to the cell. This is called biological effects.

The results of biological effect research by exposure to electric fields and ELF magnetic fields are still unclear. Valberth PA, 1997, states that exposure to the ELF magnetic field at an intensity greater than 10 uT allows for a biological effect, but Sudarti's research results, 2013, prove that

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exposure to electric and magnetic fields by SUTET 500 kV is not a factor causing public health problems who live there.

Therefore, this article presents the analysis results of exposure to electric field and ELF magnetic field in the environment around electric-powered medical equipment. The results of this study are expected to add knowledge and explain scientifically possible biological effects by exposure to electric fields and ELF magnetic fields around medical equipment.

II. RESEARCH METHOD

This study is a descriptive study aimed at describing and analyzing the intensity of exposure to electric fields and magnetic fields around medical devices and the risk of biological effects that they may cause.

The sample of this research is 12 medical equipments that use electrical energy and often used in the framework of medical service in Hospital. ELF field and electric field measurements were performed using the HI-3604 ELF Field Strength Measurement System.

The samples were 15 kinds of electric powered medical equipments commonly used in hospital such as X-ray, CT-Scan, Infant warmer, Photo Terapy, Atom Infant Incubator, Electro Miography, Ultrasonic Diathermy, Cervical Traction (Traccy), Electrical Stimulation , Embitron, Short Wave Diathermy, Laser Therapy, ASA Magnetic Fields, Ultrasonography (USG), Magnetic Resonance Imaging (MRI). The measurements were made by variation of measuring distance (10 - 20) cm, (40 - 60) cm, and 100 cm from medical equipment in ON condition (when electric current flowed).

Based on the data from the measurement of electric field and magnetic field, it will be analyzed descriptively by comparing the intensity of electric field and natural magnetic field. Moreover, it would be done an analysis on possible risks of biological effects that may be generated by exposure to electric fields and magnetic fields from medical devices based on the results of biological effects research from various scientific journals.

III. RESEARCH RESULTS

As a reference analysis of the results from this study, we conducted measurements of electric fields and natural magnetic fields on the grass field during the day. This intensity of the electric field and the natural magnetic field measurement was the accumulation of the intensity of the electric field and the magnetic field generated by the surface of the Earth and by the radiation of the Sun.

The average measurements of the intensity of the electric field and the natural magnetic field are presented in Table 1 below.

Table.1: Intensity of the Natural Field

Natural Field	Intensity
Electrical Field (V/m)	2,1480 ± 0,7632
Magnetic Field (μT)	0,0265 ± 0,0023

Tabel.1 menunjukkan bahwa intensitas medan listrik alamiah berada pada range 2,1258 V/m – 3,5522 V/m, dan intensitas medan magnet alamiah berada pada range 0,0242 – 0,0288 μT. Hal ini berarti bahwa secara alamiah semua makhluk hidup mengalami proses tumbuh kembang secara normal dibawah paparan medan listrik dan medan magnet alamiah tersebut.

In addition to the Earth, the increasing intensity of the electric field and the natural magnetic field in the environment was strongly influenced by the radiation of electromagnetic waves from the Sun. Utilization of electric energy equipment in life will also increase the intensity of electric field and magnetic field in the environment. This makes us realize that human beings on the surface of the Earth are immersed in a sea of electric fields and magnetic fields. Therefore, the exposure to ELF electric fields in the environment at high intensity is suspected to cause biological effects or potentially cause health effects. Therefore the International Non Ionizing Radiation Committee (INIRC), 1990, set the threshold value of electric field and magnetic field exposure 50/60 Hz during the working day, for exposure of electric field of 10 kV / m and magnetic field of 500 μT.

The average ELF field measurement result around medical equipment is presented in the following table.

Table.2: Intensity of Electrical Fields ELF around Medical Equipment

Medical Equipments	Intensity of Electric Field At Distance x (V/m)		
	(10-20) cm	(40-60) cm	(100-200) cm
X-ray	3,45	3,4	1,5
CT-Scan	2,35	2,75	2,3
Infant warmer	14,0	18,0	2,5
Photo Terapy	138,5	76,0	3,5
Atom Infant	10,1	6,8	2,7

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Incubator			
Electro Miography	5,35	3,0	2,6
Ultrasonic Diathermy	6,35	4,0	1,6
Cervical Traction (Traccy)	280	52,5	4,5
Electrical Stimulation	8,34	7,85	3,32
Embitron	300	166	2,75
Short Wave Diathermy	16,25	10,95	2,25
Laser Therapy	6,24	4,32	3,25
ASA Magne tic Fields	280	177	7,25
Ultrasonogra phy (USG)	61,5	11,64	2,45
MRI	10,4	5,2	1,7
Natural Field Magnetic Average			**2,148**

Based on the results of these measurements, it proved that the intensity of exposure to electric fields at a distance of 100 cm from all medical equipment was not different from the intensity of the natural electric field. The intensity of the electric field at a distance of 100 cm from both Cervical Traction (Traccy) and ASA Magnetic Fields was higher than the natural intensity, but it is due to the wiring of other electrical equipment. The intensity of the electric field at a distance of 100 cm from the X-ray, Ultrasonic Diathermy, and MRI looked lower than the intensity of the natural electric field. This was given that the measurement of the intensity of the natural electric field was done during the day which was the accumulation of natural electric field intensity coming from the Earth and the Sun.

The intensity of the electric field around the X-ray, CT-Scan, Ultrasonic Diathermy, Atom Infant Incubator, and MRI at more than 10 cm apart proved to be different, but not significant compared to the intensity of the natural electric field. While the intensity of the electric field around the medical equipment of Photo Terapy, Embitron, Traccy and ASA Magnetic Fields was more than 100 V / m, this intensity was still far from the threshold value recommended by the International Non Ionizing Radiation Committee (INIRC) 10 kV for exposure throughout the working day.

For next, the intensity measurements of ELF magnetic field exposure by medical equipment were presented in Table.03as follows.

Table.3: Intensity of ELF Magnetic Fields around Medical Equipment

Medical Equipments	Average Intensity of Magnetic Field At Distance x (μT)		
	(10-20) cm	(40-60) cm	(100) cm
X-ray	**125**	3,26	0,850
CT-Scan	0,290	0,450	0,320
Infant warmer	0,089	0,035	0,021
Photo Terapy	1,475	0,021	0,0155
Atom Infant Incubator	0,157	0,028	0,018
Electro Miography	0,113	0,117	0,133
Ultrasonic Diathermy	0,028	0,028	0,025
Cervical Traction	**9,650**	3,075	0,019
Electrical Stimulation	0,88	0,045	0,023
Embitron	**5,715**	0,500	0,154
Short Wave Diathermy	2,550	1,864	0,015
Laser Therapy	0,415	0,0356	0,095
ASA Magne tic Fields	**8,150**	1,256	0,350
Ultrasonogra phy (USG)	1,243	0,215	0,0356
MRI	2,453	0,144	0,0405
Natural	0,031		

The intensity measurement of ELF magnetic field exposure at a distance of 100 cm from all medical equipment in this study proved not significantly different from the intensity of the natural magnetic field. The magnetic field intensity around Infant warmer and Ultrasonic Diathermy ranged from 10 cm from the tool was very low and no different from the natural intensity. This meant that the two tools had no impact on increasing the intensity of the magnetic field in the environment.

The intensity of the magnetic field at a distance of more than 20 cm from the Photo Terapy tool, Atom Infant Incubator, Electrical Stimulation, and Laser Therapy was also

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no different from the intensity of the natural magnetic field. The intensity of the magnetic field at a distance of 10-20 cm from the four medical devices was slightly less than natural. This indicated that the four devices only had an effect of increasing the magnetic field that was very weak only up to a distance of 20 cm. The intensity of the magnetic field around CT-Scan, Electro Miography, Short Wave Diathermy, Ultrasonography (ultrasonography) and ultrasound devices reached less than 3 µT at 20 cm, and reached less than 2 µT at 60 cm, while the intensity of the highest magnetic field at a distance of 10-20 cm caused by X-ray reached 125 µT, by Cervical Traction (Traccy) reached 9,650 µT, by ASA Magne tic Fields reached 8,150 µT, and by Embitron reached 5,715 µT. But this intensity was still far from the ELF magnetic field exposure limit value recommended by the International Non Ionizing Radiation Committee (INIRC), which is 500 µT for exposure throughout the working day.

IV. DISCUSSION

As a basis for analyzing the health effects of exposure to electric fields and ELF magnetic fields by medical equipment, it was based on the recommendation of the International Non Ionizing Radiation Committee (INIRC) of the International Radiation Protection Association (IRPA), 1992, that the limit of exposure to electric fields and magnetic fields of 50/60 Hz (ELF) as follows:

Table.4: Threshold Value of Electric Field Intensity and ELF Magnetic Field

Field for	Electric Field Intensity (kV/m)	Magnetic Field Intensity (µ T)
Group of Worker:		
All Day Long	10	500
Short Time	30*	5000**
General Group:		
Until 24 hours/day	5	100
Several hours/day	10	1000

(Sources: IRPA,WHO, 1990)

* = The duration of exposure to the electric field between 10 and 30 kV / m shall be calculated from the formula t <80 / E ,

t = Time (hour/day)

E = Strong Field (kV/m)

** = Maximum time exposureof 2 hours / day.

This indicated that the intensity of ELF field exposure in humans during maximum working hours reached 10 kV and the intensity of ELF field exposure wasmaximumof 500 µT.

The United Nations Environmental Program (UNEP), the World Health Organization (WHO) and IRPA in 1987 issued a statement about the induced current density value with its biological effects caused by exposure to 50/60 Hz magnetic fields on the whole body as follows :

a) Between 1 and 10 mA / m2, there was no significant biological effect.
b) Between10 and 100 mA / m2, there was a proven biological effect, including effects on the vision and nervous system.
c) Between 100 and 1000 mA / m2, stimulates a stimulated tissue and there was a potential of health hazard.
d) Above 1000 mA / m2, it may cause extrasystole, and ventricular fibration of the heart (acute danger of health).

The results of Sudarti measurements, 2012, that the intensity of the electric field and the ELF magnetic field in the residential population about 500 kV High Voltage Transmission Line increased significantly compared to the natural intensity. When compared to the intensity of the natural electric field, the intensity of the electric field outside the house increased 21 times and the intensity of the electric field inside the house increased 7 times. While the intensity of the ELF magnetic field outside the home was not significantly different with the intensity of the ELF magnetic field inside the house, but there was an increase of 8-9 times compared to the natural.

The average intensity of electric field exposure by 500 kV High Voltage Transmission Line was 90 V / m and the average intensity of the magnetic field was about 0.4 to 3 µT and it didn't become as a contributing factor to the public health problems who live near the place (Sudarti, 2013).

The results of the biological effects of exposure to electric fields and the ELF magnetic field reported Sudarti, 2002, that the number of leucocytes in Norwegian Wistar Ratus maintained below 500 kV High Voltage Transmission Line with ELF field intensity (1,1620-2,148) kV and field intensity ELF magnets (1.6693 - 1.7168) µT continuously for 8 weeks are shown to significantly decrease compared to controls. The results of spermatozoa examination in Norwegicus also found the number of defective spermazoa in the mouse group maintained just below 500 kV of High Voltage Transmission Line for 8 weeks, but not significantly

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different from the control group (Sudarti, 2003). It was also evident that the number of leucocyte that experienced apopesis significantly increased in wistar white rats maintained under 500 kV of High Voltage Transmission Line intermittently 8 hours / day for 14 weeks (Sudarti, 2004).

The exposure to an ELF magnetic field with intensity (20-40) □T intermittently 8 hours / day for 15 days significantly increased the percentage of IL-10-producing lymphocytes in the Balb / C mice lymph nodes, and decreased significantly after day 30 at Said the ELF magnetic field, but still significantly higher than the control (Sudarti, 2005).In contrast, the percentage of IgG-production by lymphocytes in lymph nodes of Balb / C mice decreased after exposure to the intensity ELF magnetic field (20-40) □T intermittently 8 hours / day for 15 days, and increased significantly after day 30 being exposed by the ELF magnetic field, but still significantly lower than the control (Sudarti, 2005). While the percentage of IFN-gamma-producing lymphocytes in lymphocytes of Balb / C mice decreased significantly after exposure to the intensity ELF magnetic field (20-40) □T intermittently 8 hours / day for 15 days, and increased significantly after day 30 in the ELF magnetic field, but significantly lower than the control (Sudarti, 2006).

The results showed that exposure to the ELF magnetic field (20-40) □T intermittently 8 hours / day for 15 days and 30 days was able to suppress Th1 cell activation so that it resulted in a decreaseIFN-gamma production. The decrease in IFN-gamma production resulted in increased Th2-set activation, so that producing IL-10 was increased. The increased production of IL-10 would activate B cells to produce IgG. This showed that exposure to the ELF magnetic field (20-40) □T affected the immunological balance in Balb / C mice.

Several studies of magnetic field effects by various equipment were reported, among others, Huss A, et al, 2017, reported that exposure to magnetic fields by MRI can not be proven to cause health effects on operators. Brodic Darko & Amelio Alessia, 2015, reported that the highest exposure to the magnetic field by the laptop is at the bottom of the laptop. Lv X, et al, 2014, proved that exposure to the 0.86 μT magneticfield did not cause problems on the patient's blood vessels. Petri et al., 2017, stated that exposure to static magnetic fields is not proven to cause biological effects.

Vijay *at al*, 2012, they concluded that the CRT TV/PC screen is harmful for the blood tissue of the human beings at least the given distances and heights of the CRT TV/PC screen from earth surface.Kaushal M et al, 2012, concluded that people living near cell tower receive strong signal strength but at the expense of health.Calderon et al, 2017, They concluded that the number of phantoms was not large enough to provide definitive evidence of an increase of induced current density with age, but the data that are available suggest that, if present, the effect is likely to be very small.Woelders H, et al, 2017, They concluded that biological effects of radiofrequency electromagnetic fields (RF-EMF) in modern wireless telecommunication, there is not conclusive evidence was found for induced embryonic mortality or malformations by esposure to the used EMFs to eegs.

While Taheri M et al, 2017, proved that wi-fi and radiofrequency radiation can inhibit the growth of E coli bacteria.Istiaque Ahmed, et al, 2013, concluded that all irradiated *S. aureus* bacteria showed decrease in their growth rate compared to control samples, after exposure by ELF PEMF at 150-500 Hz, are more effective than exposures at 3-100 Hz in reducing the viability of *S. aureus* in broth.Tayebeh Barsam, et al, 2012, the results in this paper showed a positive correlation coefficient between occupational exposures to ELF electromagnetic fields and sleeping quality score, cannot reject the impact of the fields on sleep quality. Since other finding indicated the weak electromagnetic fields can have the biological effects and reducing work hours can prevent their biological effects.

While the exposure to UF magnetic field (100-150) uT intermittently 8 hours / day for 7 weeks had a significant effect on the increase of Germinal Cell Calcium on Mice Bulb / C (Sudarti, 2010). Furthermore, the development of research towards the utilization of ELF magnetic field by Sudarti, 2016, that exposure of ELF magnetic field at an intensity of 700 □T can be utilized as a sterilization method of salmonella in Gado-gado food.

Therefore, based on the results of this study indicated that exposure to electric fields and ELF magnetic fields by medical equipment could be said to have no potential biological effects for operators, considering the position of the average operator was at a distance of more than 40 cm from medical equipment. While the exposure of electric field and magnetic field ELF to the position of medical equipment operators for the ELF electric field was in the range of intensity (2.75 - 166) V / m and the ELF magnetic field was in the range of intensity (0.021 - 3.26) □T. There was no reference to the results of research that proves exposure to the intensity of the ELF electric field and the ELF magnetic field has resulted in a real biological impact.

V. CONCLUSIONS AND SUGGESTIONS

Based on the above measurements, it can be stated that the intensity of the ELF electric field and the ELF magnetic field in the working environment with medical equipment

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was still at a safe level. The exposure to the electric field and the ELF magnetic field at the position of the medical equipment operator for the ELF electric field was in the range of intensity (2.75 - 166) V / m and the ELF magnetic field was in the range of intensity (0.021 - 3.26) □T. There was no reference to the results of research that proved exposure to the intensity of the ELF electric field and the ELF magnetic field has resulted in a real biological impact. The conclusion from the results of this research is that the exposure to electric fields and magnetic fields ELF by medical equipment did not have the potential to cause biological effects.

REFERENCES

[1] Brodic Darko, Amelio Alessia, 2015, *Classification of The Extremely Low Frequency Field Radiation Measurement From the Laptop Computers*, Measurement Science Review, Volume 15 No.4, 2015.

[2] Calderon C(1), Ichikawa H(2), Taki M(2), Wake K(3), Addison D(4), Mee T)4), Maslanyj M(4), Kromhout H(5), Lee AK(6), Sim MR(7), Wiart J(8), *Cardis E(9), 2017, ELF Exposure from mobile and cordless phones for the epidemiological MOBI-Kids study*. Environ Int.2017 Apr; 101:59-69.doi: 10.1016/j.envint,2017.01.005

[3] Huss A(1), Schaap K(2), Kromhout H(3), 2017, *MRI-related magnetic field exposures and risk of commuting accidents-A coss-sectional survey among Dutch imaging technicians*, Environ Res.2017 Apr 25:156:613-618, doi:10,1016/J.envres.2017. 04.022.

[4] ICNIRP Guidelines, 1998, Guidelines for Limiting Exposure toTime-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz). Preprint Scheduled to appear in Health Physics 74(4):494-522

[5] Istiaque Ahmed, Taghrid Istivan, Irena Cosic & Elena Pirogova. (2013). Evaluation of the effects of Extremely Low Frequency (ELF) Pulsed Electromagnetic Fields (PEMF) on survival of the bacterium *Staphylococcus aureus.EPJ Nonlinear Biomedical Physics 2013, vol 1, no. 5, p. 1-17*.

[6] Ingrida Uloziene, Virgilijus Uloza, Egle Gradauskiene & Viktoras Saferis. (2005). Assessment of Potential Effects of The Electromagnetic Fields of Mobile Phones on Hearing. *BMC Public Health 2005, vol. 5, no. 39, p. 1-9*.

[7] Kaushal Muhit, Singh Tanvir, Kumar Amir, 2012, *Effects of Mobile Tower Radiation & Case Studies From Different Countries Pertaining the Issue*, International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 N0.11.

[8] Lv X, Wu Z, Li Y, 2014, *Effect of electromagnetic radiation on the coils used in aneurysm embolization*. Neuroradiol J. 2014 Jun;27(3):350-5. doi: 10.15274/NRJ-2014-10050. Epub 2014 Jun 17.

[9] Petri AK(1), Schmiedchen K(2), Stunder D)2), Dechent D(2), Bailey WH (3), Driessen (2), 2017, *Biological Effects of Exposure to Static electric fields in buman and Wertebrates*, Environ Health, 2017, Apr 17:16(1): 41

[10] Sudarti, 2002, Risiko Leukemia pada tikus Putih setelah Pemaparan Medan Elektromagnetik oleh SUTET 500 kV **Saintifika** (ISSN: 1411-5433), Vol. 3 No. 2 Juni 2002: 91-100.

[11] Sudarti, 2003, The Influnce Of Electromagnetic Field *Extremely Low Frequency* (ELF) of 500 kV High Voltage Transmission Line to The Spermatogenesis **Folia Medica Indonesia** (ISSN: 0303-7932),Vol 39 No.3 July – Sept 2003: 140 – 146

[12] Sudarti. 2004. Indikasi Peningkatan Apoptosis Leukosit Pada Tikus Putih Yang Dipapar Medan Elektromagnetik *Extremely Low Frequency* (ELF) < 0,1 mT, **Jurnal Sains dan Teknologi** (ISSN:1412-8136), Vol 3, No.1 Maret 2004: 24-29

[13] Sudarti, 2005, The Effect of Alteration IL-10 to The Immuno Modulation response on BALB/c Mice *Extremely Low Frequency* (ELF) Magnetic Fields 20 μT, **Saintifika** (ISSN: 1411-5433), Vol. 6 No. 1 Juli 2005: 36 – 44

[14] Sudarti, 2005, Pengaruh Paparan Medan Magnet *Extremely Low Frequency* (ELF) 20 – 32 μT Te **IKEASMA** (ISSN:1829-7773)m Vol1 No.2 September 2008rhadap IgG pada Mencit BALB/c,

[15] Sudarti, 2006, The Influence of Extremely Low Frequency (ELF) Magnetic Fields Induction to The Production of IFN-gamma on Bulb/C Mice, **Folia Medica Indonesia** (ISSN: 0303-7932),Vol 42 No.2 April - June 2006: 82 – 88

[16] Sudarti, 2010, *Mekanisme Peningkatan Kalsium Sel Germinal pada Mencit Bulb/C yang di Papar Medan Magnet* ELF (100 – 150 uT), **Saintifika** (ISSN: 1411-5433), Vol. 12 No. 2 Desember 2010: 169 – 182

[17] Sudarti, 2012, *Analisis Paparan Medan Elektromagnetik Extremely Low Frequency (ELF) di Lingkungan Oleh SUTET-500 kV*, **Saintifika** (ISSN: 1411-5433), Vol. 14 No. 2 Desember 2012: 132 – 139).

[18] Sudarti, 2013, *Analisis Faktor Penyebab Timbulnya Keluhan Kesehatan Masyarakat di Sekitar SUTET-500kV*. Prosiding Seminar Nasional MIPA DAN

https://dx.doi.org/10.22161/ijaers.5.7.37 *ISSN: 2349-6495(P) | 2456-1908(O)*

PMIPA I 31 Maret 2013 FKIP UNIVERSITAS JEMBER: 2 Desember 2012: 132 – 139)

[19] Sudarti dan Prihandono, 2014. "*Potensi Genotoksik Medan Magnet ELF (extremely low frequency) terhadap Prevalensi Salmonella dalam Bahan Pangan untuk Meningkatkan Keamanan Pangan bagi Masyarakat*". Jember: Universitas Jember.

[20] Sudarti, 2016, Utilization of Extremely Low Frequency (ELF) Magnetic Field is as Alternative Sterilization of *Salmonella typhimurium* In Gado-Gado, International Conference on Food, Agriculture, and Natural Resources, FANRes2015. Available online at www.sciencedirect.com

[21] Taheri M, Roshanaei G, Ghaffari J, Rahimnejad S, Khosroshani BN, Aliabadi M, Eftekharian MM. (2017). The Effect of Base Tranceiver Station Waves on Some Imunological and Hematological Factors in Exposed Persons. *Hum Antiboieds.* Vol. 25, p. 31-37.

[22] Taheri M(1), Mortazavi SM(2), Moradi M(1), Mansouri S(1), Hatam GR(3), Nouri F(4), 2017, *Evaluation the Effect of Radiofrequency Radiation Emitted from Wi-fi Router and Mobile Phone Simulator on the Antibacterial Susceptibility of Pathogenic Bacteria Listeria Monocytogenes and Esceria coli*, Dose Response, 2017 Jan 23:15(1).

[23] Tayebeh Barsam, Mohammad Reza Monazzam, Ali Akbar Haghdoost, Mohammad Reza Ghotbi & Somayeh Farhang Dehghan. (2012). Effect of extremely low frequency electromagnetic field exposure on sleep quality in high voltage substations. *Iranian Journal of Environmental Health Sciences & Engineering 2012, vol. 9, no. 15, p. 1-7.*

[24] Vijay Kumar, Anuj Tyagi and P.P.Pathak, 2012, Stdy of Harmful Effects of Low Frequency Radiation of CRT TV/PC Screen on Human Blood Tissues, International Journal of Current Research, Vol.4, Issue.05.pp.182-186.May,2012.ISSN:0975-833x

[25] Woelders H, de Wit A, Lourens A, Stockhofe N, Engel B, Hulsegge I, Schokker D, van Heijningen P, Vossen S, Bekers D, Zwamborn P, 2017, Study of Potential health effects of electromagntic fields of lelephony and wi-fi, using chicken embryo development as animal model. Bioelectromagneticsm 2017 Apr; 38(3):186-203. doi:10.1002/bem. 22026 Epub.2017 Jan 16.

[26] World Health Organization, (1987), *Magnetic Fields*, Environments Health Criteria 69, Geneva.

[27] World Health Organization, 2007, Eaxtremely Low Frequency Fields, Environmental Health Criteria 238,ISBN 978 92 4 157238 5, ISSN 0250-863X

[28] Young, H. G. 2012. *College Physics 9th Edition*. San Francisco: Pearson Education, Inc.