THE INFLUENCE OF ELECTROMAGNETIC FIELD EXTREMELY LOW FREQUENCY (ELF) OF 500 kV HIGH-VOLTAGE TRANSMISSION LINES TO THE SPERMATOGENESIS OF WISTAR WHITE RATS

Syariffuddin Mahmudsyah*, Sudarti**

ABSTRACT

This research was aimed at carrying out the assesment of the effect of the extremely low frequency (ELF) electromagnetic fields exposure on the spermatogenesis of white rat. The study examined the in vivo effects of extremely low frequency electromagnetic fields (ELF-EMF) emitted by 500 kV high-voltage power-line to the spermatogenesis of white rats. A complete randomized factorial 3 x 2 design was used in the study. This research needed 60 white rats divided into three groups and placed in a different cage. Cage I (as a control) exposed to natural electromagnetic field with the rate intensity (0.00423 kV/m; 0.04625 uT). Cage II was exposed to the intensity of 0.638 kV/m; 1.5290 uT in the cage and 1.0640 kV/m; 1.5748 uT around the cage. Cage III was exposed to the intensity of 1.1620 kV/m; 1.6693 uT in the cage and 2.1480 kV/m; 1.7168 uT around the cage. The exposure was continously held on the average of 14 h/d in the cage and 10 h/d around the cage during 4 and 8 weeks. The result of the study showed significant result ($p < 0.05$), the number of spermatogonium cells, primer spermatocyte cells and spermatid cells were influenced by the exposure intensity and the exposure duration of extremely low frequency electromagnetic fields. It can be concluded that extremely low frequency electromagnetic fields exposure emitted by 500 kV high-voltage transmission-line influences the spermatogenesis of white rats. Electromagnetic fields exposure functions as physical stressor on the spermatogenesis, but the tendency of adaptation up to 8 weeks exposure has not shown optimum results.

Keywords: *Extremely low frequency (ELF), electromagnetic fields, spermatogenesis, 500 kV high-voltage transmission line.*

INTRODUCTION

Extremely low frequency electromagnetic fields (ELF-EMF) are a magnetic field spectrum on very low frequency (300 Hz to below). This field consists of electromagnetic components of electric and magnetic field and it is generally emerged around the electrical current on the conductor, including non-ionising radiation (Grotel, 1992). In line with the rapid use of technology in daily-life activities, the ELF electromagnetic exposure in the environment will also increase continuosly. The resource of ELF magnetic exposure is assumed to have an important role in increasing the intensity of ELF electromagnetic field exposure in environment like 500 kV high-voltage transmission line. Based on the result of calculation on the intensity of electromagnetic field exposure under 500 kV high-voltage transmission line, the intensity reaches 21 times higher on the electrical field and 8-9 times higher on the magnetic field than the control area (Sudarti, 1998).

Normal cell is a microcosmos beating continuously which constantly changes its structure and function as a response to the environmental condition. ELF Electromagnetic field exposure to environment gives power to ion and molecule within the cell producing current and calor (WHO, 1989); this condition influences the membrane cell conductivity and could modify cell function (WHO, 1989; Shimizu, 1995). As natural conclusion from some biophysics mechanisms, electromagnetic field exposure influence much on many cellular process including *signal transduction, gene expression, cell proliferation, and intercellular communication,* in which theoretically the effect can disturb the growth of embryo and implantation process (Huuskonen, 1998). For that reason, germinative cell becomes sensitive to any environmental factors (Rahino, 1986), and eventually makes the process of sperm growth become a valid indicator to examine the influence of ELF electromagnetic fields exposure to environment toward reproductive function.

It has been reported that ELF electromagnetic field exposure could force down the melatonin production (Reiter, 1994; Shimizu, 1995; Niehaus, 1997). The compressed production of melatonin relatively influences the reproductive function because pineal melatonin hormone functions as regulator on hormones, including estrogen and testosterone (Huuskonen, 1998). Furthermore, Furuya (1998) concluded that long-hours magnetic field exposure causes a significant effect on proliferation and spermatogonia differentiation on rats. The effect of electromagnetic field toward embryo development is also reported by Hiroyuki et al (1998).

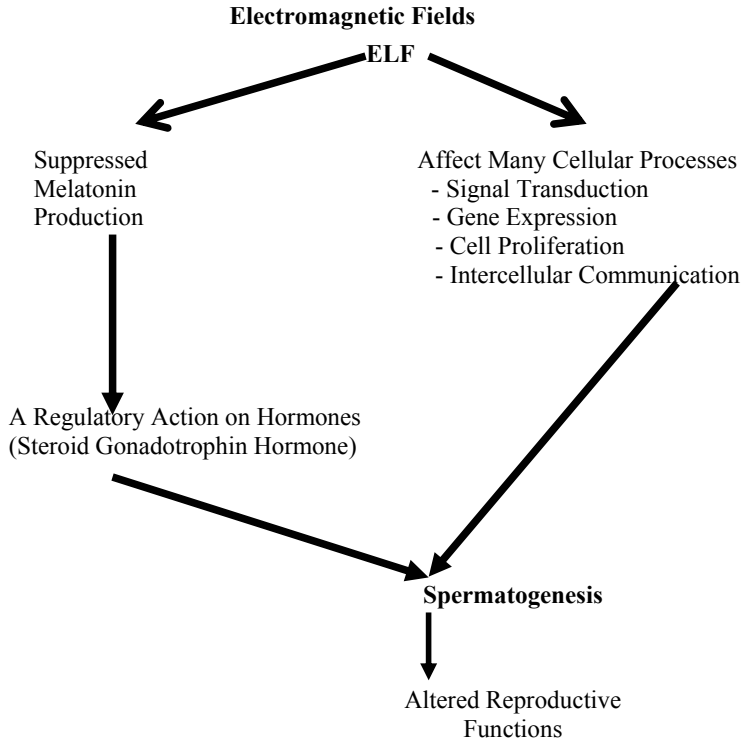
**Faculty of Electrical Engineering, ITS, Surabaya*
***Department of Physics, Faculty of Teaching and Educational Sciences, Jember University, Jember*

In detail, he said that after exposing white rats to ELF electromagnetic field with intensity 0.2 ; 1.2 ; 2.2 ; 3.2 μT (micro tesla), it had been found that the number of abnormal embryo is significantly different with those exposed under 100 Hz (p = 0,048). However, the biological mechanism on the impact of ELF electromagnetic field exposure toward fertility has not been reported yet (Feychting & ahlbom, 1995; Huskonen, 1998).

In line with the above theories, the research is conducted experimentally using white rats (*rattus norwegicus strain wistar*) as object of experiment, with the objective to prove the influence of ELF electromagnetic field exposure to spermatogenesis. The importance of this research is the significant role of spermatogenesis on determining the quality of sperma produced and its influence toward fertility and abnormality of embryo. The result of the research could be applied as preventive action to avoid the occurring of such abnormality.

Theoretical framework

Based on the above explanation, the theoretical framework of the research can be described as follows:



RESEARCH METHOD

This research was an experimental research using complete randomized factorial 3x2 designs with 10 recurrences. By using in vivo 60 white rats male *Rattus Norwegicus* Strain Wistar 8-week were exposed under ELF electromagnetic field exposure 500 kV high-voltage transmission line. The white rats were randomly divided into three different cages then exposed under 500 kV high-voltage transmission line. The cage I (as a control, 20 rats) was exposed to the natural electromagnetic field with the rate intensity (0.00423 kV/m; 0.04625 uT) that is by placing rats and the cage in Department of Biochemistry, Airlangga University School of Medicine. Cage II was exposed to the intensity of 0.638 kV/m; 1.5290 uT in the cage and 1.0640 kV/m; 1.5748 uT around the cage through placing rats and its cage under 500 kV high-voltage transmission line; 4 m above the ground. Cage III was exposed to the intensity of 1.1620 kV/m; 1.6693 uT in the cage and 2.1480 kV/m; 1.7168 uT around the cage through placing rats and its cage under 500 kV high-voltage transmission line; 2 m above the ground. The exposure was continously held on the average of 14 h/d in the cage and 10 h/d around the cage during 4 and 8 weeks.

Analizing Unit of this research was tubulus seminiferus from white rats testis after being exposed under ELF

electromagnetic field for 4 and 8 weeks. Then, the next process was calculating the number of spermatogonium, primer spermatocyte and spermatid for each observation using light microscope with 400X advancement. The obtained data was analyzed using One-way Anova analysis and continued by advanced LSD analysis.

RESULTS AND DISCUSSIONS

High-voltage transmission line of 500 kV is assumed to be the source of extremely low frequency electromagnetic field exposure which potentially becomes the cause of infertility. This research indicates that the outcome of calculation of electric and magnetic field under 500 kV high-voltage transmission line is higher 21 times for electric field and 8 to 9 times for magnetic field compared to control. Therefore it has been proved that the outcome of calculation of ELF electromagnetic field exposure intensity is still far from the WHO required limit number (1984). As spermatogenesis indicator, series of test have been conducted to the number of spermatogenesis, primer spermatocyte and spermatid from seminiferous tubule. The research analysis using Anova followed by LSD Test and described observably on the trend chart are as follows:

Table 1. Oneway ANOVA Outcome analysis and LSD test on the number of Spermatogonium, Primer spermatocyte and Spermatid

Unit Analysis	Length Time of Exposure (week)	Exposure Intensity		
		High	Midpoint	Control
Σ Spermato gonium Cell	4	(**1**) 44.43 ± 5.83^{c}	(**3**) 50.14 ± 6.40^{b}	(**5**) 55.56 ± 5.63^{a}
	8	(**2**) 32.70 ± 4.76^{d}	(**4**) 46.70 ± 6.15^{c}	
Σ Primer Spermatocyte Cell	4	(**1**) 65.04 ± 11.72^{c}	(**3**) 73.91 ± 9.46^{b}	(**5**) 82.26 ± 9.78^{a}
	8	(**2**) 42.22 ± 12.06^{d}	(**4**) 65.82 ± 7.72^{c}	
Σ Spermatid Cell	4	(**1**) 126.01 ± 22.67^{c}	(**3**) 147.90 ± 19.50^{b}	(**5**) 155.86 ± 21.87^{a}
	8	(**2**) 94.03 ± 17.24^{d}	(**4**) 142.01 ± 20.35^{c}	

Note: Different superscript in column and row are based on the factual condition with ($p < 0.05$)

Table 2. Oneway ANOVA Outcome Analysis and LSD Test on the Ratio of Spermatogonium, Primer Spermatocyte and Spermatid to Control

Unit Analysis	Length Time of Exposure (week)	Ratio to Exposure Intensity	
		High/Control	Midpoint/Control
Σ Spermatogo nium Cell	4	0.7997^{b}	0.9024^{a}
	8	0.5886^{c}	0.8405^{a}
Σ Primer Spermatocyte Cell	4	0.7907^{b}	0.8985^{a}
	8	0.5133^{c}	0.8001^{a}
Σ Spermatid Cell	4	0.8085^{b}	0.9489^{a}
	8	0.6033^{c}	0.9111^{a}

Note: Different superscrip in column and row are based on the factual condition with ($p < 0.05$)

Based on the above data, the trend chart of the mean of the number of spermatogonium, primer spermatocyte and spermatid toward the level of intensity and length time of ELF electromagnetic field exposure are shown below:

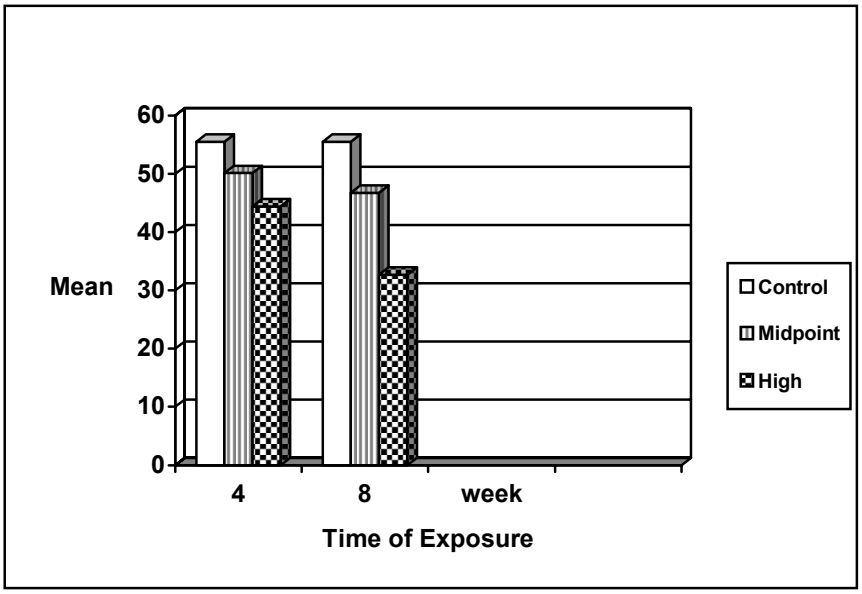


Figure 1. Mean of the Number of Spermatogonium to EM Field

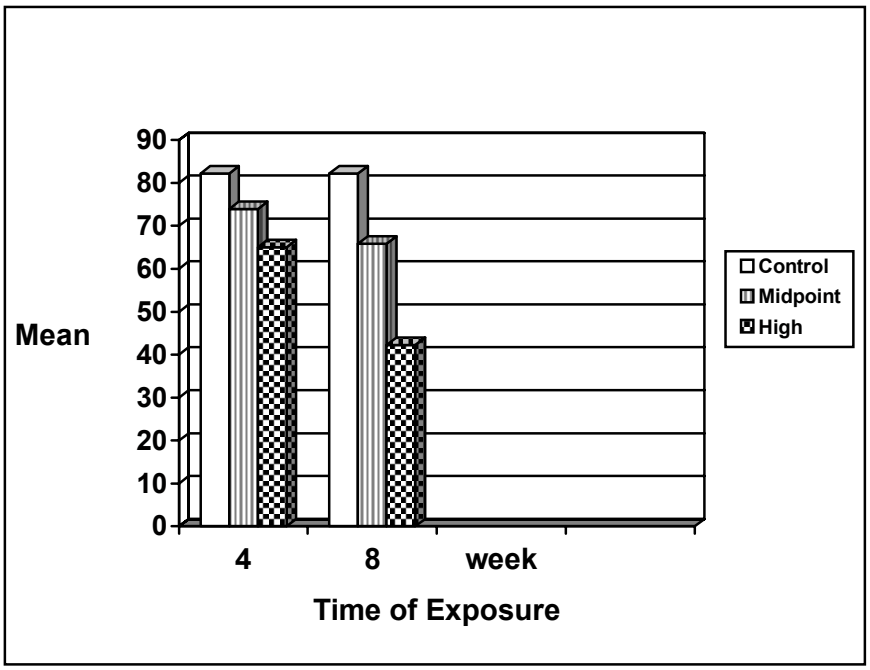


Figure 2. Mean of the Number of Primer Spermatocyte to EM Field

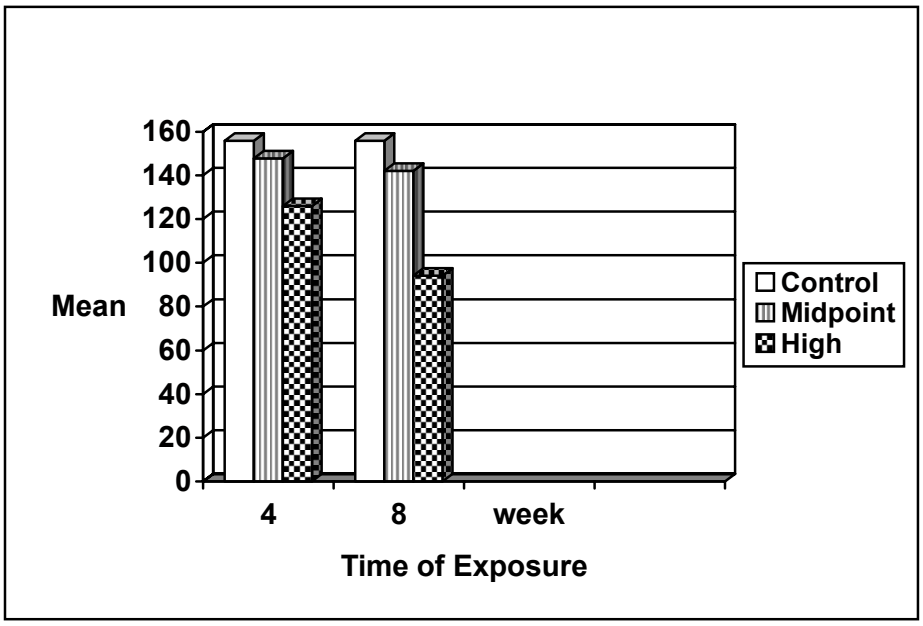


Figure 3. Mean of the Number of Spermatid to EM Field

Data analysis and the provided figures prove that the number spermatogonium, primer spermatocyte, and spermatid is obviously decreased ($p < 0.05$) toward both the increasing intensity and the length time of ELF electromagnetic field exposure by 500 kV high-voltage transmission line. The number of spermatogonium, primer spermatocyte, and spermatid on the white rats exposed under high intensity ELF electromagnetic field (1.162 – 2.148 kV/m; 1.669 – 1.717 μT) is obviously lower ($p < 0.05$) than one exposed under sufficient intensity (0.638 – 1.064 kV/m; 1.529 – 1.575 μT). Those also happen when it is compared to control (exposed on natural electromagnetic field with intensity 0.004 kV; 0.046 μT). With ($p < 0.05$), it is obvious that the number of spermatogonium, primer spermatocyte, and spermatid on the white rats exposed under ELF electromagnetic field by 500 kV high-voltage transmission line seems lower.

The ratio between the number of spermatogonium, primer spermatocyte, and spermatid, and the control explaining the development stages of spermatozoa indicates that there is no different ratio ($p< 0.05$) of spermatogonium, primer spermatocyte, and spermatid on white rats exposed under ELF electromagnetic field on a certain time and intensity. Therefore it is proved that white rats exposed under high intensity of ELF electromagnetic field exposure (1.162 – 2.148 kV/m; 1.669 – 1.717 μT) for 4 weeks shows that the ratio of spermatogonium is 0.7997, and ratio of primer spermatocyte becomes 0.7907 and later the spermatid has the ratio of 0.8085. For 8-week exposure, the ratio of spermatogonium is 0.5886, ratio of primer spermatocyte is 0.5133 and later the spermatid ratio is 0.6033. While the white rats exposed under midpoint intensity of ELF electromagnetic field (0.638 – 1.064 kV/m; 1.529 – 1.575 μT) for 4 weeks shows that the ratio of spermatogonium is 0.9024, primer spermatocyte is 0.8985 and spermatid ratio is 0.9489. For 8-week exposure, the ratio of spermatogonium is 0.8405, primer spermatocyte is 0.8001 and spermatid ratio is 0.9111.

The condition indicates the decreasing number of spermatogonium, primer spermatocyte, and spermatid that is assumed caused by the transformation of calsium homeostasis and the function of pineal hormone by ELF electromagnetic field exposure (Hatch M, 1992). The decreasing number of spermatogonium, primer spermatocyte, and spermatid shows the existence of spermatogenesis response on the white rats toward certain stressor like ELF electromagnetic field exposure by 500 kV high-voltage transmission line. It is clear that the stressor is adaptable, as described by previous clues that the changing ratio of the number of normal/abnormal spermatozoa on white rats exposed under ELF electromagnetic field exposure by 500 kV high-voltage transmission line for either 4 or 8 weeks is still on the limit required number (Tania & Sudarti, 2002). The outcome is relevant to the Selmaoui B's report (1997), in which the intense ELF magnetic field with intensity

less than 10 μT either continuously or intermittently exposed does not affect the vigor of reproduction system (Selmaoui B, 1997). However, the effect of longer period of exposure even on a very low intensity (< 10 μT) still needs further studies. For consideration, the report by Lahijani MS (2000) that 50Hz magnetic field exposure with intensity of 8.007-10.143 mT only for 24 hours exposure could irreversibly affect the development of chicken embryo.

CONCLUSIONS

The research outcome shows that the number of spermatogonium, primer spermatocyte, and spermatid is positively decreased toward either the increasing intensity or the longer time of exposure of ELF electromagnetic field by 500 kV high-voltage transmission line, but the ratio is still on the limit required number.

SUGGESTIONS

The above analysis and conclusion generate some suggestions as follows:

a. The further analysis on the moleculer influence of ELF electromagnetic field exposure by 500 kV high-voltage transmission line is still needed to get valid conclusion.

b. The study on the biological effect of ELF electromagnetic field exposure by 500 kV high-voltage transmission line for a longer period (> 8 week) should be conducted.

c. Considering the increasing exposure of magnetic field in environment due to the rapid growth of technology, the study on the influence of ELF electromagnetic field exposure around high-energy equipments in the work place is highly required.

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