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Original Research Article

MONITORING OF VARIATIONS IN SOME HEMATOLOGICAL PARAMETERS AND LIVER ENZYMES AS A RESULT OF EXPOSURE TO 50-HZ ELECTRIC FIELDS

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Abstract: Monitoring of relative variations in some hematological parameters and liver enzymes for albino rats due to 50Hz-4kV/m electric field exposures at different exposure periods is studied. Six groups of animals are used; group A considered as sham group that housed at normal environmental conditions and didn't receive any treatments. The other five groups B, C, D, E and F exposed to electric fields for different exposure periods 5, 10, 15, 20, 30 days respectively. Blood samples are collected immediately after sacrificing from each animal and complete blood count CBC and liver enzymes are examined. The results of RBCs evaluations of exposed groups indicated slight decrease but highly correlated to exposure time. Whereas, the data of WBCs evaluations showed insignificant and uncorrelated variations compared to unexposed group A. The liver enzymes (SGOT, SGPT) data figured increasing and highly correlation to exposure times compared to group A. In conclusion, exposure to ELF EMF is ambiguous and has subtle hazardous effect and the need of future works to elucidate any health consequences may be attributed to the exposure of such fields.

Key words: Electric field, RBCs, hematology, CBC, Liver

Introduction: Until recently, the natural electromagnetic background was relatively constant, but the situation changed markedly and precipitously with the development of modern communications and electrical power systems. The environment is now heavily laden with man-made electromagnetic fields (EMFs) from radio; TV, microwave relay, and many similar sources. Static magnetic fields (SMFs) are time-independent fields of constant strength. Extremely Low Frequency electromagnetic Fields (ELF-EMF) are electromagnetic oscillating fields defined as having frequencies

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below 300 Hz. ELF-EMFs are very important from a public health standpoint because of the wide spread use of electrical power at 50 or 60 Hz in most countries. Electric and magnetic fields exist around electrical equipment and wiring throughout industry. Residential peoples and occupational workers who maintain transmission and distribution lines may be exposed to very high electric and magnetic fields [1]. Purushothaman G., *et al* 2013 carried out an investigation was by exposing the adult male albino rats to the magnetic field of 202μT against the control group and both were analyzed for hematological and biochemical changes. The results showed that the magnetic field (MF) exposed animals showed significant increase in RBCs, WBCs, Hbs and platelet count as well as decrease in Red blood cell indices values of MCV, MCH and MCHC. In addition, the MF exposed group also showed significant increase of AST and ALT levels in plasma indicating the involvement of MF on liver cell membranes. The haematological parameters and liver enzymes were affected by the electromagnetic field exposure suggesting the possible induction of hazardous biological effects during the exposure to magnetic field [2].

On the same regards, the effects of 120 days of high-intensity (80-kV/m) 60-Hz electric field exposure on hematologic constituents were investigated [3]. The results indicated that the total white cell count, lymphocyte count, and eosinophil count were significantly lower in field-exposed subjects; however, none of the red cell evaluation parameters differed significantly. Moreover, the observed hematologic variations related to the exposure of a high-intensity electric field are consistent with those observed in animals responding to a mild stressor. DilekUlker., *et al* 2009 indicated that the applied ELF-EMF exposure may induce slight but statistically significant alterations in some hematological parameters of rats, within the physiological range. There was no significant difference in total leukocyte, neutrofil, lymphocyte, monocyte, eosinophil and basophil counts, or in erythrocyte, Hct, MCH, MCHC, RDW, PLT and PDW levels between the exposed and sham-exposed groups [4]. Touitou Y., *et al* 2013 studied male electrical workers chronically exposed to 50-Hz magnetic fields for a period of 1–20 years by examining the nocturnal profiles of their blood counts. The data was quite small; only 15 workers and the same number of controls. The exposure levels were also rather low. According to the writers, the results suggest that magnetic fields have no cumulative effects on the haematological or immune system functions [5]. Magdi Y El-Ashry *et al* 2008, conducted a study to evaluate the influence of 50 Hz magnetic field on some liver enzymes tests; alanine aminolransferase (ALT), aspartate aminolransferase (AST), alkaline phosphatase (ALP), serum bilirubin, serum albumin and serum protein. The study was conducted on Sparague-Dawely male rats of an average weight of 140-160 gm. The exposure period was 7 days (2 h/day). The results showed an increase ($p<0.05$) in all investigated liver enzymes [6].

Cabrales LB *et al*. 2001, studied some hematological and biochemical parameters of peripheral blood, as well as some histological aspects of liver and spleen during chronic exposure (1, 6, and 8 months) to ELF-MF. The results have shown no ELF-MF–cancer relationship during experimental exposure time. However, leukopenia, hemoglobin decrease, and liver and spleen weight increase were remarked. The spleen hyperfunction may be correlated to the observed variations, which could have been produced by chronic exposure to this ELF-MF.

The effects of 50-Hz magnetic field exposure on rat's spleen is studied by A. M. Khalil *et al*, 2015. Seven main groups, namely A, B, C, D, E, F, and G are used. Group A is unexposed group didn't receive any treatment and housed at normal environmental conditions. Groups B, C, D and E are continuously exposed to magnetic fields of (0.1, 0.2, 0.3 and 0.4 mT-50Hz) respectively for a period of 10 days. Group F

and G animals are discretely exposed to magnetic field of (0.3 and 0.4 mT-50 Hz) for 30 consecutive days (8h/day). All animals are sacrificed after exposure periods and immediately spleen samples are collected and dielectric measurements are carried out. The dielectric relaxation, relative permittivity and dielectric loss are measured for all spleen samples at frequencies up to 5 MHz. Results indicated obvious abnormality in the exposed samples as compared to the unexposed group A. It was concluded that further investigations are necessary, performed in cooperation with medical researchers, concerning regular medical examination of individuals exposed to such fields. Consequently, it becomes mandatory to revise dose limits recommended by the different commissions for exposure to such extremely low frequency magnetic fields [8]. Nihal S. El-Bialy, *et al*; 2012; aimed a study to evaluate the possible effects of in vivo exposure to extremely low frequency magnetic fields (ELF-MF) on some hematological parameters, pathological variations and DNA structure in newborn rats. Six female pregnant Wistar rats were obtained from the National Research center in Egypt and gave birth to 30 rats at the animal house of Cairo University. The newborn rats were divided into two separate groups: one exposed group (50 Hz, 0.5 mT, 30 days, 24 h/day) and one control (sham). Red blood cells (RBCs), hemoglobin and hematocrit levels decreased significantly ($P< 0.02$) while white blood cells (WBCs) and platelet levels significantly increased ($P< 0.04$) in newborn rats that were exposed to ELF-MF. There was no significant difference in mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV) levels and DNA structure between the exposed and sham-exposed groups. ELF-MF induced a marked necro-degenerative change in kidney tissue and peri-portal fibrosis in liver tissues. However, the results indicated that the applied ELF-MF exposure may induce statistically significant alterations in some hematological parameters, kidney and liver tissues of newborn rats [9]. In spite of all these studies that have been carried out over the past years there is still no persuasive evidence that the fields pose any risks on all biophysical parameters at low doses. Moreover, the limited researches on the effect of ELF MF on the biophysical parameters that can affect hematological parameters in rat's blood; made some international organizations such as the (WHO), (ICNIRP) and (IARC) recommended to do more researches in all areas of exposure to the magnetic fields to measure it's risk degree on health [10-14].

Still effects of exposure to ELF EMF are ambiguous and the question whether such fields may cause health consequences has no answer. The present work is aimed to evaluate different hematological parameters and liver enzymes of albino rats exposed to ELF electric field of strength 4kV/m at different exposure periods.

Materials & Methods: In the present work 50 male albino rats, each of average weight 200± 10 gm. divided into five main groups, namely group A, B, C, D, E and group F. Animals of group A (15 animals) are used as unexposed group and didn't receive any treatment and housed at normal environmental conditions (the temperature inside the lab varied between 240 and 270 C, lighting condition are natural light from large windows during the day and complete darkness during the night). Animals of groups B,C,D,E and F were exposed 8 h/day to an electric field of 4 kV/m-50 Hz for periods of 5, 10, 15, 20 and 30 days respectively. At the end of the exposure period the animals were immediately sacrificed and whole blood samples from each animal was collected for experimental investigation.

The exposure mean is carried out by using cage of Perspex chamber, with an exposure volume of dimension 100x30x35 cm^3 located between two parallel aluminum plates, which extended vertically along two parallel sides of the exposure cage. In order to prevent any animal shock from direct contacts with the electrodes,

the aluminum plates were covered by front fixed Perspex plates of similar measure. It is worthy to mention that, the Perspex material has a negligible effect on the field homogeneity [13]. The two Al electrodes were connected to a step up transformer with an output voltage of 4kV/m and 50Hz when connected to the main supply. For more precautions an electric timer was used to adjust the exposure times specially when mains fall. The electric inside the chamber was measured through the use of field meter and was found to be homogeneous and reads 4kV/m.

The rats were slaughtered after the exposure periods, and leukocyte formulae (Leucocytic count WBC, Staff (Presegmented) St, Segmmented S, Lymphocytes L, Monocytes (Phagocytes) M, Eosinophilis E and Basophilis B), erythrocyte indexes (Red blood cell RBC, Hemoglobin Hb, Hematocrit PCV, Mean corpuscular volume MCV, Mean corpuscular Hemoglobin MCH, and Mean corpuscular Hemoglobin Conc. MCHC), and liver enzymes (SGOT, SGPT) were determined in whole blood samples. These analysis were carried out with an Abbott Cell-DYN 3700 M.A.P.S.S. Laser Differential machine by impedance (coulter) and ‘‘optic laser scatter’’ methods. Statistical analysis was performed with SPSS 8.0 package (SPSS Inc., Chicago, IL). The analysis of differences between exposed groups and sham groups for each variable on given days was performed using independent sample *t* test.

Results & Discussion: Blood is the only tissue that flows throughout your body. This red liquid carries oxygen and nutrients to all parts of the body and waste products back to your lungs, kidneys and liver for disposal. It is also an essential part of your immune system, crucial to fluid and temperature balance, a hydraulic fluid for certain functions and a highway for hormonal messages. Full blood analysis (complete blood count CBC) was carried out for blood samples collected from all groups. The analysis includes RBCs evaluation (RBC, Hb, PCV, MCV, MCH, and MCHC) and WBCs evaluations (WBC, St, S, L, M, E and B). In addition to the CBC, the liver enzymes SGPT and SGOT are examined for all collected blood samples from all groups. Then after the mean values and its standard deviation were calculated for all hematologic parameters and listed on Tables 1, 2, and 3. The correlation factor equations dependent on exposure times in hours for each hematological parameter of each group were calculated and tabulated in table-4. All hematologic parameters obtained from unexposed group animals were well within normal physiological range. It is worthy to mention here that the data obtained from groups B and C compared to group A; depicted unclear sequencing changes and not like the obtained changes from the other exposed groups. The results of RBCs evaluations (Hb, PCV, RBCs, MCV and MCH parameters) for groups D, E, and F indicated slight decrease but highly correlated to exposure time as compared to group A. On contrary, the results of groups D, E, and F elucidated uncorrelated increase of MCHC as compared to group A. On the other hand, the data of white blood cells evaluations (WBCs, S, St, L, M, and E parameters) showed insignificant and uncorrelated variations compared to unexposed group A. Figure-1 and Figure-2 represents a histogram of the hematological parameters of all groups. The liver enzymes (SGOT, SGPT) data figured increasing and highly correlation to exposure times in comparison to group A. Figure-3 shows the variations of liver enzymes as a function of exposure time in hours for all groups. The figure depicts steep increase in liver enzymes for groups B and C, and meager increase for groups D, E and F relative to exposure periods.

Table-1: represents list of data for RBC, Hb, PCV MCV, MCH, and MCHC of blood samples collected from all groups.

Parameters Group	Hb	PCV	RBC	MCV	MCH	MCHC
Group A	11.1 ± 0.07	34.27 ± 0.44	3.94 ± 0.11	86.2 ± 0.98	28.2 ± 0.32	33.23 ± 0.12
Group B	9.28 ± 0.62	30.67 ± 1.21	3.36 ± 0.53	91.0 ± 1.45	27.5 ± 1.33	30.49 ± 0.95
Group C	9.86 ± 0.63	29.57 ± 1.32	3.51 ± 0.45	83.9 ± 1.36	28.1 ± 1.04	33.52 ± 1.04
Group D	11.1 ± 0.15	33.57 ± 0.56	3.98 ± 0.12	84.3 ± 1.04	27.8 ± 0.41	33.21 ± 0.16
Group E	10.7 ± 0.11	31.29 ± 0.72	3.81 ± 0.08	82.0 ± 1.21	28.0 ± 0.36	34.35 ± 0.19
Group F	10.1 ± 0.16	30.43 ± 0.61	3.68 ± 0.10	82.3 ± 0.99	27.6 ± 0.28	33.64 ± 0.17

Table-2: represents list of data for WBC, S, St, L, M, E and B of blood samples collected from all groups.

Parameters Group	WBC/1000	S	St	L	M	E	B
Group A	7.467 ± 0.119	57.33 ± 0.85	4.07 ± 0.14	33.33 ± 0.76	4.00 ± 0.08	1.26 ± 0.06	0.000
Group B	7.833 ± 0.214	60.67 ± 1.78	4.83 ± 0.91	30.78 ± 1.75	4.00 ± 0.17	1.44 ± 0.28	0.000
Group C	7.086 ± 0.179	57.86 ± 1.94	7.71 ± 1.12	28.67 ± 1.43	5.33 ± 0.21	1.33 ± 0.65	0.000
Group D	3.757 ± 0.110	58.29 ± 1.07	4.86 ± 0.32	31.86 ± 0.91	3.57 ± 0.11	1.43 ± 0.21	0.000
Group E	6.114 ± 0.147	54.00 ± 1.33	5.71 ± 0.41	33.86 ± 1.06	4.57 ± 0.18	1.86 ± 0.22	0.000
Group F	5.843 ± 0.182	57.57 ± 1.77	6.43 ± 0.15	30.14 ± 0.98	4.28 ± 0.09	1.57 ± 0.16	0.000

Table-3: represents list of data for liver enzymes SGOT and SGPT of blood samples collected from all groups.

Parameters Group	SGOT	SGPT
Group A	**59.56 ± 7.33**	**42.0 ± 8.53**
Group B	**100.3 ± 10.5**	**67.5 ± 15.7**
Group C	**124.0 ± 11.8**	**191 ± 24.3**
Group D	**127.3 ± 8.91**	**138 ± 13.2**
Group E	**147.3 ± 12.5**	**217 ± 17.1**
Group F	**103.0 ± 9.87**	**163 ± 10.4**

Table-4: represents a correlation equations list of hematological parameters as a function of exposure time in hours for all groups and its correlation factors.

Correlation equation of each hematological parameter dependent on exposure time in hours	**Correlation factor**
Hb= -0.0041 x Exposure Time (hours) + 11.285	$R^2 = 0.8009$
PCV= -1.38 x Exposure Time (hours) + 35.84	$R^2 = 0.9543$
RBC= -0.0011 x Exposure Time (hours) + 3.9905	$R^2 = 0.6474$
MCV = -0.0176 x Exposure Time (hours) + 85.99	$R^2 = 0.8381$
MCH= -0.0025 x Exposure Time (hours) + 28.224	$R^2 = 0.7531$
MCHC = 0.0026 x Exposure Time (hours) + 33.262	$R^2 = 0.2447$
WBC = -6.0698 x Exposure Time (hours) + 6584.3	$R^2 = 0.1567$
S= -0.0028 x Exposure Time (hours) + 57.159	$R^2 = 0.0212$
St = 0.01 x Exposure Time (hours) + 3.9609	$R^2 = 0.9584$
L = -0.0107 x Exposure Time (hours) + 33.686	$R^2 = 0.4104$
M = 0.0018 x Exposure Time (hours) + 3.8781	$R^2 = 0.1706$
E= 0.0017 x Exposure Time (hours) + 1.3159	$R^2 = 0.4357$
SGOT = -0.0038Exposure Time (hours)^2+1.0969Exposure Time (hours)+60.051	$R^2 = 0.9599$
SGPT= -0.0055 Exposure Time (hours)^2+1.8974 Exposure Time (hours)+31.625	$R^2 = 0.7797$

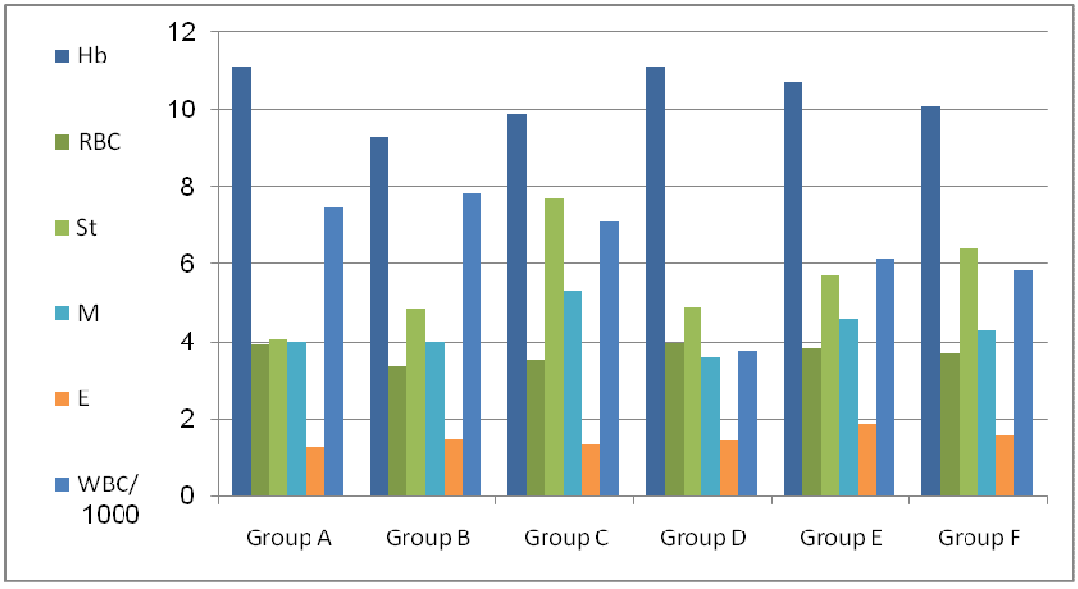

Figure-1: shows a histogram of hematological parameters (HB, RBC, St, M, E, and WBC) for each group.

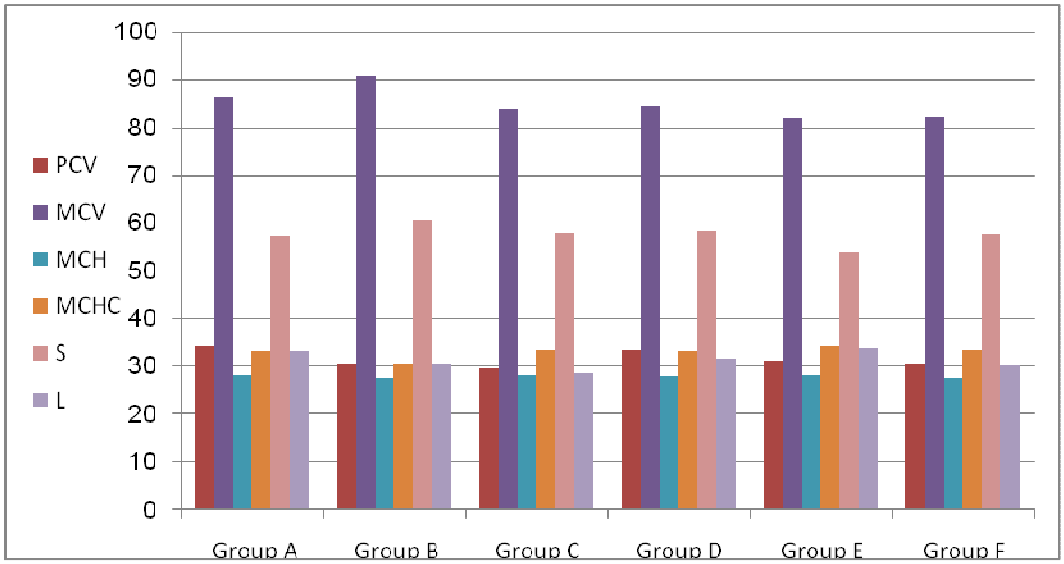

Figure-2: Shows a histogram of hematological parameters (PCV, MCV, MCH, MCHC, S and L) for each group.

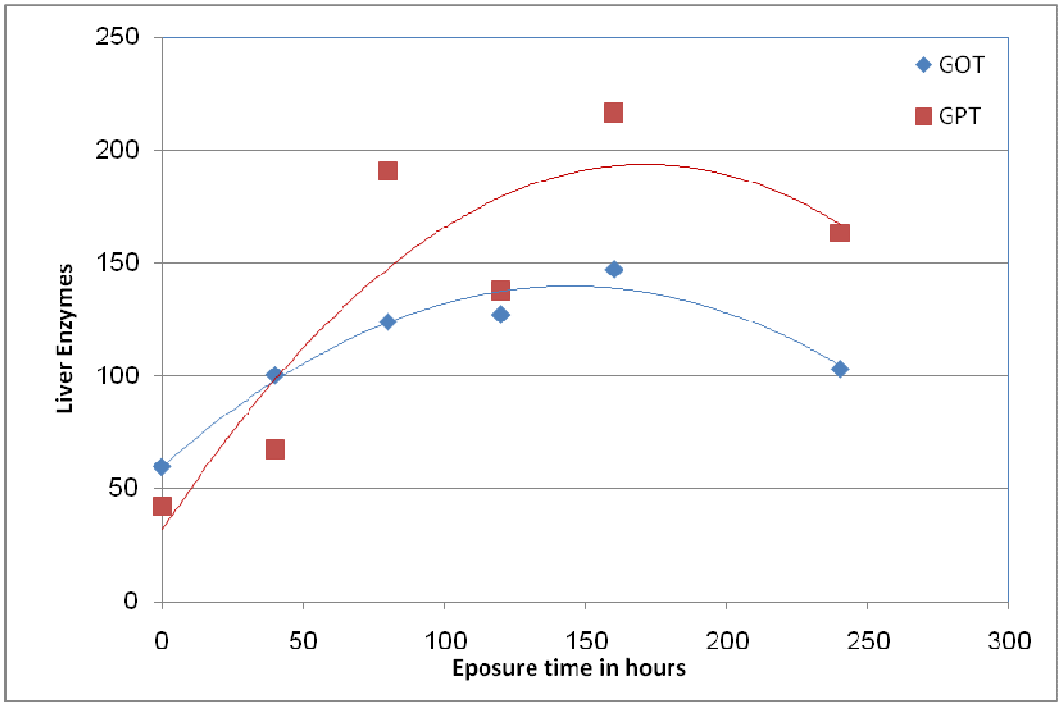

Figure-3: shows the variations of liver enzymes as a function of exposure time in hours for all groups.

Conclusion: The results indicated that the effects of ELF EMF exposure are still ambiguous and have subtle hazardous effect. The nonlinear exposure response and contradictory of the literature data are highlighting the need of further work to ascertain health consequences to the exposure of such fields.

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