The Device For Studying The Electromagnetic Effects On The Vital Cells I

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Abstract— The exposure to electromagnetic fields EMF has become an active area of biophysics research. Modern lifestyle exposes nearly all humans to EMF, particularly to man-made visible light. Prolonged exposure to EMF induces persist changes in weight and neuronal activity. However, the modulation of synaptic efficiency by EMFs in vivo is still unclear. The study focuses upon design, evaluation and investigation of a Linear Source Lamp (LSL) device. The LSL visible light irradiation issued for the bio-electromagnetic effects. The living organism, particularly in humans, can be affected adversely by highly coherent EMF. Twenty-seven mice were divided into 3 groups in addition to the sham and control group. The three groups were exposed to the visible field for different durations (5, 10, 15days). Every day they were exposed for 8 hours as a daily dosage. The exposure doses were produced by LSL neon lamps. The sham and control group was placed in an identical chamber with no electromagnetic field. After the exposure period, mice were weighted daily. The exposure area on the bottom of cage was measured, evaluated and treated by the software SURFAR7 to determine the optimum area of irradiation as well as the intensity of the EMFs. On the basis of a detailed analysis of the present situation and experimental conditions, the number of recommended doses was chosen to prompt higher degree of electromagnetic bio-compatibility between these fields and the living human organism. This new scientific findings can be used to update human standard doses. Certain studies, because of their strength of evidence or because of the severity of the health out come under study, may be more likely to prompt a reevaluation of the science informing standards than others. Changes to standards or policies should be made after a proper assessment of the science case as a whole to ensure that the conclusion of the research in a given area is consistent.

Index Terms— Visible Field Exposure System - change of weight - Mice - Electromagnetic field-data standards .

1 INTRODUCTION

The strength of electromagnetic field (EMF) to which humans are exposed has been increasing gradually. This increase was a result of the growth of electric power generation and transmission, the development of new devices and the advances in medical and industrial applications. Although the health effects of EMF on humans have been of research interest for several decades, development of standards that incorporate the limits of human exposure to non ionizing radiation (NIR) has occurred more recently for some parts of the electromagnetic frequency spectrum(1).The effects of electromagnetic radiation (EMR) on biological systems are a hot topic today (2). As the number of EM artificial sources is more and more increasing, we are in a consequent need for safety standard and risk assessment. The understanding of the fundamental mechanisms and sites of interaction between fields and systems is complex. It still deserves strong investigation efforts. Research efforts are mainly addressed to the basic principles of coupling between electromagnetic energy and molecular biological structures. The study of the interaction between electromagnetic energy and living organisms involves aspects of both physical and biological science that is less than perfectly understood. A mix of studies in different research areas is essential for the evaluation of the potential adverse health effects of electromagnetic fields.

Many of the reported biological effects of non-ionizing electromagnetic fields occur at levels too low to cause significant heating i.e. they are non-thermal effects. Most of them can be accounted for by electrical effects on living cells and tissues and their membranes. The alternating field generates visible fields that flow to the cell and tissues. They remove structurally important calcium ions from cell membranes, which then causes the membranes to leak (3,4). This is the normal mechanism by which cells sense mechanical membrane damage. If the damage is not too severe or prolonged, a stimulation of growth seems beneficial. On the other hand, if the exposure is prolonged, these mechanisms overcome any stimulation and the result is ultimately harmful (5,6).

Electromagnetic radiation is capable of propagating through space at a speed of $9x10^9$ Km/sec. That is why its effects extend at vast distances. There has recently been an increasing interest in biological effects, associated with exposure to EMF (7,8). Although numerous papers have been published (9-11), their work has only considered EMF exposure in the visible energy range. Commercial packages such as Groningen Molecular Simulation (GROMOS) and Molecular Orbital Package (MOPAC) are customized so that the bio-electromagnetic interaction can be studied (12-14).In the area of biological effects and medical applications of non-ionizing radiation, approximately 25,000 articles have been published over the past 30 years. Despite the feeling of some people that

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more research needs to be done, scientific knowledge in this area is now very extensive. Based on a recent in-depth review of the scientific literature (I think you need to reference the study here), the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic field radiation. Some gaps in knowledge about biological effects exist and need further research. As new scientific information becomes available, standards should be updated. A standard is a general term incorporating both regulations and guideline. It can be defined as a set of specifications or rules to promote the safety of an individual or a group of people. The ultimate goal of health-based EMF standards is to protect human health. Standards can specify either the limits of emission from a device or the limits of human exposure from all devices that emit EMF into a living or working environment. These limits can be developed for the general public or for specific populations such as workers, medical patients, military personnel, children, and the elderly. Many forms of EMF find applications in medical practice, often at exposure levels that are much greater than the general population dosage. Certain studies, because of their strength of evidence or because of the severity of health out come under study, may be more likely to prompt a reevaluation of the science informing standards than others. Changes to standards or policies should only be made after a proper assessment of the scientific case as a whole to ensure that the conclusions of the research in given area are consistent.

2 Materials and Methods

2.1 Analytical Approach

The analytical approach is a mixture of empirical data and physical models, which leads to laws that predict undiscovered phenomena. The physicist, unlike the biologist, approaches nature using constructs that only exist in simple geometric model with perfect conductivity, e.g. in an attempt to reduce the number of variables and establish functional relationships. This method has not yet been applied to bio-electromagnetic phenomena and hence there is no physical explanation of the EMF effects on biological systems (14). The field distribution inside the cage and on the surface of animals was calculated numerically using the Finite Difference Method (FDM) (15). It was measured experimentally along the bottom line of the cage using a small electromagnetic probe meter. Agreement between the calculation and the measurement was reasonable, which shows the usefulness and practically of the exposure system in many applications. The maximum area of equal irradiation energy was calculated using the software SURVER'7(16). The reason is to visualize an actual or theoretical surface, and to see patterns or final anomalies. It was also used to interpolate values in between points sampled on a surface to estimate the equal intensity area for those specific points.

2.2 Technically Approach

I: Designing Requirements For designing an electromagnetic field exposure system, there are certain requirements:

1) The electromagnetic field that irradiates the cage should be uniform and homogenous in space. It should also be constant during the exposure time, which sometimes could last for several hours daily (8 hours/day).
2) The irradiation system should be able to generate different intensities.
3) The system should have isothermal control (constant temperature) during the exposure time.
4) The shape and volume (i.e. X, Y, Z dimensions)of the cage should not be stressful for the experimental animals. The area of irradiation should be sufficient for a number of experimental animals. This optimizes our statistical analysis and the accuracy of the data.
5) The control of environmental factors such as water, food supply, temperature and animal behavior should be ideal.

It is possible to satisfy requirements by using apolymers cage. The EMF radiation comes down from the source of light (group of line lamps with controller) on the cage. Therefore, the plane electromagnetic wave radiation is not changed or deformed with time or space during the exposure time using time controller. The propagation of electromagnetic wave system has taken a form shown in figure 1.

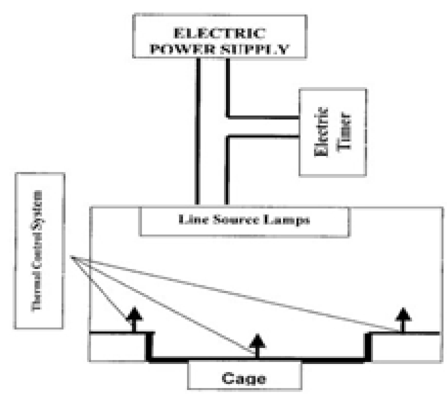

Fig. 1: Arrangement for application of electromagnetic field

The figure shows electromagnetic radiation system components. 1-Linear source Lamps (LSL) was designed as square plate with a reflected mirror. Eight Neon Lamps were fixed on the mirror with electric controller that determines the number of lamps. 2- Some mirrors are to increase the intensity of irradiation field. 3- Thermal control is used to keep the temperature in the cage and path of radiation constant during the exposure time. 4- Holder is used to change the perpendicular distance between the light sources and the cage in the bottom.

II: Instruments requirements To study the effects of man-made light radiations on the biological cells, we need the following instruments.

1- Linear Source Lamps (LSL) was designed as square plate with reflected mirror. Eight lamps were fixed on it with switch to irradiate electromagnetic rays from different number of lamps. We used Neon lamps 60 cm in length with far distance 5 cm and with diameter 3.3 cm. The intensity of electromagnetic field was measured using photometer, with different number of lamps (N) and at different perpendicular distances between the bottom cage surface and the plane of the lamps (D).

2- Thermal control system consists of three thermometers, which were used to determine the temperature of three different places on the bottom surface of cage due to the irradiation of electromagnetic radiation from the operating lamps only. The optimum condition was determined to be a constant temperature due to the electromagnetic ray which is 1-2^{o} C higher than the room temperature.
3- Electric timer control system was used to irradiate the electromagnetic rays for only eight hours a day. It was also used to control the environmental factors such as temperature and animal behavior.
4- Photometer instrument was used for measuring the intensity of electromagnetic radiation incident from the (LSL) on the bottom surface of the cage. The cage was divided into small areas 5×5 cm^2. The intensities of the radiation were measured at each of these areas. The optimum condition was used as the maximum equal-intensity area. This area was set to be larger than the area of the cage. This gave equal electromagnetic radiation intensity on all the mice in cage**.**
5- Mice cages were prepared from a polymer material, which is not dielectric material. The cage (39 × 20.5 × 12 cm) was used as optimum condition. It constituted the optimum area for irradiation of about 30 mice.

III : **The experimental animal** The experimental animal groups are four animal's cluster with different exposure durations.

1- First group (G1) was irradiated for 5 days and8 hours daily with perpendicular distance 60 cm between the irradiation lamps and cage's bottom.
2- Second group (G2) was irradiated for 10 days and 8 hours daily with the same intensity.
3- The 3^{ed} group (G3) was irradiated for 15 days and 8 hours daily with the same intensity. .
4- The control group (GC)was not subject to any electromagnetic radiation from the system. It was placed in an identical chamber with no electromagnetic field.

IV: Experimental measurements

The physical optimum experimental condition was chosen to form the standard instrument. To confirm the results of calculations on the system of radiation, measurements were made on the system. In the measurements, variable photo inductance type of probe field meter was used (Photometer model: Pasco Scientific) to measure the EMF intensities at different points in the bottom of the cage. Since the field intensity is distributed on the bottom surface of the cage, the temperature distribution with perpendicular distance between LSL and bottom of the cage was measured. The temperature at different locations was measured and used to control the isothermal process. The weight of experimental animals was measured every day and after every exposure period for each group of animals (four groups). The change of the weight was calculated and recorded as an estimate of the rate of growth.

3.Results and discussion

The relation between the temperature (T) at the bottom surface of the cage (i.e. temperature of the biological samples) and the perpendicular distance (D) far from LSL were measured. The difference in temperature (ΔT) from the room is illustrated in table 1.It was found that the temperature difference decreased with increasing the distance. Its value was lessthan one degree higher than the room temperature at distance great than 0.4 m. This is due to the thermal control on the instrument which had a strong influence at far distance greater than 0.4 m. Therefore, the optimum condition of far distance between the (LSL) and the bottom of animal cage must be larger than 0.4 m, perpendicular from the bottom of the cage.

TABLE 1
THE TABLE SHOWS TEMPERATURE DIFFERENCE ΔT (^{O}C) AT THE BOTTOM OF THE CAGE AND WITH A PERPENDICULAR DISTANCE D(M) FROM THE (LSL) AT DIFFERENT NUMBER OF LAMPS.

Distance D in m	0.1	0.2	0.3	0.4	0.5	0.6
No of lamps N	ΔT	ΔT	ΔT	ΔT	ΔT	ΔT
1	3.1	2.1	1.5	0.8	0.3	0.2
2	3.3	2.2	1.5	0.8	0.3	0.2
3	3.4	2.3	1.6	0.8	0.3	0.2
4	3.5	2.4	1.6	0.8	0.3	0.2
5	3.7	2.6	1.7	0.9	0.3	0.2
6	3.9	2.7	1.7	0.9	0.3	0.2
7	4.1	2.8	1.8	0.9	0.3	0.2
8	4.4	3.0	1.8	0.9	0.3	0.2

The intensity of electromagnetic radiations was measured at the bottom of the cage at different locations to determine the optimum distance far from the source (D), as well as the suitable area for exposure (optimum area A) with suitable

TABLE 2

Table 2: The measured intensities on the center of each square at the bottom of the cage with different number of lamps (N=1-8) and at distance far from the irradiation(LSL) which equals D= 0.4 m

		1	2	3	4	5	6	7	8	9	10	11	12
Side	Lamps	The intensity in the center of square at the bottom of the cage											
A	1	25	40	4.5	6	6	65	6.5	6	55	5	4	2.5
	2	6	8.0	8.0	10	10	10	10	10	10	10	10	7.0
	3	10	13	13	15	15	16	16	18	18	18	16	12
	4	14	16	20	22	24	26	26	26	26	23	18	14
	5	14	16	21	22	25	26	25	25	25	21	20	18
	6	25	31	38	44	50	51	51	51	50	42	37	29
	7	43	43	47	49	49	53	50	50	50	50	48	48
	8	56	59	59	62	65	64	62	63	63	60	58	55
B	1	4	5	6	7	8	8	8.5	8	8	8	6	5
	2	10	10	12	13	14	14	15	15	15	13	12	10
	3	10	14	16	18	18	20	20	20	20	18	16	12
	4	20	22	24	28	30	30	30	32	32	30	28	25
	5	22	24	30	34	36	38	38	38	36	33	30	20
	6	26	30	38	44	52	53	53	53	52	48	39	28
	7	43	44	48	53	56	55	54	54	54	53	49	47
	8	57	60	63	66	66	66	67	67	67	64	60	55
C	1	55	7	8	95	105	105	10.5	10	95	8	8	6
	2	10	12	14	16	18	20	20	20	18	17	14	12
	3	18	20	24	30	31	32	32	32	30	26	24	17
	4	20	24	28	32	34	35	36	36	35	32	30	26
	5	26	28	33	38	40	42	42	42	42	38	32	22
	6	27	34	38	44	55	56	56	56	56	48	42	28
	7	45	49	50	54	58	66	66	66	62	58	53	47
	8	55	63	78	77	77	77	77	77	76	73	60	57
D	1	6	7	8.5	10	11	11	11.5	11.5	11	10	8	6
	2	10	14	18	20	22	23	23	23	22	18	14	10
	3	18	18	26	30	32	34	34	34	33	30	26	20
	4	16	20	27	32	35	35	36	36	34	30	24	20
	5	24	30	32	40	42	45	46	45	44	40	30	22
	6	28	33	38	47	55	55	56	56	56	43	38	29
	7	48	49	56	66	66	66	66	65	60	53	49	46
	8	57	73	77	76	77	77	76	76	77	77	69	60
E	1	5	7	9	9.5	10	11	11	11.5	11.5	10	8	6
	2	10	14	18	20	22	23	23	22	22	20	16	12
	3	18	16	22	26	28	30	32	32	32	26	20	20
	4	13	17	21	26	30	32	32	32	30	26	20	14
	5	22	26	32	36	40	40	40	40	40	36	30	22
	6	25	30	38	45	55	55	56	56	56	42	36	29
	7	48	52	55	57	62	66	66	65	64	55	48	46
	8	60	63	73	74	76	76	77	76	77	73	65	59
F	1	54	58	8.2	9	9.5	10.5	11.5	11	10.5	9	7	5
	2	10	12	13	16	19	20	21	21	20	16	14	10
	3	14	16	22	26	28	30	32	32	32	26	20	12
	4	13	16	21	22	24	26	26	26	24	20	16	12
	5	20	20	24	30	32	36	40	38	38	32	26	18
	6	26	28	37	40	48	52	53	53	53	42	35	28
	7	43	44	50	53	61	66	66	65	60	53	49	48

number of lamps (N) from the LSL. The bottom of the cage was divided into squares with areas 5x5 cm^2. The intensity was measured in the center of each square. The values of measured intensities at perpendicular distance equal to 0.4 m and at different number of lamps (from 1 to eight lamps)are tabulated in table 2.

The intensities at each square area at the bottom of the cage were measured at different far distances (D) and with different numbers of lamps (N). They are illustrated in table 3. This gives the area of equal-intensity as function of the perpendicular distance (D) and the number of lamps (N).

The intensity distribution at different number of lamps (N) and with different perpendicular distance (D) was

TABLE 3
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This table illustrates the relation between the area of equal intensities and intensity at different distances (D) between (0.3 m to 0.6 m).

Number of LSL		1	2	3	4	5	6	7	8
Distance (m)									
0.3	Intensity	15.46	40.88	56.0	64.0	73.6	99.55	105.6	136.88
	Area	15.99	16.87	20.31	22.5	28.35	31.78	34.6	36.8
0.4	Intensity	11.5	23	35	36	46	56	66	77
	Area	22.5	30.0	32.5	40.0	45.0	55.0	57.5	72.0
0.5	Intensity	6.596	14.72	20.16	23.04	26.49	35.83	38.01	49.27
	Area	23.5	31.89	35.9	42.33	48.0	58.0	60.9	74.0
0.6	Intensity	4.865	10.22	14.22	16.0	18.39	24.88	29.33	34.22
	Area	28.9	50.9	60.4	86.4	109.5	136.5	140.0	140.0

treated using the software coded bySURFER7 (16, 20) which simulates the contour information at the equal intensity areas. The treated equal intensity zones are illustrated in figure 2 with different number of lamps (N) and at far distance equal to (D= 0.4 m.)

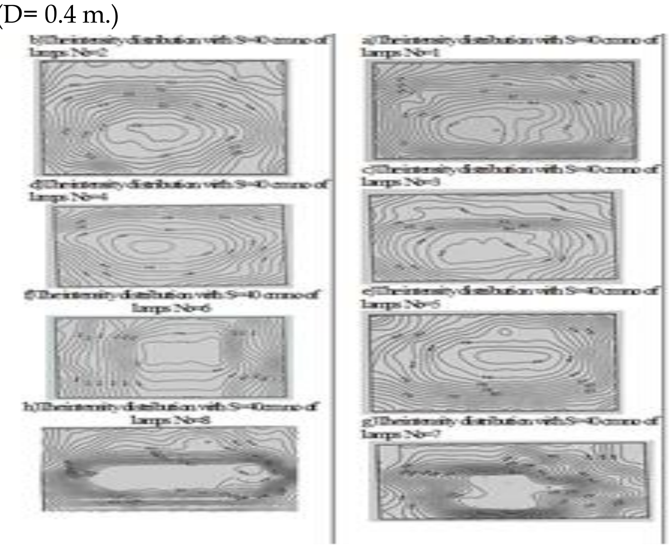

Fig 2: The contouring area of EMF irradiation on the bottom of the cage with different number of lamps (source of irradiation) and at far distance D=0.4 m

The areas of the equal intensity zones were computed using the software (theoretical value), and calculated from experimental data (experimental average) at far distance (D=0.4 m) and with different number of lamps. These area values are tabulated in table 4. The average area of equal-intensity was computed as a function of the number of lamps (number of sources) at far distance (D=0.4 m). It was found that the intensity increases with increasing the number of lamps at fixed far distance (D).

Table 4: The table illustrates the average experimental and theoretical intensity. It also illustrates the average theoretical value and maximum value of irradiation area value

Number of line source(N)	Experimental average intensity	Theoretical value intensity	Theoretical average value	Maximum value
1	8.43	7.118	9.29	11.5
2	16.25	14.0	18.75	23
3	24.85	21.2916	28.83	35
4	26.38	22.9895	30.75	36
5	33.36	28.1979	37.08	46
6	43.51	42.3020	45.41	56
7	55.12	52.4479	59.08	66
8	67.88	64.3975	73.167	77

The change in weight of the experimental animals was measured in different groups according the irradiation time (days) in addition to the control group. The animals were divided into four groups. The first group is the control (GC: about 10 mice). The second group is five days duration (G5: about 9 mice). The third group is the ten days duration (G 10: about 9 mice). The forth group is the fifteen days duration (about 9 mice). All groups were irradiated to the LSL with different exposure periods (8 hours per day) except for the control group which stayed at a sufficient distance from the system of radiation. Table 5 shows the exposure time for each group

Table 5: This table illustrates the calculated exposure period for each group.

Animals group	Group symbol	Exposure days	Exposure hours	Exposure seconds
Control group	GC	0	0	0
Second group	G5	5	40	$1.44x10^5$
Thirs group	G10	10	80	$2.88x10^5$
Forth group	G15	15	120	$4.32x10^5$

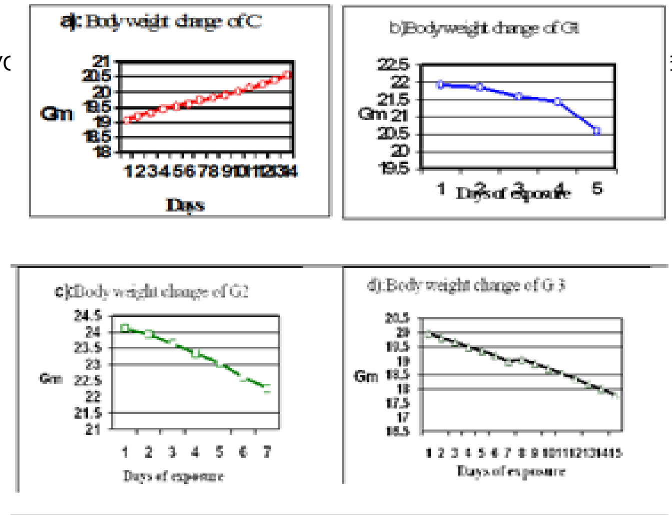

Figure 3: The figure shows body weight change of different Group figure a) is for control group Gc. Figure b) is for G5. Figure c) is for G10. Figure c) is for G15.

The body weight of experimental animals was calculated daily during the different exposure periods. The animals of different exposure groups showed loss appetite and accordingly a decrease in body weight than the control group. Therefore, the decrease in body weight increased with increasing the exposure time. The biological part of our experiment showed that the irradiated group lost both appetite and activity, and as a result their weight decreased. The change inweight is illustrated in the figure 3. In addition, the rate of decreasing weight due to the irradiation time is tabulated in table 6.

Table 6: The table shows the average change weight and the rate of changing.

Animal group	Average changing	Loss weight	Loss rate
Gc	+ 1.66/15	0	+
G5	0.5 - 1.3/5	1.8	3.9%
G10	1.1 - 1.85/7	2.95	3.68%
G15	1.65 - 2.4/15	4.05	3.5%

In general, the exposure to different doses for different durations(days& hours) decreased the body weight of all subgroups compared with control group. Non-significant increase in body weight recorded in all different groups.

4.Different types of studies needed

A mix of studies in different research areas is essential for the evaluation of a potential adverse health effect of electromagnetic fields. Different types of studies investigate distinct aspects of the problem. Laboratory studies on cells aim to elucidate the fundamental underlying mechanisms that link electromagnetic field exposure to biological effects. They try to identify mechanisms based on molecular or cellular changes that are brought about by the electromagnetic field. Such a change would provide clues to how a physical force converted into a biological action within the body. In these studies, single cells or tissues were removed from their normal living environment, which may inactivate possible compensation mechanisms (20-22).Another type of study, involving animals, is more closely related to real life situations. These studies provide evidence that is more directly relevant to establishing safe exposure levels in humans. They often employ several different field levels to investigate dose-response relationships

5.Conclusions

To simulate the natural conditions of exposure to electromagnetic field on living animals, the applied electromagnetic field needs to be as uniform in time and space as possible. In addition, the irradiation system has to satisfy the requirements of keeping the animals (biological system under study) in the condition of minimum stress and isothermal medium effects. Using the numerical calculation technique with finite difference method (FDM), we have designed field-exposure system for mice. The present system helps to study and describe some serious biological effects caused by one kind of man-made electromagnetic radiation. These effects include the reproductive capacity of mice. The present results imply the need of avoidance of human exposure to all kinds of EMFs. Changes to standards or policies should only be made after a proper assessment of the science findings as a whole to ensure that the conclusion of the research in a given area is consistent.

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7.REFERENCES

[1] Frank S. Barnes and Ben Greene Baum, "Biological and Medical Aspects of Electromagnetic Fields" 2007,CRC Taylor & Francis Group:290 – 293.
[2] Ghadi, O.,1990: " Biological effects and Medical Applications of Electromagnetic Energy" : Englwood Cliffs, Nf, P.9-13.
[3] Adey WR (1990): electromagnetic fields, cell membrane amplification, and cancer promotion" in Wilson BW, Stevens RG, Anderson LE (eds) Extremely low frequency electromagnetic fields: the Question of cancer. Batteller Press, Columbus, Ohio, pp311-249.
[4] Alberts B, Johnson A, Lewis J, Raff m, Roberts K, Walter P(2002) Molecular Biology of the cell. (Grarland Science, New York).
[5] Arrieta MC, Bistritz L, Meddings JB(2006) ;" Alterations in intestinal permeability". Gut 55;1512-1520.
[6] Andeew Goldsworthy (2012); "The Biological Effects of Weak Electromagnetic fields: Problems and solutions" reports and Lectures from Imperial College London.
[7] Peter Stavroulakis (2003),"Biological Effects of ElectromagneticFields":Springer-Verlan Berlin Heidelberg.
[8] Allen, S. G.; Blackwell, R. P.; Chadwick, P. J.; Driscoll, C. M.; Pearson, H.; Unsworth, A. J. and Whillock, C. (1994): Review of occupational exposure to optical radiation and electrical and magnetic fields with regard to the proposed CEC Physical Agents Directive, Chilton, NRPB-R265, HMSO, London.2
[9] Archer, C. W. and Ratcliffe, N. A. (1983): The effects of pulsed magnetic fields on chick embryo cartilaginous skeletal rudiments *in vitro*. J. Exp. Zool., 225: 243-256.
[10] Atef, M. M.; Elhaset, M. S. A.; Elkareem, A.; Aida, S. and Fadel, M. S. (1995): Effects of a static magnetic field on haemoglobin structure and function. Int. J. Biol. Macromol., 17: 105-111.
[11] Ahmadi H, Mohseni S, Shayegani Akmal AA.(2010). Electromagnetic fields near transmission lines – problems and solutions. Iran J Environ Health Sci Eng. ;7(2):181–188.
[12] Riey ,K.F (1974) "Mathematical Methods for the Physical Science " Cambridge university press p.272
[13] De-Raedt H. , Kole J.S. , Michielsen K.F.L. and Figge M.T. (2002)" Numerical Methods for solving the Time-Dependent Maxwell's Equations" Invited Talk presented at the international Computational Accelerator Physics conference. www.compphys. Org.
[14] Taflove A. and Hagness S.C. (2002)" computational Electrodynamics -The Finite Difference Time Domain Method," Artech House, Boston.
[15] Findlay R.P. and Dimbylow P. (2006), J.Phys. Biol. 51,2339.
[16] Davis,(1986):"statistics and Data Analysis in Geology, Wiley p353-383.
[17] El-Bardie, Kh. B. (2000): Assessment of electromagnetic flux effects on the embryonic Development of mice. MSc. Thesis , Fac. Sci. Tanta Univ. Egypt.
[18] Abou-Zaid, F. A.; Omar, Kh. M.; Salem, S. I.; Alm-Eldeen, A. A. and Bekhite, M. M. (2006):Can man-made visible light radiation affect the reproductive capacity of male mice, Egypt. J. Exp. Biol., 2:81-89.
[19] Abou-Zaid, F. A.; Sauer, H.; El-Shourbagy, I. K.; Omar, Kh. M. and Bekhite, M. M.(2005):Differentiation of Embryonic Stem Cells towards the chondrogenic and osteogenic lineage can be enhanced by magnetic field. Egypt. J. Exp. Biol., 1:187-194.
[20] Adey, W. R. (1981): Tissue interactions with non-ionizing electromagnetic fields. Physiol. Rev., 61:435.
[21] Amat, A.; Rigau, J. ; Waynant, R. W. ; Hev, I.K. and Anders, J. J. (2006): The electric field induced by light can explain cellular responses to electromagnetic energy: A hypothesis of mechanism. J. Photochem. Photobiol., 82 (B): 152 – 160.
[22] Krajewski, S. A. and Gibbs B. l. (1994) 'computer contouring Generates Artifacts, Geotimes. April, p15