



Effect Of Electromagnetic Radiation On Vital Organs In Rats

Samta Sharma, Anjali sharma and Sangeeta Shukla

Reproductive Biology and Toxicology Laboratory, UNESCO Satellite center of Trace Element Research & School of Studies in Zoology, Jiwaji University, Gwalior (M.P.) India

ARTICLE INFO

Received 01 Dec 2016
Revised 01 March 2017
Accepted 24 March 2017
Available online 3 April 2017

Keywords: Antioxidant enzymes, biochemical parameters, Electromagnetic radiations oxidative stress, rat, toxicity

Email: samta46@yahoo.co.in

ABSTRACT

The global and indispensable mobile communication systems are the incessant environmental source of electromagnetic radiation (EMR). In the present study we have investigated the affect of mobile phone radiation on various organs i.e. liver, kidney and brain. Rats were exposed to 900 MHz EMR produced by mobile radiation for 2h daily for 3 months. Results indicated that mobile phone radiation significantly increased the levels of lipid peroxidation and suppressed the activity of reduced glutathione, glutathione peroxidase, superoxide dismutase. A mixed trend was observed in the activity of catalase, while an increase was observed in the levels of serum transaminases, uric acid, urea, creatinine and bilirubin. A significant alteration in blood components of rats was observed. This study provides considerable damage in liver, kidney and brain tissue following electromagnetic radiations.

INTRODUCTION

Every technological development comes with some element of health concern, and cell phones are of no exception. The global system for mobile communications (GSM) standard operating in the 900 MHz frequency band is largely used, over the past decade. EMR are harmful to public health. In 2011, the World health organization, International Agency for Research on Cancer (IARC) has been identified electromagnetic from mobile phones and other wireless devices constitutes "a possible human carcinogen" 2B (IARC 2011). EMR may be absorbed by various body organs according to places the mobile are carried especially liver and kidney (Topali et al. 2015).

Electromagnetic radiations affect biochemical processes of all the vital organs via causing alterations in the cellular membrane potential that further disturb the regular distribution of ions and dipoles (Lerchl et al. 2008; Fatima et al 2016,). Furthermore, EMR may affect biological systems by increasing free per oxidation and by changing antioxidant activities thus lead to oxidative stress (Irmak et al. 2002; Ilhan et al. 2004; Nawal et al. 2016), the causative factor in every exposed associated organ dysfunction found to be similar. (Huber et al. 2002; Krause et al. 2007; Hao et al. 2015) neurotransmitter systems (Mausset-Bonnefont et al., 2004), and blood-brain barrier permeability (D'Andrea et al. 2003; Reddy et al. 2016). The toxicity of 900 MHz electromagnetic produced by mobile phones has been previously analyzed in vital organs (Acar et al. 2009). EMF has been reported to be genotoxic and carcinogenic (Gandhi et al. 2005). There is an increased risk of several other types of cancers following prolonged exposure to mobile phone/ tower radiation, such as, salivary gland tumors, uveal melanoma, lymphoma, facial nerve tumors, skin, blood, testicular and breast cancer (Elisabeth et al. 2011; denis et al. 2011; Kundi et al. 2009; Ahlbom et al. 2004).

This study analyzed mobile induced hazards in terms of antioxidants level, enzymological activity, biochemical parameters, and hematological profiles of various organs. The understanding of toxicological effects of EMR radiation in a mammalian model is necessary for studying human health hazards and could help in the establishment of guidelines for the safe use of the mobile phones.

MATERIALS AND METHODS

Animals and Chemicals

Male wistar rats, approximately 120±10 g body weight, were used for the study. Before the tests, they were acclimatized to laboratory conditions (12-h light/12-h dark cycle, 22C temperature) for a minimum of 10 days. The rats were divided into two groups; each group contained six male rats housed in cages that have sterile paddy husk as bedding materials. Standard food pellets (provided by the animal facility) and clean tap water were provided ad libitum. The experimental protocols were carried out according to the approved guidelines set by the Institutional Animal Ethics Committee.

Experimental Design

Animals were allocated into two groups: group I (n = 6), control without near source of electromagnetic radiation; and group II (n = 6) were exposed to the mobile phone radiation 2h/day constantly for 90 days.

Exposure system

The electromagnetic radiations were produced by a real GSM mobile phone electromagnetic radiation. Mobile phones operated by local network at 900 MHz frequency band and specific absorption rate (SAR) equivalent to 1.10 W/kg. The mobile phone was put in a small perforated polycarbonate cell in the center of cage in order to prevent any damage caused by rats. A call was given with another mobile phone and it will ensure that mobile phone is switched on and with call accepting mode and rats is in close proximity to the mobile phone. False mobile phones will put in the control. Conditions of exposure were similar to those to which a mobile phone user is exposed and were determined according to previous study (Motawi et al., 2014).

At the end of each experimental period rats were sacrificed and the blood was drawn from the animal's eye by puncturing the retro-orbital venous sinus. The brain, liver, and kidney were dissected out, rinsed in a cold 0.9% sodium chloride solution, placed in pre-chilled homogenization buffers for further procedure.

Indices of oxidative stress

Tissue lipid peroxidation (LPO) was measured by estimating the thiobarbituric acid reactive substances (TBARS) as described by Sharma and Krishna-Murti (1968). Tissue-reduced glutathione (GSH) was measured following the method described by Brehe and Burch (1976).

Assay on antioxidant and associated enzymes

Catalase (CAT) activity was estimated following Aebi (1984). Total superoxide dismutase (SOD) activity was estimated by measuring the inhibition of the auto-oxidation of epinephrine according to the method described by Misra and Fridovich (1972). Tissue glutathione peroxidase was measured following the method described by Paglia and valentine, (1969).

Assay on antioxidant

Catalase (CAT) activity was estimated following Aebi (1984). Total superoxide dismutase (SOD) activity was estimated by measuring the inhibition of the auto-oxidation of epinephrine according to the method described by Misra and Fridovich (1972).

Blood biochemistry

Serum was isolated from the blood samples by centrifugation at 2000 r/min for 15 min and was collected in vials and used to determine the levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) following the methods described by Reitman and Frankel (1957). The levels of albumin, bilirubin, creatinine, urea, and uric acid in the serum were determined by standard procedures used in clinical biochemistry laboratories based on manual biochemical kits following manufacturer's

directions (E-Merck Limited, Mumbai, India) and using an auto analyzer (Micro Lab 200, Merck, Germany).

Hematological analysis

Determination of hematological parameters (RBCs, WBCs, Hb concentration and platelets count), by an automated hematologic analyzer using whole blood sample.

Statistical analysis

Values are expressed as mean ± SE for six rats in each group and significance of the differences between mean values were determined by the Student's t-test according to the Snedecor and Cochran (1994). The minimal level of significance was considered at P ≤ 0.05.

RESULTS

Oxidative stress marker in tissue

Lipid Per-oxidation and Reduced glutathione

Lipids are susceptible to oxidation and lipid peroxidation products are potential biomarkers for oxidative stress. A significantly elevated LPO

level follows electromagnetic radiation exposure for 3 months in all tissues (Fig 1/A). Enhanced LPO was expressed in terms of thiobarbituric acid reactive substances in electromagnetic exposed groups. However a considerable slump in the reduced glutathione contents of liver, kidney and brain after EMR exposure (Fig 1/B).

Antioxidant and associated enzymes in tissue

A fall was observed in SOD activity in both exposed group which indicates susceptibility of vital organs against ROS produced by EMR (Fig 1/C). The defensive antioxidant enzyme next to SOD is catalase. CAT traps the harmful hydrogen peroxide and converts into water and oxygen. A mixed trend was observed in CAT activity. EMR exposure enhanced CAT activity in brain and liver while depleted activities observe in kidney tissue (Fig 1/D). Glutathione peroxidase plays important biochemical role in reducing most organic and inorganic hydroperoxides in many tissues and cells. Electromagnetic radiation exposure significantly inhibited the enzymatic activity of GPx in liver, kidney and brain (Fig.1/E). In exposed group decrease in GPX activity observed statically significant compared with control (P ≤ 0.05).

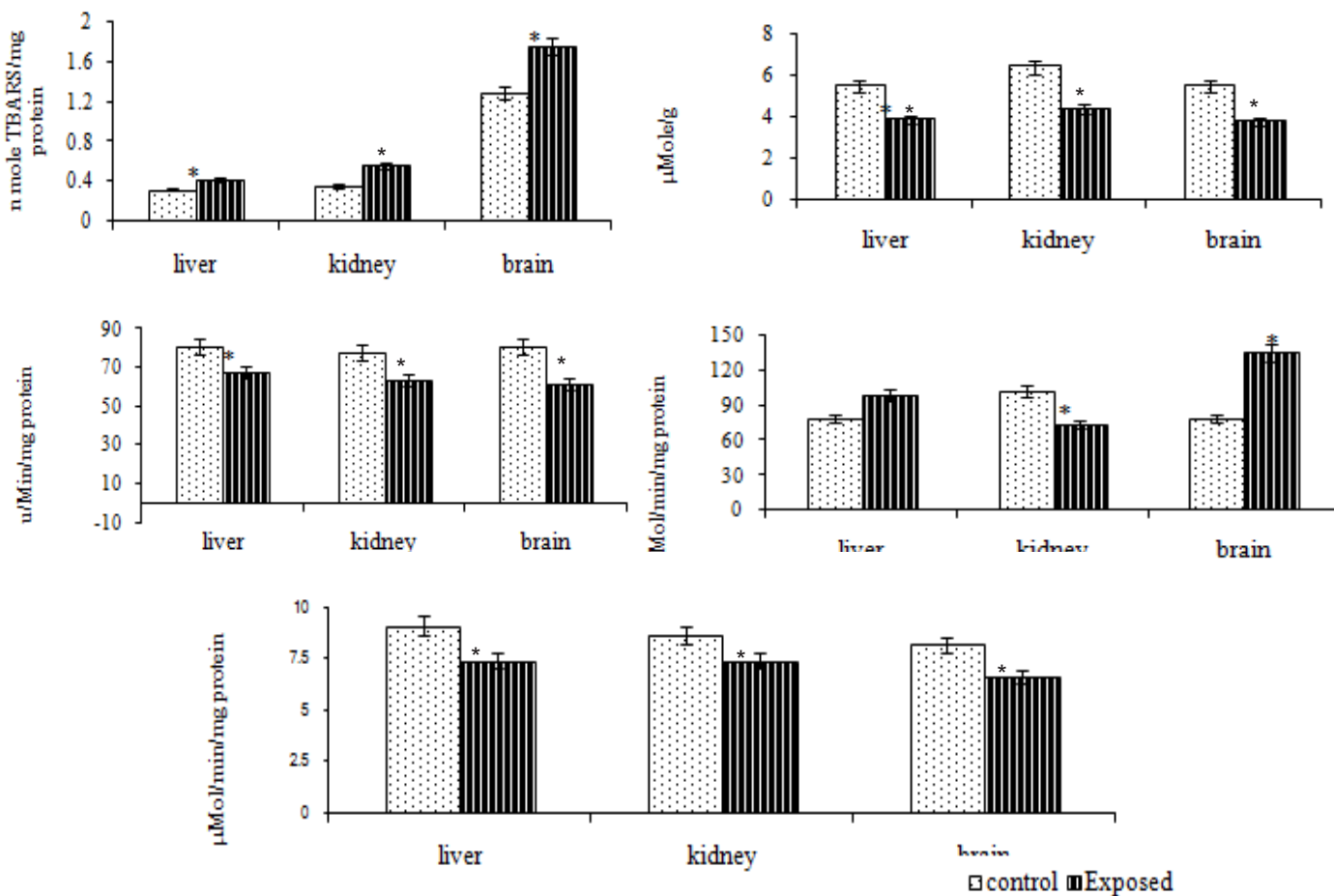


Figure 1. Effects of microwave radiation oxidative stress markers and antioxidant enzyme in rat liver, kidney, and brain. (a) representation of lipid peroxidation (B) Representation of reduced glutathione (C) Representation of superoxide dismutase (D) Representation of catalase (E) Representation of glutathione peroxidase. Value represent the mean±SE of six animal in each group. * Exposed vs control significant at P ≤ 0.05..

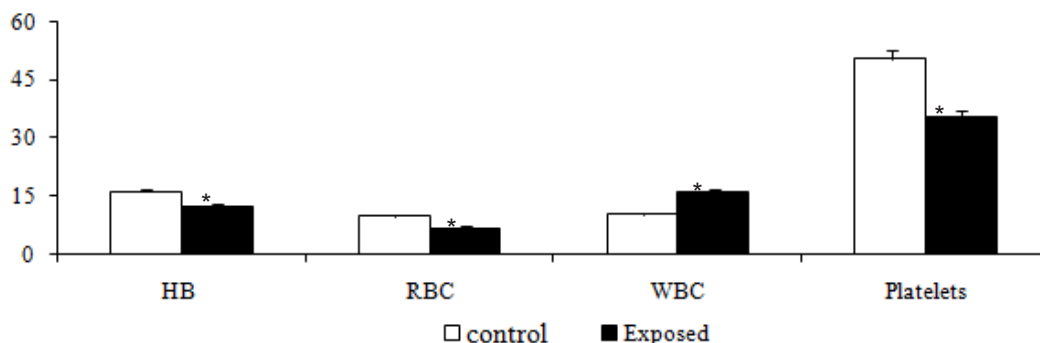


Figure 2. Effects of microwave radiation on oxidative stress markers in blood. GSH; Reduced glutathione, LPO; Lipid per oxidation, CAT; Catalase. Value represent the mean±SE of six animal in each group. * Exposed vs control significant at P ≤ 0.05.

Table 1: Depicts effect of electromagnetic radiations produced by mobile phone in serum biochemical parameters in rats. .

| Liver function test | | | | Kidney Function test | | | |
|---------------------|------------|------------|-----------------|----------------------|--------------|-------------------|-------------------|
| Groups | AST (IU/l) | ALT (IU/l) | Albumin (mg/dl) | Bilirubin (mg/dl) | Urea (mg/dl) | Uric acid (mg/dl) | Creatinine (g/dl) |
| Control | 42.2±2.3 | 53.9±2.9 | 4.5±0.2 | 0.4±0.02 | 23±2.8 | 53.9±2.9 | 0.44±.02 |
| Exposed | 65.1±3.5* | 73.1±4.1* | 3.1±0.17* | 0.68±0.03* | 38.5±2.1* | 73±4.0* | 0.61±0.03* |

Data are mean ± SE, N=6; Exposed Vs control at $p \leq 0.05$

Blood Biochemistry

Changes in the levels of enzyme activity such as ALT and AST are presented in table. ALT and AST levels in rats exposed to EMR were significantly higher than the control ($p \leq 0.05$). Variations in biochemical parameters such as uric acid, urea, creatinine, albumin, and bilirubin levels indicate kidney dysfunction. Serum uric acid, urea, creatinine and bilirubin levels in experimental rats were higher than the control group ($p \leq 0.05$), whereas a significant depletion in albumin level in serum (Table 1) exposed to EMR compared with the control group ($p \leq 0.05$).

Hematological parameters

From a biological point of view, blood can be considered as a tissue comprising various types of cells (Hb, RBCs, WBCs and platelets) and a liquid intracellular material (Plasma). A significant effect in blood components due to the exposure to mobile phone electromagnetic radiations. Value of Hb, RBCs, WBCs, and platelets decrease significantly in exposed group compare to control group (Fig. 2).

DISCUSSION

The widespread mobile phone usage has raised the possibilities of inevitable exposure of electromagnetic radiation (EMR). Previously, there were several apprehensions were established in explaining the ill-effects of EMR on human health (Goldwein and Aframian 2010). Despite the several research related to harmful effect of mobile radiations toxicity in vital organs like brain, kidney, and liver is still poorly elucidated. Therefore, in the present study, we have investigated the effect of EMR in terms of antioxidants level, enzymological activity, biochemical parameters, and hematological profiles of various organs and the possible deleterious effects of EMF.

Alterations in the level of antioxidants, biochemical molecules, enzymological activity and hematological profile are well considered as the indicators of deteriorating animal homeostasis that further resulted in stress and decline functional ability (Gecit et al. 2014; Saravanan et al. 2012). Oxidative insult via deterioration of antioxidant defense capacity is a pathogenic pathway involved in all the organ dysfunction or disorders (Saravanan et al. 2012). Ample of studies have shown that EMF exposure is capable of causing the substantial oxidative damage to the body (Sharma et al. 2014; Aydin and Akar et al., 2011; Maaroufi et al., 2014). Similarly in our study we observed a regular alteration in the level of oxidative molecules like GSH, LPO, CAT, GPx and SOD in all the vital organs. Additionally the estimated level of GSH and LPO was also altered in blood directing towards the continual level of oxidative stress in the systemic flow.

In the present study the high level of oxidative stress in brain tissue account for the higher vulnerability of brain towards the EMR exposure. These results coincide with findings of Ragy et al. (2014).

Furthermore, we have also assessed the liver and kidney toxicity following EMF exposure. In response to any cellular injury in liver the level of intracellular enzymes, like serum alkaline phosphatase, transaminases and bilirubin get increased in the circulation (berrahal et al. 2009). During liver damage the elevated level of enzymes like ALT and AST are considered as the preliminary indicators of the structural and functional damage of both cellular and mitochondrial membranes as observed in this study following EMF exposure (rajesh and Latha 2004; Sharma et al. 2013). Serum urea, uric acid and creatinine were also found to be higher, directing towards renal damage, which also corroborates with other study (Moussa 2009; Tsji et al. 1996). These increments could be considered as a reflection of deteriorating renal performance (Geraci et al. 1990) due to the ammonia formed by deamination of amino acids in the liver which converted to urea or to increased breakdown of nucleic acids (Yarmonenko 1998). Since irradiation may cause breaking of DNA

molecules and destruction of their bases (the purines) which may be catabolized into uric acid (Ganong 1992). As creatinine is formed largely in muscles and occurs freely in blood plasma and urine, its increased levels in plasma serve as an index of renal function impairment. Additionally, the abnormalities in hematological profile in terms of RBCs count, haemoglobin and monocyte count as observed in this study also provides corroboration to the detrimental effects of EMF exposure on blood. This means that these components of blood are broken due to irradiated by Mobile phone electromagnetic radiation. The decrease in the Hb may be attributed to hemolysis, anemia, or the suppression of hemopoiesis. Alongwith the apparent significant effect on bilirubin (a byproduct of red blood cell lysis) prove the possibility of hemolysis. Previously El-Bediwi et al. (2011) also reported an increased in the level of bilirubin in rats after exposure to mobile phone.

We would highlight that in this study to generate the reality of the human exposition the exposure was provided by the commercial cellular phone. Present study showed an evident oxidative insult in liver, kidney and brain. Most of the studies regarding EMF effects were targeted on a particular organ or mechanism. Here in this study we propose that during EMF exposure due to excessive mobile usage various vital organs get equally affected with the similar blood stream. Present study will provide an effectual consideration in developing therapeutic strategy regarding multiple organ conditions and relating mechanisms during EMF exposure.

This study provides an insight regarding mobile emitted radiations could induced alteration in blood as well in vital organs liver, kidney and brain tissue.

Disclosure statement: No potential conflict of interest was reported by the author.

Financial and proprietary interest: Nil

Financial support: Indian Council of Medical Research, New Delhi for providing financial support

REFERENCES

- Acar G.O., Yener H.M., Savrun F. K, Kalkan T, Bayrak I, Enver O., (2009). Thermal effects of mobile phones on facial nerves and surrounding soft tissue. *Laryngoscope*. 119, 559-562.
- Aebi H., (1984). Catalase in: method in enzymatic analysis. Edited by Bergmeyer HU. New York: Academic press. 673-684.
- Ahlbom A., Green A., Kheifets L., (2004). Epidemiology of health effects of radiofrequency exposure. *Environmental Health Perspectives*. 112(17), 1741-1754.
- Aydin B., Akar A., (2011). Effects of a 900-MHz electromagnetic field on oxidative stress parameters in rat lymphoid organs, polymorphonuclear leukocytes and plasma. *Archives of Medical Research*. 42(4), 261-7.
- Berrahal A.A., Lasram M., Elj N.E., Kerkeni A., Gharbi N., El-Fazzaa S., (2009). Effect of Age-Dependent Exposure to Lead on Hepatotoxicity and Nephrotoxicity in Male Rat. *Environmental Toxicology*. 26(1), 68-78.
- Brehe J.E., Burch H.B., (1976). Enzymatic assay for glutathione. *Analytical Biochemistry*. 74, 189.
- D'Andrea J.A., Chou C.K., Johnston S.A., Adair E.R., (2003). Microwave effects on the nervous system. *Bioelectromagnetics*. 6, 107-47.
- Denis A., (2011). Mobile Phone Use and Brain Tumors in Children and Adolescents: A Multicenter Case-Control Study. *Journal of the National Cancer Institute*. 103(16), 1264-1276.
- El-Bediwi A., El-kott A.F., Saad M., Eid E., (2011). Effects of electromagnetic radiation produced by mobile phone on some visceral organs of rat. *Journal of Medical Sciences* 11, 256-260.
- Elisabeth C., Siegal S., (2011). Indications of possible brain tumour risk in mobile-phone studies: should we be concerned. *Occupational and Environmental Medicine*. 68, 169-171.
- Fatima M.Z.A., Hassan S.M.A., Sherif S.Z., (2016). Environmental Impacts of Electromagnetic Radiation Induced by High Voltage-Power Lines. *International Journal of Innovative Research in Science, Engineering and Technology*, 5(3), 1111-1122
- Gandhi G., Naru J., Kaur M., Kaur G., (2005). DNA and Chromosomal Damage in Residents Near a Mobile Phone Base Station. *International Journal of Human Genetics* 14(34), 107-118.
- Ganong W.F., (1999). Energy balance, metabolism and nutrition. *Review of medical physiology*. 22, 465.
- Gecit I., Karak S., Yuksel M.B., (2014). Effect of shortterm treatment with levosimendan on antioxidant stress in renal tissues of rats. *Toxicology and Industrial Health*. 30(1):47-31
- Goldwein O., Aframian D.J., (2010). The influence of handheld mobile phones on human parotid gland secretion. *Oral Diseases*. 16, 146-50.

16. Hao Y., Zhao L., Peng R., (2015). Effects of microwave radiation on brain energy metabolism and related mechanisms. *Military Medical Research*. 2, 4.
17. Huber R., Tryer V., Borbély A.A., Schuderer J., Gottselig J.M., Landolt H.P., (2002). Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. *Journal of Sleep Research* 11, 289–95.
18. Ilhan A., Gurel A., Armutcu F., Kamisli S., Iraz M., Akyol O., Ozen S., (2004). Ginkgo biloba prevents mobile phone induced oxidative stress in rat brain. *Clinica Chimica Acta* 340, 153-162.
19. International Agency for Research on Cancer (IARC), (2011). IARC Classifies Radio frequency Electromagnetic Fields as Possibly Carcinogenic to Humans. www.iarc.fr.
20. Irmak M.K., Fadilloglu E., Gulec M., Erdogan H., Yagmurca M., Akyol O., (2002). Effects of electromagnetic radiation from a cellular telephone on the oxidant and antioxidant levels in rabbits. *Cell Biochemistry and Biophysics*. 20, 279-283.
21. Krause C.M., Pesonen M., Haarala B.C., Hamalainen H., (2007). Effects of pulsed and continuous wave 902 MHz mobile phone exposure on brain oscillatory activity during cognitive processing. *Bioelectromagnetics*. 28, 296–308.
22. Kundi M., (2009). The controversy about a possible relationship between mobile phone use and cancer. *Environmental Health Perspectives*. 117(3), 316-324.
23. Lerchl A., Kruger H., Niehaus M., (2008). Effects of mobile phone electromagnetic fields at non thermal SAR values on melatonin and body weight of Djungarian hamsters (*Phodopus sungorus*). *Journal of Pineal Research* 44, 267–272.
24. Matusset-Bonnefont A.L., Hirbec H., Bonnefont X., Privat A., Vignon J., De Seze R., (2004). Acute exposure to GSM 900-MHz electromagnetic fields induces glial reactivity and biochemical modifications in the rat brain. *Neurobiology of Disease*. 17, 445–54.
25. Mishra H.P., Fridovich I., (1972). The role of superoxide anion in the autoxidation of epinephrine and a simple assay for superoxide dismutase. *The Journal Biological Chemistry*. 247, 3170-3175.
26. Moussa S.A., (2009). Oxidative stress in rats exposed to microwave radiation. *Journal of Biophysics*. 19, 149-158.
27. Nawal A., A., Nasr M.R., Heba S.A., Noha, A.S., (2017). The antioxidant effect of Green Tea Mega EGCG against electromagnetic radiation-induced oxidative stress in the hippocampus and striatum of rats. *Electromagnetic Biology and Medicine*. 36 (1), 63-73.
28. Ragy M.M., (2014). Effect of exposure and withdrawal of 900 MHz electromagnetic waves on brain, kidney and liver oxidative stress and some biochemical parameters in male. *Electromagnetic Biology and Medicine*. 1-6
29. Rajesh M., Latha M., (2004). Preliminary evaluation of the antihepatotoxic activity of Kamilari, a polyherbal formulation. *Journal of Ethnopharmacology*. 91, 99-104.
30. Reddy D.R., Singh T.D., Guru, P.K., Sakusic A., Gajic O., O'Horo J.C., Rabinstein A.A., (2016). Identification of acute brain failure using electronic medical records. *Journal of Critical Care*. 34, 12-16.
31. Reitman S., Frankel S., (1957). A colorimetric method for the determination of serum glutamic oxaloacetic and glutamic pyruvic transaminases. *American Journal of Clinical Pathology*. 28.
32. Saravanan M., Devi U.K., Malarvizhi A., (2012). Effects of ibuprofen on hematological, biochemical and enzymological parameters of blood in an Indian major carp *Cirrhinus mrigala*. *Environmental Toxicology and Pharmacology*. 34 (1), 14–22.
33. Sharma S., Raghuvanshi B.P.S., Shukla S., (2014). Toxic Effects of Lead Exposure in Rats: Involvement of Oxidative Stress, Genotoxic Effect, and the Beneficial Role of N-Acetylcysteine Supplemented with Selenium. *Journal of Environmental Pathology Toxicology and Oncology*. 33(1), 19-32
34. Sharma S., Shrivastava S., Shukla S., (2013). Reversal of lead-induced toxicity due to the effect of antioxidants. *Journal of Environmental Pathology Toxicology and Oncology* 32(2), 1-11
35. Sharma S.K., Krishnamurti C.R., (1968). Production of lipid per oxidation by brain. *Journal Neurochemistry*. 15, 147-149.
36. Snedecor G.W., Cochran W.G., (1994). *Statistical analysis* (8th edn). Iowa State University Press: Ames, IA.
37. Topali Z., Hanci H., Mercantepe T., Erol H.S., Keles O.N., Serkan H., (2015). The effects of prenatal long-duration exposure to 900-MHz electromagnetic field on the 21-day-old newborn male rat liver. *Turkish Journal of Medical Sciences* 45, 1-7
38. Tsji Y., Nakagawa M., Suzuki Y., (1996). Five-tesla static magnetic fields suppress food and water consumption and weight gain in mice. *Industrial Health*. 34, 347-357
39. Yarmonenko S.P., (1998). In *Radiobiology of humans and animals*, Mir Publishers.



© 2017 by the authors; licensee Scientific Planet Society, Dehradun, India. This article is an open access article distributed under the terms and conditions of the Creative Commons by Attribution (CC-BY) license (<http://creativecommons.org/licenses/by/4.0/>).