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Chronic Exposure of Electromagnetic Radiation from GSM MASKS on West African Dwarf Bucks at Ijan-Ekiti, Nigeria

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ABSTRACT

This study examines the impact of the base station mask on animal health using the West African Dwarf (WAD) bucks. Environmental electromagnetic fields derive from man-made sources, such as cell phones and base stations, and have contributed to heightened public awareness over their potential detrimental human health effects. Twenty bucks, aged 3-6 years were randomly selected based on the proximity to the mask station for this study. The animals were randomly selected into five (5) groups: Group I (0-50m), Group II (150 -200m), Group III (250-300m), Group IV (350-400m), and Group V >2000m with four (4) bucks per group. The results revealed that animals in Groups I, II and III had more effect ($p<0.05$) on behavioral, physiological, and reproductive parameters, while Groups IV and V produced a lesser effect ($p>0.05$). Hence, the electromagnetic radiation (EMR) from the base station posed an adverse effect on West African Dwarf (WAD) Bucks' welfare. The study suggests that a residential building should be kept away from the base station masks.

Keywords: *Electromagnetic radiation, base station masks, behavioural parameter, physiological parameter, reproductive parameter, radiofrequency*

INTRODUCTION

Electromagnetic radiation (EMR) or radiofrequency fields impact biological processes by raising free radicals, which primarily improve lipid peroxidation, and thus modify the antioxidant protection systems in human tissues, contributing to oxidative stress (Ozguner *et al.*, 2005). In recent years, the number of EMRs in our country has grown due to the large-scale extension of communication networks such as mobile phones, base stations, WLAN, Wi-Fi, Wi-MAX, etc. As a result, leakage of irradiation into the atmosphere is unavoidable due to a growing apprehension about the modernization of society and technical advancements that have driven people to the increasing use of electronic devices, which is continually subjected to electromagnetic radiation and radio wave effects (Feychting *et al.*, 2005). In comparison to man-made sources, radiation from natural sources such as the sun and the planet is routinely released (Zhang *et al.*, 1995). As a result of the global concern for the potential health hazard induced by electromagnetic radiation (EMR), a considerable amount of research has focused on the modulation of normal physiological function especially the brain (Narayanan *et al*., 2009; Fragopoulou *et al.*, 2010; Ammari *et al.*, 2008 and Nittby *et al*., 2008).

Currently, there have been many studies referring to adverse effects due to exposure to radiofrequency electromagnetic fields (RF-EMF). Harm to living tissue by radiation involves modification of the cell structure and damage to DNA; the extent of damage depends on the form of radiation. Some cells are often more susceptible to radiation; most cell damage is healed; some cells do not heal as well and become cancerous (EPA, 2012). Heat production and activation of the inducible nitric oxide (NO) synthase may be the cause of the biological effects of EMF exposure (Paredi *et al.*, 2001). ELF-EMFs have been related to alterations in cell development, morphology, differentiation, death, and nerve impulse transmission (Kerr *et al.*, 1972; Pirozzoli *et al.*, 2003; Grassi *et al.*, 2004) and human fertility (La Vignera *et al.*, 2012).

Exposure to electromagnetic radiation (EMR) has increased the production of reactive oxygen species (ROS), including superoxide anion, hydrogen peroxide, and hydroxyl radicals (Aweda *et al.*, 2003). Melatonin (N-acetyl-5-methoxy-tryptamine) is primarily synthesized by the pineal gland and has been considered a potent antioxidant, much more potent than vitamin E, and detoxifies a number of ROS in many pathophysiological conditions (Pieri, and Marcheselli,, 1994; Ekmekcioglu, 2006) and is of great concern to human health due to its increased usage in everyday life. In fact, MW radiation raises the temperature of the biological system, i.e., thermal effects (Olcerst and Rabinowitz, 1978; Adair and Peterson, 2002). Increasing use of cell phones and the number of related base stations are becoming a widespread source of non-ionizing electromagnetic radiation. Any biological consequences are expected to arise at low-level EM fields.

Increasing data show that oxidative stress can be associated with the adverse effects of radiofrequency (RF) radiation on the brain. Since mitochondrial DNA (mtDNA) effect is closely associated with numerous diseases of the nervous system, mtDNA is highly susceptible to oxidative stress. It has significantly contributed to the exponentially growing EMF smog, an unprecedented source of ambient radiation pollution that has driven scientists to explore human effects. In addition, a complex reaction of the nervous system to radiofrequency radiation (RFR) is based on length and amount of exposures and the interaction of these two parameters (Lai, 1997). The precise mechanism underlying these effects is yet unknown, but the consensus is that extremely low frequency field (ELF) interacts with biological systems through electric fields, either applied or induced by time varying magnetic fields (Liburdy, 1995). Microwave (MW) radiation from wireless networking and a number of electrical equipment used in homes or healthcare establishments may have harmful effects on reproductive patterns.

Therefore, there is a need to ascertain the effect of base stations or masks on some physiological parameters using WAD Bucks. However, nothing has been done to determine the harm sustained to goats that are constantly exposed to EMFr present in the area. Initial research showed that the reproductive organs of male rats were significantly damaged and may have a comparable effect on higher mammals. Further study on the long-term effect of RF-EMR from telecommunications using unrestrained WAD bucks in Nigeria is therefore needed.

MATERIALS AND METHOD

Experimental Design

Twenty (20) healthy West African Dwarf. (WAD) bucks aged 3-6 years with the same genetic background and within their home range were used for this study at Ijan-Ekiti (7º37[1] N 5º24[1]E), Ekiti State, Nigeria. They were randomly selected based on their proximity to the mask station. The bucks were sample into five (5) groups; Group I (negative control) (0 - 50m); Group II (150 -200m); Group III (250-300m); Group IV (350-400m) and Group V (positive control) (>2000m) comprising four (4) bucks per group.

Behavioural responses

The manifestations of behavioural activity were observed as described by Sofowora (1984), and behavioural observations were measured and recorded using a categorical scale (Reis and Judd, 2000).

Physiological parameters

Physiological parameters of the WAD-bucks were taken as reported by Fatoba *et al* (2006), in which a clinical thermometer was used for the rectal temperature and a stethoscope was used for pulse rate, heart rate, and the respiratory rate.

Semen collection and analysis

Semen was collected through the electro-ejaculator into a collecting tube while semen evaluation was done according to Karagiannidis *et al* (2000) and Oyeyemi *et al* (2001) procedures. The color of the semen was determined by visual evaluation. Mass activity was determined within one minute of collection by a drop of concentrated semen without a slip under low magnification (x4). The semen was placed in a buffer solution for further analysis.

Haematological Parameters

Blood samples were taken from each animal's jugular vein in bottles labeled with ethylene diamine tetra acetate (EDTA) for haematological determination using the Baker and Silverton (1985) process.

Biochemical Parameters

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Two (2) ml blood samples were dispensed into heparinized tubes (Vitic and Stevanovic, 1993; Nazifi *et al*., 2000) containing EDTA as anticoagulant after local disinfection with methylated spirit using a 21 gauge 2.54 inch sterile needles and 5ml syringes for plasma. Blood samples were allowed to clot at room temperature, the blood plasma separated and transported within 60 minutes to the laboratory.3ml of blood samples were delivered into heparinized tubes (without EDTA) and the blood serums were separated for 15 minutes by centrifugation at 3000gm and processed at about 20^0C before examination at the Chemical Pathology Department of Okitipupa Specialist Hospital, Okitipupa, using suitable test kits. Sodium and potassium were determined with flame photometer (Hawk *et al*., 1954), Calcium and magnesium by the atomic absorption spectrophotometer, Shimadzo, AA-670, Kyoto, Japan (Gindler and King, 1972: Oser, 1979); Chloride by the calorimetric (Mercury nitrate method); cholesterol (Allain *et al*., 1953) Glucose by the O-Toluidine method; Total protein and Albumin by the Biuret method of Reinhold (1953). Alkaline phosphatases and Enzyme transaminases were analyzed spectrophotometrically by using commercially available diagnostic kits (Randox® test kits) as described (Reitman and Frankel, 1957). Testosterone and FSH levels were determined by the E1A method using appropriate enzyme immunoassay Test kits following the procedure of Nduka (1981), Dada *et al*. (1984), and Forsberg *et al*. (1993).

Statistical Analysis
The data generated were analyzed using One-way ANOVA followed by Duncan's Multiple Range Test using SPSS Version 18.

RESULT AND DISCUSSION

Table 1: Behavioural Activity in WAD –Bucks following exposure to Electromagnetic radiation

Parameters	GROUPS					
(%)	I	II	III	IV	V	S.E
Activeness	25.00	25.00	50.00	75.00	100.00	0.7013
Alertness	25.00	25.00-	50.00	75.00	100.0	0.7013
Grooming	0.00^b	25.00^{ab}	50.00^{ab}	75.00^{ab}	100.00^a	0.9682
Restlessness	100.0^a	100.00^a	75.00^a	25.00^b	25.00^b	0.9682
Aggression	0.00^b	0.00^b	25.00^{ab}	50.00^{ab}	100^a	1.2245
Mating activity	0.00^b	0.00^b	25.00^{ab}	50.00^{ab}	100.00^a	1.2245

a, b, c; values along the same row with different superscripts are significant ($p<0.05$)
S.E = Standard error

The behavioural responses are presented in Table 1. The animals show decreased restlessness but increased alertness, activeness, grooming, aggression, and mating activity in the bucks across the groups. The effect was expressed ($p<0.05$) in grooming, restlessness, aggression, and mating activity, while an insignificant difference ($p>0.05$) was observed in activeness and alertness. The result could be non-thermal effects that have shown variations in cell metabolism for both resonance absorption and induced EMFs (Aweda *et al.*, 2003), when neural structures are involved, often accompanied by a specific behavioral response in migratory animals.

The results from the responses could be linked to the exposure of humans to EMR, which had been linked to melatonin impairment (Wilson *et al.,* 1990; Wood *et al.,* 1998), which caused a delay and reduced sleep, disorientation, confusion, and depression (Abelin *et al.,* 1999). This inhibits pineal gland development of melatonin (N-acetyl-5-methoxy-tryptamine), which has been considered a powerful antioxidant, much more potent than vitamin E, which in several pathophysiological states detoxifies a range of reactive oxygen species (ROS) Pieri and Marcheselli, 1994; Ekmekcioglu, 2006) and possibly lack of concentration which could made the bucks in I, II, and III to exhibit these behaviours. The result confirmed the works of Aweda *et al* (2003), Ozguner *et al* (2005), and Desad *et al* (2009), who reported a consequence resulting from increased development of reactive oxygen species (ROS), including superoxide anion, hydrogen peroxide, and hydroxyl radicals, susceptibility to electromagnetic radiation (EMR). Electromagnetic radiation (EMR) or cellular mobile phone radio frequency fields can affect biological systems by free radicals (Grindler *et al.,* 1992) and may affect recombinations of radical pairs (Kivrak *et al.,* 2017). They appear to increase lipid peroxidation and modify human tissues' antioxidant defense mechanisms, leading to oxidative stress.

These results suggest that the brain stress system is triggered after field exposure, and it can be concluded that corticotropin-releasing factor (CRF) could be released from its source (hypothalamic paraventricular nucleus magnocellular cells) and thus correlated with the behaviors found in this study. The observed activity indicated a rise in brain CRF, suggesting increased restlessness and depression as a result of stress exposure (Ciccocioppo *et al*., 2001). In this respect, the evidence showed that all dopamine-related activities, including sniffing, rearing, and locomotor operation, were enhanced in animals after field exposure. The above-mentioned behaviors can be observed only after brain dopamine increment (Richardson and Gratton, 1996), which is postulated to be involved in animal feeding behavior (Salamone *et al*., 1997).

The findings of this study indicate that long-term exposure to low-intensity (pulsed) electromagnetic radiation from GSM base stations can have major effects on the actions of WAD bucks, causing restlessness reported in both humans and laboratory animals, and demonstrating distance variations in response to the EMR source. RF-EMR activation and exposure have been reported to result in adverse neurobehavioural development in both animals and humans.

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Table 2: Biochemical parameters of the WAD bucks exposed to chronic electromagnetic radiation

Parameters	GROUPS					
	I	II	III	IV	V	S.E
SODIUM (mmol/L)	139.44	136.38	134.17	132.31	129.34	1.1763
POTASSIUM (mmol/L)	7.16[a]	6.84[a]	6.29[a]	4.34[b]	4.07[b]	1.6213
CALCIUM (mmol/L)	4.63[a]	4.26[a]	4.03[a]	3.17[b]	3.02[b]	1.1375
MAGNESSIUM (mmol/L)	3.17[a]	3.06[a]	2.98[a]	2.28[b]	2.16[b]	0.6041
CHLORIDE (mmol/L)	137.06	136.53	134.27	131.32	132.04	1.1379
UREA (mmol/L)	5.74[a]	5.57[a]	5.27[a]	3.25[b]	2.28[b]	0.7814
CHOLESTEROL (mmol/L)	7.43[a]	7.28[a]	6.87[a]	4.32[b]	4.07[b]	0.7401
GLUCOSE (mmol/L)	6.47[a]	6.16[a]	5.89[a]	3.78[b]	3.34[b]	0.7923
TOTAL PROTEIN (mmol/L)	81.18[a]	72.37[a]	65.21[ab]	56,78[bc]	52.43[c]	3.0372
ALBUMIN (mmol/L)	42.16[a]	39.53[a]	35.16[ab]	27.23[bc]	23.71[c]	1.1274

a,b,c; values along the same row with different superscripts are significant ($p<0.05$)
S.E = Standard error

The biochemical parameters are shown in Table 2. The results revealed that some of the blood electrolytes did not significantly differ ($p>0.05$) for two parameters, which are sodium and chloride, but were significant ($p<0.05$) in potassium. The two minerals (magnesium and calcium) were significantly different ($p<0.05$). This shows decreased urea and serum metabolites (cholesterol and glucose), total protein and albumin values were noticed across the table and were statistically different ($p<0.05$). All the biochemical indices decreased across the table and followed the same trends. However, experiments have also demonstrated the influence of 2.45-GHz electromagnetic radiation on blood biochemical parameters, hormones, the immune system, and the reproductive system (Aweda *et al.*, 2003; Hossmann and Hermann, 2003; Kim *et al.*, 2019).

In addition, the effect of waves on the stress system depends on the time of exposure. The result on plasma glucose level confirmed the report of Mahdavi *et al* (2014) who stated elevated values with RF-EMF. The high glucose levels could be a result of stressful situations, which might interrupt and cause glucose metabolism in the brain of the bucks upon exposure to RF-EMF, which provides evidence that the brain is sensitive to RF-EMF effects (Volkow *et al*, 2011). The ability of the RF-EMT to interfere with and cross the blood-brain barrier has been reported, which could account for a decrease in insulin production (Li and Dai, 2005; Sakurai and Satake, 2004) and leakages of glucose in the bloodstream (Havas, 2008). Increased blood urea in WAD bucks may be due to heat stress, which may mean the kidneys encountered induced blood flow during heat stress.

Radiofrequency EMF-mediated compromised blood and kidney function in different experimental animal organs has also been reported (Zare, Alivandi & Ebadi., 2007). These modifications have been shown to occur after exposure to the electromagnetic field could be due to changes in the field's ability to alter protein function both within and/or outside the cell (Kula *et al.*, 1999; Levitt, 2008). RF-EMFs released from mobile phones are taken into the brain to a degree that may affect neuronal function (Kleinhegel *et al.*, 2008; Jeong *et al.,* 2015; Jiemg *et al.,* 2016) and may allow Albumin to leak through the blood brain barrier (Salford *et al.,* 1994, 2003, 2008; Nittby *et al.,* 2009). Exposure to radiofrequency electromagnetic field (EMF) levels that raise brain temperature by more than 1°C, and will reversibly increase the permeability of the blood brain barrier (BBB) to macromolecules. The exposure of EMR changes the permeability of BBB (Johnson and Guy, 1972).

Table 3: Plasma Concentrations of Hormone and Enzyme Activities in WAD-Bucks following chronic exposure to EMR.

Parameters	GROUPS					
	I	II	III	IV	V	S.E
Alkaline Phosphatase (IU/L)	343.00[a]	331.75[a]	260.00[b]	83.75[c]	21.50[d]	5.7140
Alanine aminotransferase (IU/L)	31.25[a]	30.00[a]	28.00[a]	11.25[b]	07.25[b]	4.7145
Aspartate aminotransferase(IU/L)	344.00[a]	337.25[a]	297.50[b]	52.50[c]	23.00[c]	5.5507
Testosterone (ng/ml)	1.55[b]	1.88[b]	2.10[b]	2.85[b]	7.20[a]	0.8281

a,b,c,d; values along the same row with different superscripts are significant ($p<0.05$)
S.E = Standard error

The hormonal and enzyme activities are presented in Table 5. The enzyme activities ALP, AST, and ALT were decreased ($p<0.05$), but increased ($p<0.05$) hormonal testosterone levels were observed across the groups. The bucks in Group I had the highest values of enzyme activity, and the lowest occurred in Group V, which were found to be statistically different ($p<0.05$). However, Group V had the highest testosterone values, and Group I produced the lowest values, which were statistically different ($p<0.05$). These data show that one of the most influential organs that can be activated following field exposure to the brain is shown by behavioural and hormonal changes in animals. The finding was consistent with the report of Zare *et al.* (2007) that radiofrequency EMF caused dysfunction in multiple experimental animal organs. However, elevated AST levels occur with damage to the heart and skeletal muscles and to the liver (Vozarova *et al.*, 2002). In addition, stress can directly influence the brain dopamine system by interfering directly with the enzyme tyrosine hydroxylase receptors for corticosterone and D1 (Czyrak *et al*., 2003).

Serum transaminases (AST, ALT) and ALP) exhibited significant increase in Electromagnetic field influenced bucks compared to group V which in agreement with a study done by Pashovikna and Koev (2011) which have been identified as unique enzymes that increase hepatic diseases with toxic damage to liver cells The elevated enzymatic values following exposure to EMF radiation can be due to direct damage induced by radiation and to the overproduction of ROS by microwave radiation.

Therefore, increases in antioxidants may be due to the degradation of the cell membrane in the liver. The observed elevated values of enzymes may be due to the rate and quantity of biochemical reaction products that could be impaired by EMF radiation via a free radical process, including direct enzyme action, and could also account for the differences found in these enzyme parameters. The perception of the influence of EMR on the blood and blood-forming mechanisms has been reported to rely on the absorption of biological potentials and the thermoregulatory system of the irradiated organism, in line with the effects on the animal (Till *et al.*, 1998). The observation on the behavioural and physiological parameters revealed that the RF-ELF impartation was on animals at home range < 350m, which was corroborated with the value of < 300m (Santini *et al.* 2002).

Table 4: Physiological parameters of WAD Bucks upon chronic exposure to Electromagnetic radiation

Parameters	GROUPS					
	I	II	III	IV	V	S.E
Heart rate (beats /min)	122.00[a]	120.00[a]	116.00[a]	100.00[b]	91.50[b]	1.4080
Respiratory rate (beats /min)	45.00[a]	40.00[ab]	39.50[b]	30.00[c]	29.00[c]	1.4514
Rumination rate (beats /min)	36.50[a]	34.00[ab]	30.50[ab]	29.00[bc]	28.00[c]	2.1065
Rectal temperature (°C)	39.50[a]	39.25[a]	38.25[b]	37.50[bc]	37.00[c]	1.2384
Scrotal Temp.	36.50	36.45	36.03	36.08	35.94	0.3122
Packed cell volume (%)	14.27[c]	18.13[c]	20.47[bc]	27.65[ab]	31.63[a]	1.8499
Red blood cell (RBC)	4.48[c]	6.87[c]	9.74[bc]	12.32[ab]	15.41[a]	1.7141
White blood cell (WBC)	28.37[c]	24.81[c]	18.16[b]	11.24[c]	08.29[c]	2.4967

a,b,c; values along the same row with different superscripts are significant ($p<0.05$)
S.E = Standard error

Some physiological parameters of the bucks were shown in Table 4. The heart respiratory rate, rumination rates, and rectal temperature values were decreased across the groups. The animals in Group I had the highest values of rectal temperature, heart, respiratory, and rumination rates, and the lowest in Group V. The results of some physiological parameters of the bucks used in the study revealed a significant difference ($p<0.05$) in the parameters determined. Rectal temperature was highest in Group I and lowest in Group V, and the values followed the trend of Groups I > II > III > IV >V and were significantly different ($p<0.05$). However, rectal temperature shows no significant difference ($p>0.05$) between IV and V, which signifies that the EMR did not produce a harmful effect on the parameter tested. The results obtained on rectal temperature have been linked to the brain's blood circulation, which can reduce the excess heat by increasing local flow and may be due to this thermal effect (Thomee *et al*., 2007). Preliminary studies have already reported that EMR affects brain functioning and behaviours (Fernie and Reynolds, 2005; Hamblin and Wood, 2002). For example, the electromagnetic field generated by a mask modifies brain excitability and enhances electroencephalogram alpha-band power.

Rectal temperature is usually known to be a reasonable index of deep body temperature, even though there is significant variance at various periods of the day, the higher magnitude of the rise in rectal temperature of the WAD goats during the season (heat stress) implies that these animals can store body heat during the heat stress period and can promote the loss of water and increased use of energy correlated with increased respiratory rate. The hematological parameters are presented in Table 4. The findings revealed an improvement in ($p<0.05$) Packed Cell Volume and Red Blood Cell with reduced ($p<0.05$) White Blood Cell values between the groups. EMF has a different impact on RBCs, and this effect can be determined by the selective activity of EMF on haematopoietic processes and the rhythm of cell maturation. An increase in WBC in bucks may be a sign of a self-defense strategy against foreign bodies (Abbas et al., 1995). The findings showed that the PCV, RBC, and WBC of the bucks had been influenced by the EMF. Reduction in RBC in group I may mean stress in the animal system and suggest that EMR may cause ROS cell damage and destruction to hepatocyte liver cell membranes. PCV decreased relative to group V, which can be expounded as a result of a significant decrease in Hb, which could cause a decrease in RBC size and a final decrease in PCV which could result in anaemia (Adebayo and Olabisi, 2018), Haemolyticanaemia is mainly the result of increased red cell destruction (Bullmore and Sporns, 2009) that stimulates erythropoiesis. Measurements of enhanced red cell loss and parameters of rapid erythropoiesis, where the reticulocyte count is assessed, should be used in the assessment of potential haemolyticstytes. These observations are consistent with Lahijani *et al.* (2009) that intense sensitivity to ELF-EMF contributes to increased oxidative stress in chick embryonic cells and human erythrocytes.

Exposure of some experimental models to EMF has led to a significant increase in WBC counts and some differential WBC counts over time (Rusnani et al., 2008). Elevated WBC counts can represent inflammation (Sabatire *et al.,* 2002) and cause damage to RBC counts and their indices (Jibreal *et al.*, 2018). The significant increase in overall WBC count is due to a significant increase in lymphocytes; the adverse effect of exposure to electromagnetic waves triggers the haemopoietic system to release more lymphocytes, resulting in an increase in their number in the bloodstream (Jibreal *et al.,* 2018). The decrease in RBC counts in animals exposed to EMF can be deduced by the effect of EMR on the haematopoietic radiation system and by the high mitotic activity of the bone marrow, which makes it the most susceptible organ system to radiation (Adebayo and Olabisi, 2018). This drop is a sign of various forms of anemia (Adebayo and Olabisi, 2018; Jibreal *et al.*, 2018). The findings of this research thus indicate that long-term sensitivity to low-intensity (pulsed) electromagnetic radiation from GSM is likely to disrupt the physiological parameters. The findings are consistent with Michal and Marta (2004), who have shown that extremely ELF-EMF exposure can activate the immune system by reducing serum levels of ACTH and cortisol, which may have adverse effects on blood components and their function. Although there are changes in haematological parameters, these can be due to differences in the frequency of the EMF used and/or length, distance, and time of exposure, the mitotic rate of the exposed cell population, and the differences in the animal species used (Adebayo and Olabisi, 2018; Jibreal *et al.,* 2018). The exposure of bucks to electromagnetic fields alone exhibited a general increase in WBCs (leukocytosis). Significant decline was recorded related RBC, PCV compared to Group V.

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This finding agrees with Abdel Aziz *et al.* (2010), that several haematological variables (WBC, RBC, and PCV) are sensitive to RF/MW exposure. Radiation alters sleep rhythm, influences the cancer-fighting ability by damaging the immune system, and changes the form of electrical and chemical signals that interact between cells. The variation causes functional changes in the nervous system, allowing red blood cells to leak heamoglobin, leading to heart disease and kidney stones.

Table 5: Effect of Electromagnetic radiation on Spermiogramic parameters of WAD-Bucks

	TREATMENTS					
Parameter	I	II	III	IV	V	S.E
Colour	milky	Milky	Milky	Milky	milky	-
Mass activity	2.0^{b}	2.0^{b}	2.0^{b}	2.5^{ab}	3.0^{a}	1.7326
Mass motility	40^{c}	43^{c}	45^{c}	58^{b}	75^{a}	3.0045
Sperm conc. (x 10^{7})	5.45^{a}	572^{ab}	$6,18^{b}$	7.21^{c}	7.34^{c}	0.8765
Sperm abnormality	70^{a}	65^{ab}	53^{b}	28^{c}	20^{c}	2.9649

a, b, c, d; values along the same row with different superscripts are significant ($p < 0.05$)
S.E = Standard error

The reproductive parameter is shown in Table 5. The semen colour was milky with increased mass activity, motility, and sperm concentration but decreased abnormality across the tested groups. The effects of EMR on the mass motility and concentration of the semen of the animals exposed were an increase in its activity ($p<0.05$). The values of the Groups I, II, and III are similar ($p>0.05$) but differ ($p<0.05$) from Groups II and I. The abnormality was significantly higher ($p<0.05$) following EMR exposure. The observation in the study indicated that electromagnetic fields (EMF) increase free radical activity in cells (Lai and Singh 1997; Simkó *et al* 2007), through Fenton reaction (Lai and Singh, 2004), The Fenton reaction is a catalytic mechanism of iron converting hydrogen peroxide, a result of oxidative respiration in mitochondria, into a hydroxyl free radical, which is a very potent and harmful free radical and thus affects DNA by an indirect secondary process. The use of mobile phones by men is associated with reduced semen content, sperm count, motility, viability, and normal morphology and is related to cell phone use (Agarwal *et al.*, 2006).

However, the level of harm is likely to increase with the exposure time (Forgacs e*t al.*, 2006). Hales *et al.* (2005) documented oxidative stress at the level of the testes that is capable of disrupting the steroidogenic genotoxicity of the Leydig cells and the ability of germinal epithelium to differentiate normal spermatozoa (Naughton *et al.*, 2001). Results show that the semen features were compromised by the EMR. The result obtained from this work explains the restlessness observed in the treated Groups, which is in line with the interference of mobile phones with brain modulation associated with continuous use of the phone (Eberhardt *et al*. 2008). The observed decrease in sperm concentration following exposure to radiation and the accompanying steady proportion of abnormal spermatozoa indicated that the radiation had an adverse effect on the spermatogenic cells. This could be due to the presence of gamma rays, which could affect the epididymal sperm and spermatogenic efficiency due to an effect on the testes (La Vignera *et al*., 2012). The increase in spermatozoa abnormalities in this study indicates that the EMR caused a high destruction of spermatozoa and inhibited the maturation of sperm cells. The findings of this study indicate that long-term exposure to low-intensity (pulsed) electromagnetic radiation from GSM base stations can have major effects on populations of WAD bucks, as reported for wild birds (Fernie & Reynolds, 2005).

CONCLUSION

The present research found that the effects of electromagnetic field exposure on animals depend on distance and time. This finding suggests that the mechanism(s) that regulate the body's fuel may be affected by RF-ELF, with the subsequent production of potentially harmful electromagnetic fields (EMF) following heat and activation of the inducible form of nitric oxide (NO) synthase, may be the source of the biological effects of EMF exposure found in this research. The results may therefore corroborate and justify some of the health problems encountered by settlers living near telecommunications base stations and fairly manifested on internal organs found in ionizing radiation studies. The study showed that the reproductive organs of WAD bucks were significantly disrupted and may have a similar impact on higher mammals. It is proposed that more research be performed on the long-term impact of telecommunications RF-EMR on other animal species. The ionizing variety can be undesirable because it can cause DNA damage and mutations, so we should all restrict our exposure to its sources, radioactive materials, and solar radiation, among them. Based on the findings, we recommend residential buildings should be a minimal distance of >350m from the base stations.

Conflict of interest
The author declares no Conflict of interest

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