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TV AND RADIO BROADCAST ELECTROMAGNETIC RADIATIONS ANALYSIS ON THE MALE SPERM INFERTILITY

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Abstract: ***A hazardous effect on male fertility may be manifested by a decrease in the amount of sperm cells, disorders in their mobility, as well as structure. In this study; the analysis has been done on the impact of electromagnetic radiations on the male sperm infertility by considering the radiations from broadcasting antenna to the testis by variations of electromagnetic field with the distance from the broadcasting towers. It was found that; there is significant effects brought by radiations for those who are living close to the broadcasting towers due to the fact that electromagnetic energy from towers are being converted into thermal (heat) energy which is absorbed by the testis issues and hence cause the sperm infertility in terms of sperm count, sperm motility and any other associated effects. The SAR values was observed to decrease as one moves far away from the towers. So regulatory authorities should set safe distance before broadcasting operators erect/build their broadcasting infrastructures.***

Keywords: *Broadcasting antenna, electromagnetic radiations, Male sperm, infertility, Sperm motility, radio waves, Specific Absorption Rate (SAR).*

I. INTRODUCTION

Infertility is defined as inability to conceive after a year of sexual intercourses without the use of contraceptives. In half of the cases the causative factor is the male. Males are exposed to the effect of various environmental factors, which may decrease their reproductive capabilities. A decrease in male fertility is a phenomenon which occurs within years, which may suggest that one of the reasons for the decrease in semen parameters is the effect of the development of techniques in the surrounding environment. A hazardous effect on male fertility may be manifested by a decrease in the amount of sperm cells, disorders in their mobility, as well as structure. The causative agents may be chemical substances, ionizing radiation, stress, as well as electromagnetic waves.[1]

Broadcasting is the distribution of audio and video content to a dispersed audience via any audio or visual mass communications medium, but usually one using electromagnetic radiation (radio waves). The receiving parties may include the general public or a relatively large subset thereof. Broadcasting has been used for purposes of private recreation, non-commercial exchange of messages, experimentation, self-training, and emergency communication such as amateur (ham) radio and amateur television (ATV) in addition to commercial purposes like popular radio or TV stations with advertisements.[2]

The purpose of radio and television transmitter stations is to provide full coverage for television, radio, and multimedia broadcasting services. Long ranges are achieved through high-power transmissions, but the resulting high field strengths affect the environment. The move from analog to digital broadcasting methods does not result in any real change in this situation, although a tendency to lower field strengths has been reported.[3]

Broadcast towers are used for transmitting a range of services including AM and FM radio and UHF, VHF and digital television. The tower will either act as an antenna itself or support one or more antennas on its structure, including microwave dishes.

In Tanzania, the use of mobile phones has increased considerably in recent years and it is as an essential means of communication in commerce and society. Currently there are seven cellular phones operators with more than 4,000 base stations distributed all over the country. The number of mobile phone users has increased from 10 million in 2008 to more than 26 million by February 2012. A high increase in the number of radio stations (82) and TV stations (26) served by 55 transmitting towers was also observed during the same period. The increase in these communication systems has resulted into increased public anxiety over possible adverse health effects due to electromagnetic fields (EMF) radiated by these equipment.[4]

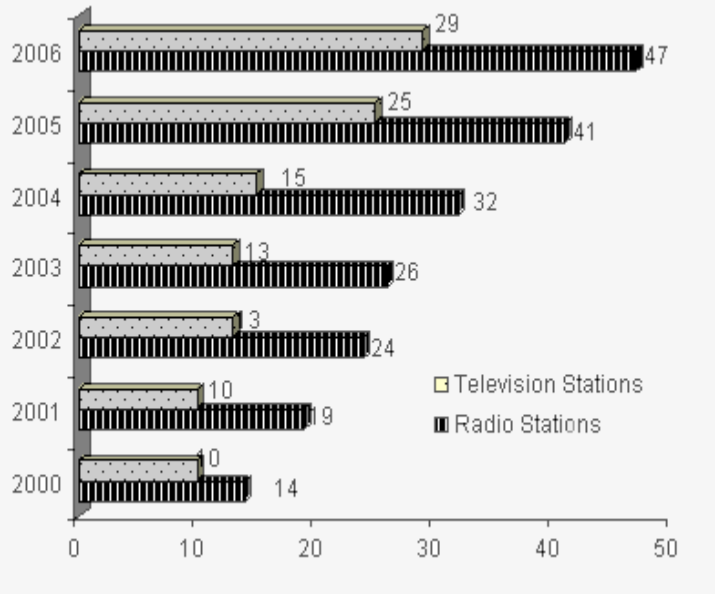


Figure 1: Statistical figure showing the number of TV and radio stations up to 2006(TCRA report 2008)

Heating is the primary interaction of RF fields at high frequencies, above about 1 MHz.

There are many animal studies that show that electromagnetic waves have a wide range of damaging effects on the male reproductive system and sperm parameters. However, similar studies are quite limited in humans, and the results of animal studies should be interpreted with caution when considering their application to humans. One of the biggest concerns is their possible association with increased risk of cancer and their possible effects on cellular DNA. Electromagnetic waves can inflict their results through both thermal and non-thermal effects.[5]

According to [6]; there are data suggesting that EMR emitted by cellular phone influences human sperm motility. In addition to these acute adverse effects of EMR on sperm motility, long-term EMR exposure may lead to behavioral or structural changes of the male germ cell. These effects may be observed later in life, and they are to be investigated more seriously.

Thermal and non-thermal effects are the main mediators of EMW interaction with biological system and both the electrical and magnetic properties determine sequelae of such effects on human body. Specifically, both electrical fields and magnetic fields can induce electrical fields and currents inside living tissues. However, the generated internal electrical currents are of much lower strength and of different directions from the external ones. These alterations in strength and directions reflect the electrical properties of human body, such as the permittivity and conductivity. To understand these properties, human tissue is best described as lose medium with dielectric properties due to high content of water in addition to other organic molecules and ions. When living tissue is exposed to EMW the dielectric (dipole) molecules will be polarized, the extent of such polarization is called permittivity. Conductivity, on the other hand, describes the conduction current density produced by an applied electrical field. Essentially, the high water content renders human body poor conductor to the applied electrical field. In contrast, the applied magnetic field is easily transmitted through human body and this property is called permeability[7, 8]

Calcium ion efflux/influx is an established biological effect of EMR exposure and it changes the biological response of cells. Because modulation frequencies are critically involved, and low intensity exposures are observed under some circumstances to produce greater effects than some higher exposure conditions, resonant interactive processes are indicated and heating is definitely not involved except to establish a homeostatic range.[9]

The most common causes of male infertility are related to sperm usually problems with sperm count and the quality of that sperm. Sperm-related problems includes low sperm count, sperm that don't move quickly enough they die before they reach the egg, sperm that are not formed correctly, seminal fluid that is too thick sperm can't move around in it very easily and no sperm. Heat can have a detrimental effect on normal sperm production. Too much time spent soaking in a hot tub can raise the temperature of the testicles and interrupt sperm production.[10]

II.GENERAL OVERVIEW

A. BROADCAST RADIATIONS AND HEALTH EFFECTS

VHF/UHF radio and TV towers are placed on the highest point in an area so the transmitted signal has a clear path to receiving antennas. The transmitted antenna pattern is designed so that the radiating beam is projected away from the tower almost horizontally so that as much area as possible is covered. This minimizes the signal strength at ground level near the tower. Broadcast towers produce weak RF EME exposure levels in the everyday environment.

The power of AM transmitters range from 250 watts (serving only one or two towns) to 50,000 watts (can be heard over 1,000 miles away). FM transmitters range from 100 watts (15 miles broadcast) to 100,000 watts (65 miles). This shows how FM radio signals still travel less than 10% the distance of AM stations with ½ the power. Each station broadcasts on a different frequency, which keeps stations from interfering with each other's broadcast. AM stations broadcast on frequencies from 535 to 1605 kilohertz, while FM stations broadcast on frequencies between 88 to 108 megahertz. Programs carried by radio waves travel at the speed of light, instead of the slower speed of sound. Transmission of video signals is based on amplitude modulation, with high-frequency electromagnetic waves acting as the carrier waves to be modulated. This produces the video part of the television signal, which is then amplified to a power of 1,000 to 10,000 watts.[11]

When a radio frequency electromagnetic field in air impinges on a biological body it is reflected, transmitted, refracted or scattered by the biological body; the refracted and scattered fields may proceed in directions different from that of the incident RF field. These phenomena are described and governed by the well-known Maxwell's equations of electromagnetic theory. The transmitted and refracted fields from the RF exposure induce electric and magnetic fields in the biological systems that interact with cells and tissues in a variety of ways, depending on the frequency, waveform, and strength of the induced fields and the energy deposited or absorbed in the biological systems. Thus, to achieve a biological response, the electric, magnetic or electromagnetic field must couple into and exert its influence on the biological system in some manner, regardless of what mechanism(s) may be accountable for the response.[12]

Because the FM and TV antennas have been designed to radiate a disc-like beam pointed slightly below the horizon, radiation towards vertical direction along the tower is much

smaller than towards the main beam which is normally inaccessible. Typically the most hazardous area is confined to a distance of about 15 m from the dipoles. Statistical analysis of the measurement showed an increase in mean exposure in the center of the DVB-T starting areas which was mainly based on the increase in the radiated power at the transmitter stations. The maximal exposure value for analogue TV in the 'before' measurement was 0.9 mWm-2 and 6.5 mWm-2 in the 'after' measurement for DVB-T. A comparison of analogue FM radio and DAB showed that FM exposure was more than a factor of 10 higher. However, planned increase of DAB transmitter power to improve DAB indoor coverage will reduce this difference. Relatively high body average electric field up to 200 V·m-1 (100 W·m-2) has been measured in Finland inside a relatively small digital TV antenna.[13]

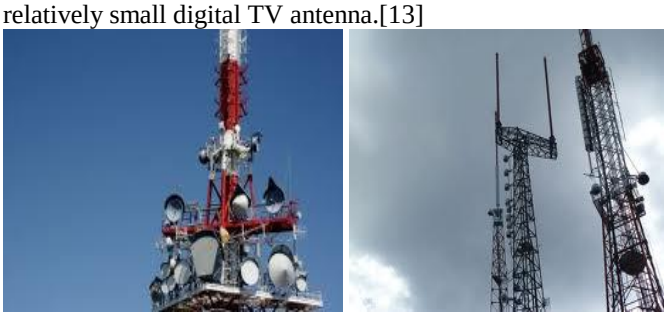


Figure 2 : Radio and TV broadcasting antennas [14]

Around broadcast towers the ground level exposure patterns are a function of the power of the source signal and the antenna gain, the gain, expressed as a function of the Equivalent Isotropic Radiated Power (EIRP) is a function of the technology used to focus the signal. Antennae are complex elements that attempt to efficiently focus the main beam and minimize the side-lobes. The ability to do this to some extent is a function of the carrier frequency. Because of these side-lobes a complex antenna pattern is formed with undulating peaks in the 'near field' towers, which typically extends out to 5 to 6 km. [15]

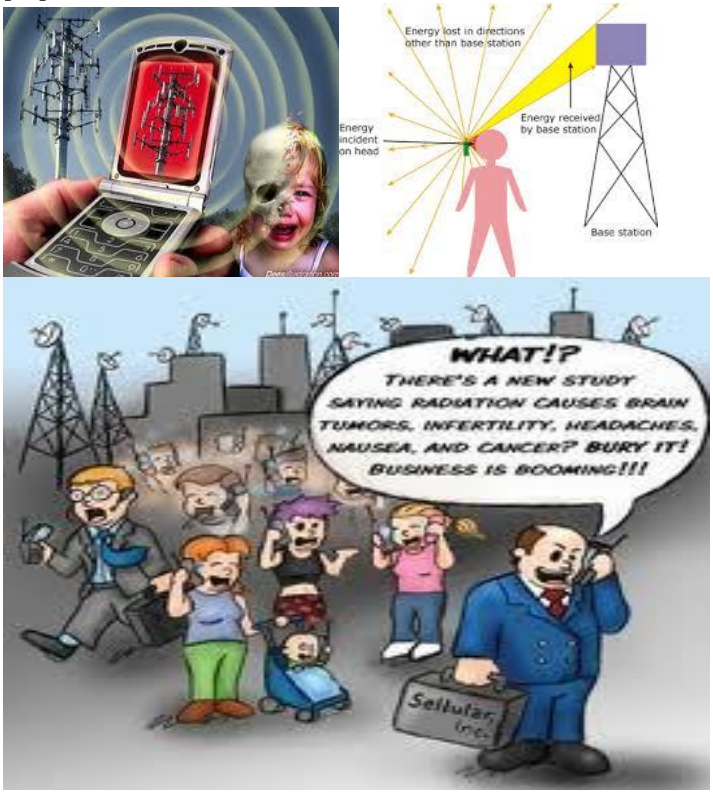


Figure 3: Different pictures showing the electromagnetic radiations from broadcasting towers[16]

High exposure levels that raise the temperature outside the homeostatic range will produce no effects. Hence only non-thermal exposures produce these effects. Thus people are moving through constantly changing fields at home, at work and in the environment. They pass through windows of effect and no effect all the time. The cumulative effect of the 'effect' windows produces dose-response increases in health effects associated with extremely low mean exposures. The calcium ion effects are shown in brain tissue and heart muscle tissue, implicating neurological and cardiac effects. Ca2+ efflux from pinealocytes (cell in the pineal gland) is likely to reduce melatonin production. This has implications for many kinds of sickness, cancer, miscarriage, neurological disease etc. because melatonin is a very potent free radical scavenger.[17]

There is also robust evidence that there is a causal relationship between sleep disturbance, depression, suicide and brain cancer from chronic exposure to electromagnetic fields and radiation. The symptoms of radiofrequency or microwave syndrome must not be dismissed as simply subjective reactions. They are real and biologically sensible responses of an electromagnetic organ to electromagnetic interference. All of these symptoms and disease rates are being enhanced by electromagnetic fields of homes, radiofrequency fields and radio and TV towers and the extensive installation of cell sites and the use of cellular telephones.[18]

According to [19]; there are possible bio-effects of RF fields at the molecular level which are:

1) Thermal effects due to the dielectric heating phenomenon that is typical of nonionizing radiation (NIR), such as microwaves. NIR has not sufficient quantized energy to interact with the outer orbitals of atoms and break intra- or extra-molecular bonds, so radiation-induced agitation of polar molecules accounts for temperature enhancement as its only plausible effect. This has been well established to occur, even for very small temperature changes, since cells have a complex mechanism to respond to them, including molecular cascades, heat shock proteins, etc. With exposure to large temperature changes for a sufficient time, denaturation of some molecules, such as proteins, may ensue. For small thermal heating, which might occur when cells are exposed to low-level RF, only indirect effects such as these are plausible and they have been sufficiently well documented;

2) Non-thermal effects have been theoretically proposed as other interaction mechanisms not due to direct or indirect increases in local temperature. A large number of these models have been proposed and experimentally studied in *in vitro* preparations. A number of authors have claimed that they could be demonstrated, but this is still an open debate in the scientific community, since many studies have also been unable to demonstrate that they exist. In many cases, it has been argued that these effects are actually due to normal responses of living cells to heating. As shown below, of all non-thermal effects that have been reported to occur in cells, such as changes in enzyme levels, none have been shown to have any health consequence, since the body easily compensates for them.

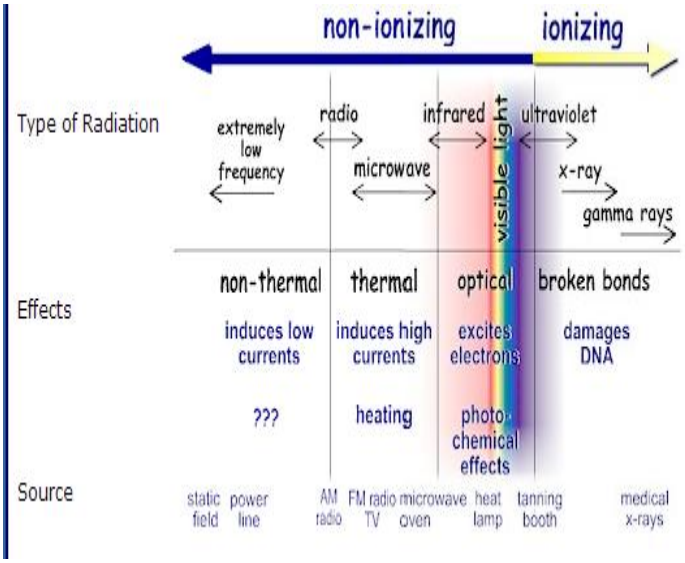


Figure 4: Showing the types of radiations in electromagnetic spectrum[20]

The amount of RF energy to which the public or workers might be exposed as a result of broadcast antennas depends on several factors, including the type of station, design characteristics of the antenna being used, power transmitted to the antenna, height of the antenna and distance from the antenna. Since energy at some frequencies is absorbed by the human body more readily than energy at other frequencies, the frequency of the transmitted signal as well as its intensity is important.[21]

The power received from transmitting power can be found by considering the power density radiated from it through the following formula;

$$S_{av} = \frac{P_t * G_t}{4 * \pi * d^2} \qquad (1)$$

Where:

S_{av} = Radiated power density from cell phone tower

P_t = Power transmitted from cell phone tower

G_t = Gain of the transmitter

d = distance from the transmitting antenna to the rece

$EIRP = P_t \times G_t$

Where $EIRP = Effective\ Radiated\ Isotropic\ power.$

So the average power received by human body is computed by:

$$P_r = S_{av} * A_{eff} \qquad (2)$$

Where

A_{eff} = Area of the human body(In this case, it is assumed to be cylindrical)

So, principally knowing the gain of the transmitting antenna, power transmitted from cell phone towers and the distance from the location of the cell tower to where the human being is, it could be simple for anybody to know the extent of exposure he/she is having to electromagnetic radiation. And when this received power is known, then it could be also simple to determine the SAR. The effects of electromagnetic radiation can easily be analyzed by considering the threshold values of the specific absorption rates(SAR) in which the factors like Electric field intensity(E) though relative dielectric constant(ε), electric conductivity(σ) and the mass density(ρ) are considered. The SAR in W/Kg can be found by:

$$SAR_{(i,j,k)} = \frac{\sigma_{(i,j,k)} * (E_{(i,j,k)})^2}{\rho_{(i,j,k)}} \qquad (3)$$

E is the electric field magnitude in V/m, σ is the material conductivity in S/m and ρ is the mass density in kg/cubic meters.

Also the SAR can be determined by the following relationship

$$SAR = C_p \, {dT}/{dt} \qquad (4)$$

Where c is specific heat, *d*T is rise in temperature, and *d*t is a short time period, So the rise in temperature in a specified duration may cause to the raise of SAR.

The SAR values always decreases when the exposed skin get or move away from the radiating cell tower antenna. So the tissues around the nearby cellphone towers are more exposed compared to the tissues which are far away from the radiating cell tower antenna.

B. MALE REPRODUCTIVE SYSTEM AND FERTILIZATION

In simple terms, reproduction is the process by which organisms create descendants. This miracle is a characteristic that all living things have in common and sets them apart from nonliving things. But even though the reproductive system is essential to keeping a species alive, it is not essential to keeping an individual alive.

In human reproduction, two kinds of sex cells or gametes are involved. Sperm, the male gamete, and a secondary oocyte (along with first polar body and corona radiata), the female gamete must meet in the female reproductive system to create a new individual. For reproduction to occur, both the female and male reproductive systems are essential. It is a common misnomer to refer to a woman's gametic cell as an egg or ovum, but this is impossible. A secondary oocyte must be fertilized by the male gamete before it becomes an "ovum" or "egg".

While both the female and male reproductive systems are involved with producing, nourishing and transporting either the oocyte or sperm, they are different in shape and structure. The male has reproductive organs, or genitals, that are both inside and outside the pelvis, while the female has reproductive organs entirely within the pelvis.

The male reproductive system consists of the testes and a series of ducts and glands. Sperm are produced in the testes and are transported through the reproductive ducts. These ducts include the epididymis, ductus deferens, ejaculatory duct and urethra. The reproductive glands produce secretions that become part of semen, the fluid that is ejaculated from the urethra. These glands include the seminal vesicles, prostate gland, and bulbourethral glands.

Because the testis is a superficial organ, it may absorb more EMW energy than other organs. Human testes need physiological temperature 2ºC lower than body temperature for optimal spermatogenesis and an elevation of testicular temperature may be reversible detrimental factor to sperm production[22]

The scrotum is contained within the abdominal cavity in the embryonic stage. Shortly before birth, they come down and remain outside throughout life. This is because the testes cannot produce sperms at the body temperature. A temperature

2-3 degrees lower is ideal for the production of sperms. The scrotal sacs hang loose when it is hot and when it is cold the skin of the scrotal sacs contracts and this keeps them in close contact with the body.[23]

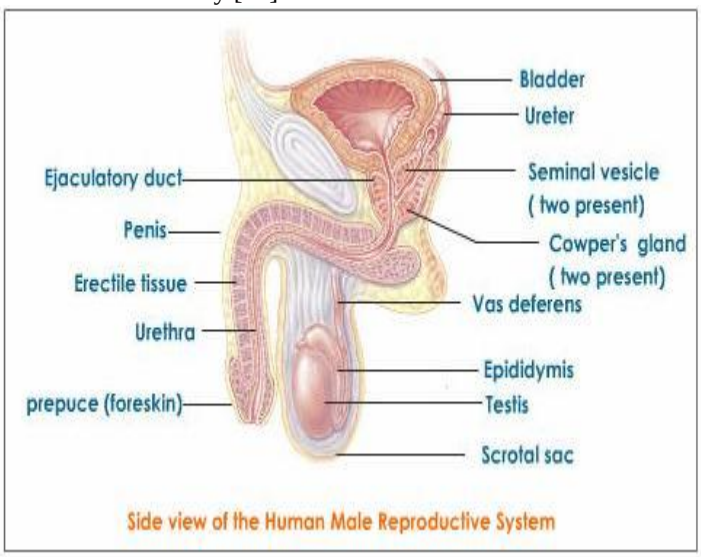


Figure 5: The human male reproductive system[23]

The sperm is the main reproductive cell in males. The sperms differ in that each carry a set of chromosomes dividing each into either a male, or female sperm. The females differ in that they carry a X gene, while the male sperm carry a Y gene. The female sperm also differ phenotypically in that they have a larger head in comparison to the male sperms. This contributes to the male sperm being lighter, and therefore faster and stronger swimmers than their female counterparts (although statistically there is still a 50% chance of an either XY or XX embryo forming.

Spermatozoan stream lines are straight and parallel. The tail flagellates, which we now know propels the sperm cell (at about 1-3 mm/minute in humans) by rotating like a propeller, in a circular motion, not side to side like a whip. The cell is characterized by a minimum of cytoplasm. During fertilization, the sperm's mitochondria gets destroyed by the egg cell, and this means only the mother is able to provide the baby's mitochondria and mitochondrial DNA, which has an important application in tracing maternal ancestry. However it has been recently discovered that mitochondrial DNA can be recombinant.

Spermatozoa are produced in the seminiferous tubules of the testes in a process called spermatogenesis. Round cells called spermatogonia divide and differentiate eventually to become spermatozoa. During copulation the vagina is inseminated, the spermatozoa move through *chemotaxis* to the ovum inside a Fallopian tube or the uterus.

Fertilization is the process by which a sperm combines with an oocyte, or egg cell, to produce a fertilized zygote. The sperm released during ejaculation must first swim through the vagina and uterus and into the fallopian tubes where they may find an oocyte. After encountering the oocyte, sperm next have to penetrate the outer corona radiata and zona pellucida layers of the oocyte. Sperm contain enzymes in the acrosome region of the head that allow them to penetrate these layers. After penetrating the interior of the oocyte, the nuclei of these haploid cells fuse to form a diploid cell known as a zygote. The zygote cell begins cell division to form an embryo.[24]

Male infertility is the inability to cause a pregnancy and often is due to low sperm count.

The most common causes of male infertility are related to sperm usually problems with sperm count and the quality of that sperm.

Sperm-related problems includes low sperm count, sperm that don't move quickly enough they die before they reach the egg, sperm that are not formed correctly, seminal fluid that is too thick sperm can't move around in it very easily and no sperm. Heat can have a detrimental effect on normal sperm production. Too much time spent soaking in a hot tub can raise the temperature of the testicles and interrupt sperm production.[25] Sperm-related problems may result from too much or too little of some of the hormones that guide sperm making. Another cause of male infertility is a problem with ejaculation. In some cases, tubes inside the male reproductive organs are blocked. If so, you may have a hard time ejaculating, or nothing comes out when you have an orgasm. Sometimes, the ejaculation goes backward from the prostate into the bladder instead of out of the body.

III. METHODOLOGIES

The biological effects of electromagnetic radiation are studied through investigations and research such as numerical bio-electromagnetic modelling, experimental (*in vivo* and *in vitro*) investigations and epidemiological studies.
Various power and frequencies for TV, AM and FM radio waves were used in simulating the results to find the electric and magnetic fields variation using FEKO simulating software.
A multidisciplinary approach is crucial to obtain relevant information on the biological effects. The technical sources of radiation and their key features are best known to the engineers engaged in their design, while the process of propagation and absorption is analyzed by applying the physical laws of propagation, technical methods of analysis and simulation[26].
In order to determine the biological effects of electromagnetic waves electromagnetic radiation it is extremely significant to define the amount of absorbed energy of the incidental wave and its distribution in the volume of the object.
It is rather difficult to recreate the real internal structure of tissues and organs. That is why we apply simplified organ and tissue modelling. This makes it possible to model tissues from homogeneous layers that constitute the skin, subcutaneous tissue, bones, skulls, etc., whereas organs are modelled as ellipsoidal structures resembling for instance the brain, eyes, kidneys, or stomach. Such models are suitable for use in numerical simulation programs alongside source models (mobile phones, broadcasting antennas, etc.). [26]
The obtained results of the field components, absorbed energy and SAR values in such models, although numerically correct, are not very useful for medical professionals since these results cannot be easily associated with biological effects.[27] This is due to the fact that they do not entirely reflect the true structure, thus making it difficult to localize anatomical structures. For example, in a descriptive model of the head, it is not possible to locate the pineal gland and calculate the amount of energy absorbed in it, although some studies have indicated

that the pineal gland is particularly sensitive to the effects of electromagnetic radiation

The author assumes that; it is possible to link the results of modelling absorbed energy in tissues with the real structure of the tissue, and thus locate the parts of tissue where the biological effects of radiation can be seen. For example in this case; I assume that the tissue present in testes are the investigative parts which can give us the required simulated results.

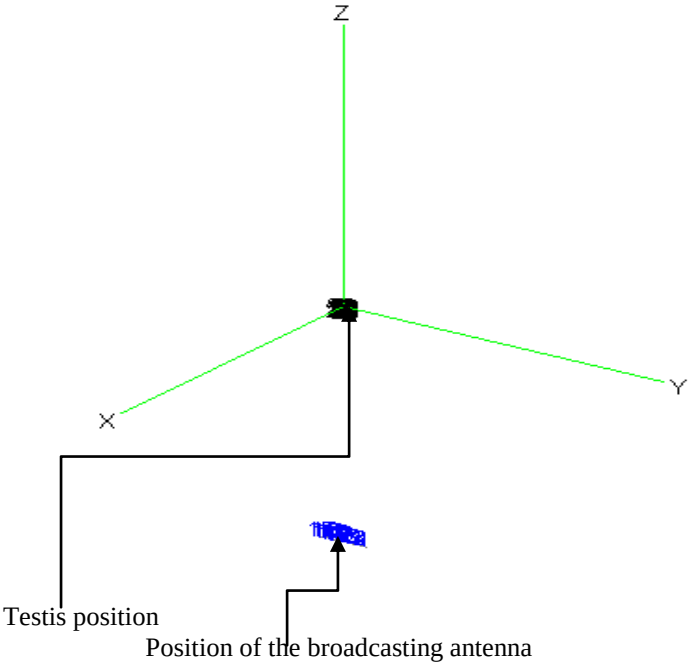


Figure 6: Simulated diagram showing the position of the testis from the broadcasting TV, AM and FM antennas

IV. RESULTS AND DISCUSSION

After going through the methodologies above, analysis has been done on the experimental values obtained through the use of FEKO software after varying the distances of the broadcasting antennas to the position of the testis for TV, AM and FM signals, with different power and operating frequencies of the TV, AM and FM inserted.

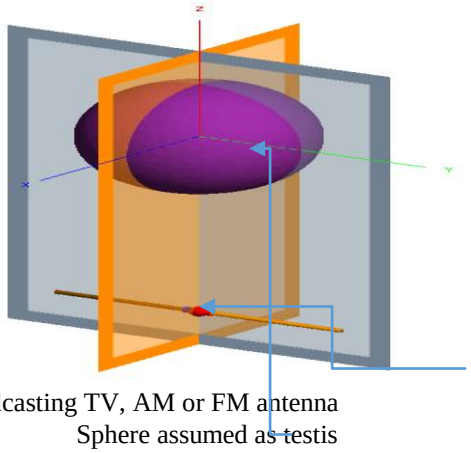
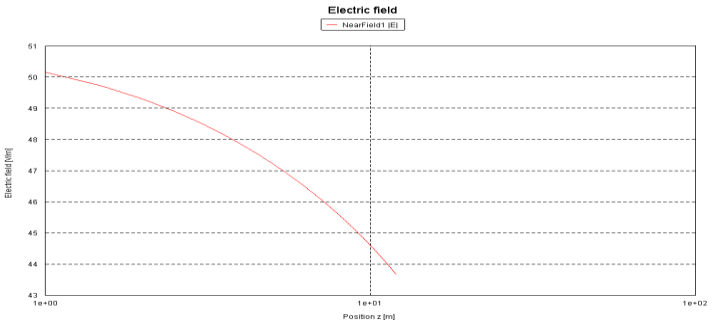


Figure 7: Showing the setup of the experiment analysis of the radiation effects on testis



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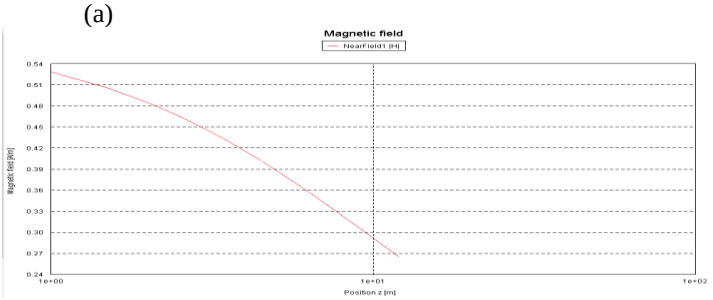

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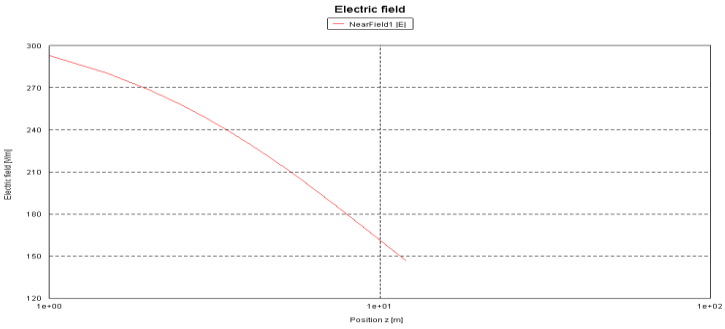
Figure 8: Graphs showing the variation of electric and magnetic fields with distance between the testis and the broadcasting antennas for AM radio waves.



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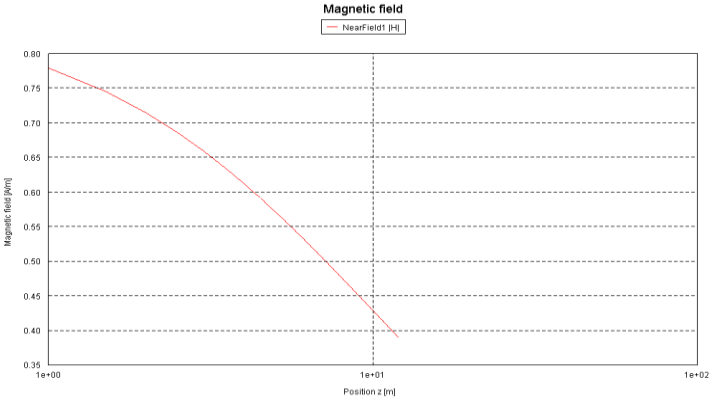

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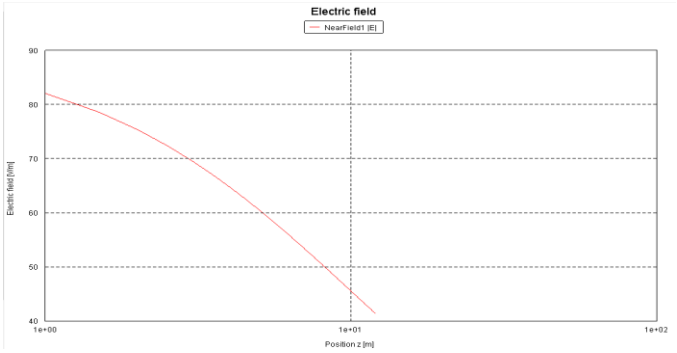
Figure 9: Graphs showing the variation of electric and magnetic fields with distance between the testis and the broadcasting antennas for FM radio waves.



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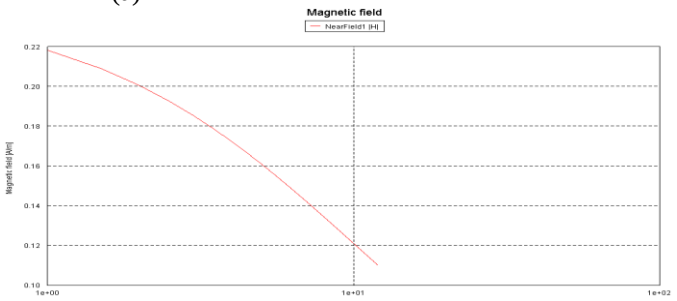

(b)

Figure 10: Graphs showing the variation of electric and magnetic fields with distance between the testis and the broadcasting antennas for TV radio waves.

From the graphs above; it is observed that whenever the distance between the broadcasting tower and the testis position decreases then the electric field absorbed by the testis increases which eventually increases the SAR of the testis by considering the fact that, the SAR of the body is directly proportional to the square of the electric field ($SAR \propto |E|^2$) where E= electric field intensity in V/m. It is also observed that; there is an inversely proportional relationship between the magnetic field and the position (or distances) as when one variable increases, the other decreases and since magnetic field intensity is directly proportional to the electric field then that means the SAR also directly relate to the magnetic field so the increase in magnetic field intensity causes to the increase in SAR of the testis and which finally causes the male sperm infertility if exposed for a while.

V. CONCLUSION

From theoretical point of view, it is clearly known according to the law of conservation of energy that energy cannot be created nor destroyed but it can be converted from one form to another. In this study; the electromagnetic energy is easily converted to thermal or heat energy and thus can disturb sperm production which will eventually lead to low sperm count and hence cause infertility problem, also this thermal energy can lead to the reduced sperm motility which also contributes to infertility as the sperm speed is being reduced to the extent that it can struggle to reach the female egg for ovulation. Since there is energy absorbed by testis tissues during radiation (received power from the TV, AM and FM broadcasting towers also found as the product of radiation power density times effective area of the testis), this energy is related to SAR values through electric fields. The SAR values always decreases when the exposed skin/tissues get or move away from the radiating TV, AM or FM broadcasting towers or antennas. So the tissues of the people (male) around the nearby towers are more exposed compared to the tissues of the people (male) which are far away from the radiating mobile towers antenna. So living close to the broadcasting towers can lead to male sperm infertility.

VI. RECOMMENDATIONS

From this study, I recommend that the regulatory authorities should restrict the broadcasting operators to erect/build their towers nearby surroundings where people are living because if you are living on the main beam of broadcasting antennas or towers then you are exposed to comparatively high radiation levels and they should provide the safe distance to build those towers. Also avoid wearing tight underwear as they increase scrotal temperature which causes the decrease in sperm production and hence cause infertility.

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