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Analysis of the Impact of Electromagnetic Radiations from Cell Phones on Male Sperm Infertility

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Abstract- Tanzania telecommunication sector has witnessed fast growth in the number of mobile telephone users now served by seven cellular operators. Until February 2012, there were about 26 million mobile phone subscribers served by more than 4,000 base stations spread all over the country. Despite the many advantages brought by these systems, there is increased public concern over possible adverse health effects due to electromagnetic fields (EMF) radiated by these equipments. This paper aimed to analyze the impact of the electromagnetic radiations from cellular phones to male sperm infertility. The cellular phones with operating frequency of 900MHz and operating frequency 1800MHz were placed at a certain distance near the male reproductive organ (testis) and then electromagnetic wave radiated by the phone were analyzed by measuring the SAR of the testis. It was concluded that there is significant impact on the male sperm fertility on the exposure of the male reproductive organ to the radiations from the cellular phones at the specified operating frequencies near the testis. Several recommendations has been provided, that radiating devices should not be placed on the male pocket trouser for storage and also making calls while the cell phone is in pocket trouser (ie using headphones to receive or make a call) should be completely avoided.

Index Terms- Specific Absorption Rate (SAR), Electromagnetic radiation (EMR), cell phones, male sperm fertility, sperm count.

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]

Despite the relative importance of infertility due to the male, infertility evaluations have traditionally focused on women, because women tend to seek gynecological care and

because men often are reluctant to seek advice. A variety of disorders ranging from hormonal disturbances to physical problems, to psychological problems can cause male infertility. Although many treatment options are now available, in many cases treatment will not work. In many instances, male infertility is caused by testicular damage resulting in an inability of the testicle to produce sperm. Once damaged, the testicle will not usually regain its sperm-making capabilities; this aspect of male infertility is analogous to menopause (though not natural like menopause) for women and cannot usually be treated. Despite medicine's limited ability to treat male infertility, many successful treatment options are available for its many causes. Besides testicular damage, the main causes of male infertility are low sperm production and poor sperm quality.

Radiofrequency (RF) energy is a type of nonionizing radiation, including EMR produced by cellular phone, and is not strong enough to cause ionization of atoms and molecules.[2]

Cellular phones emit low levels of RF in the microwave range while being used. Although high levels of RF can produce health effects (by heating tissue), exposure to low-level RF may not produce heating effects and causes no known adverse health effects. Several experimental studies demonstrated that exposure to electromagnetic or static magnetic fields had adverse effects on the reproductive system. [3]

Cell phones transmit and receive microwave radiation at frequencies which excite rotation of water molecules and some organic molecules, associated with thermal effects and non-thermal effects. The thermal effects includes headache, sensation of warmth or burning around the ear, burning sensation on the facial skin and alteration of the blood-brain barrier. [4]

In recent times there has been some controversy over the impact of electromagnetic radiation on human health. The significance of mobile phone radiation on male reproduction is a key element of this debate since several studies have suggested a relationship between mobile phone use and sperm quality.

The evaluation of the effect of mobile telecommunications on the state of human health is a difficult issue, which results from the fact that there is a problem with isolating from various environmental factors the particular one that may be caused by electromagnetic waves emitted by mobile phones. In addition, waves of the same frequency waves emitted by phones in association with other factors should also be considered. It may be presumed that people who intensively use phones more often perform sedentary work. This is conducive for the elevation of temperature in the region of the scrotum, and infertility. People

who talk on the phone, to a greater degree may be exposed to stress, which by affecting the level of cortisol, prolactin and testosterone may contribute to the decrease in the concentration of the semen. [5]

Figure 1: Different pictures showing the biological effects caused by electromagnetic radiation from cellular phones

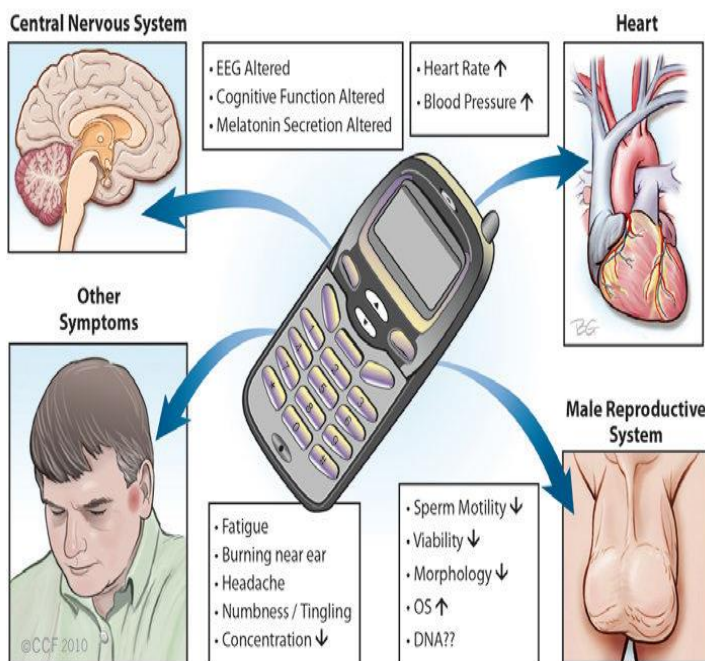


Figure 2: Effects of Cellular Phone Usage on the Human Body. Usage of cellular phones is associated with alterations in various body systems including the central nervous system, cardiovascular system, and male reproductive system. Taken from Makker 2009[8]

II. CELL PHONES ELECTROMAGNETIC RADIATION IN RELATION TO MALE BIOLOGICAL EFFECTS.

The Tanzania telecommunication sector has witnessed fast growth in the number of mobile telephone users now served by seven cellular operators. Until February 2012, there were about 26 million mobile phone subscribers served by more than 4,000 base stations spread all over the country. A considerable increase in the number of FM radio (82 stations) and TV (26) stations has also been observed. These are served by about 55 transmitting towers. Increase in other sources such as Radar was also noticed. Despite the many advantages brought by these systems, there is increased public concern over possible adverse health effects due to electromagnetic fields (EMF) radiated by these equipments.[6]

During recent years there has been increasing public concern on potential health risks from power-frequency fields (extremely low frequency electromagnetic fields; ELF) and from radiofrequency/microwave radiation emissions (RF) from wireless communications. Non-thermal (low-intensity) biological effects have not been considered for regulation of microwave exposure, although numerous scientific reports indicate such effects. Health endpoints reported to be associated with ELF and/or RF include childhood leukemia, brain tumors, genotoxic effects, neurological effects and neurodegenerative diseases, immune system deregulation, allergic and inflammatory responses, breast cancer, miscarriage and some cardiovascular effects. Regarding ELF a new lower public safety limit for habitable space adjacent to all new or upgraded power lines and for all other new constructions should be applied. A new lower limit should also be used for existing habitable space for children and/or women who are pregnant. A precautionary limit should be adopted for outdoor, cumulative RF exposure and for cumulative indoor RF fields with considerably lower limits than existing guidelines. The current guidelines for the US and European microwave exposure from mobile phones, for the brain are 1.6 W/Kg and 2 W/Kg, respectively. Since use of mobile phones is associated with an increased risk for brain tumor after 10 years, a new biologically based guideline is warranted.[7]

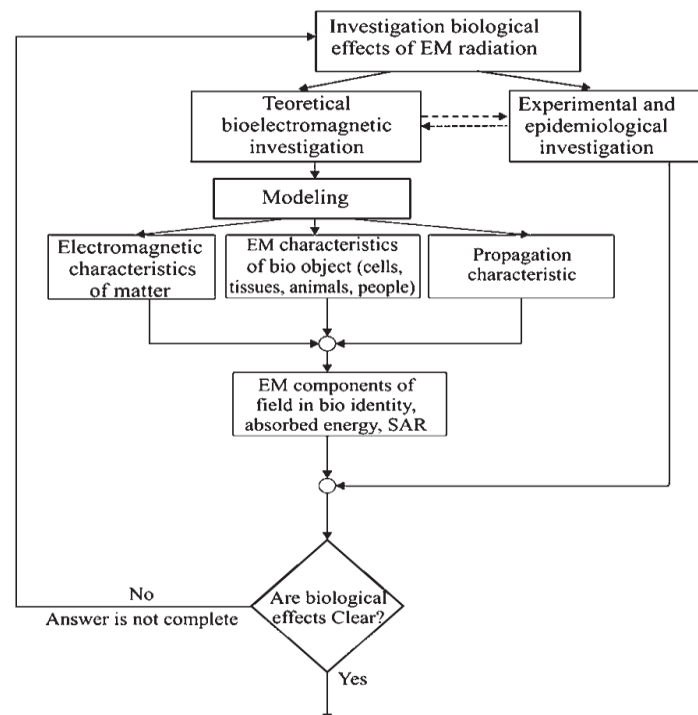


Figure 3: The function algorithm for the research of biological effects of EM radiation according to[9]



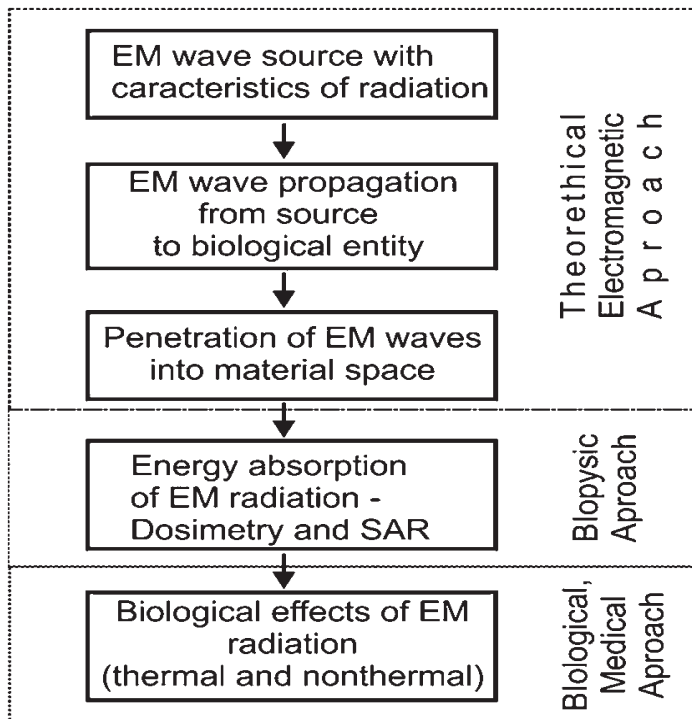


Figure 4: The procedure of examining biological effects of EM radiation emitted from the source of known characteristics according to [9]

Radio frequency electromagnetic radiation (RF-EMF) as produced by mobile phones, like all other forms of electromagnetic radiation cause enough of disruption to our body's cells and physiological functions to warrant real caution in the use and protection against its negative health and fertility outcomes in both men and women.

There are 2 major ways in which mobile phone radiation may impact *infertility*:

1. It disrupts the hypothalamic, pituitary, thyroid, ovarian/testicular axis, which ensures optimum reproductive function – thus affecting male and female reproductive function, with sperm being most heavily affected but women also need to be very cautious because a hypothalamic/ovarian axis disruption can cause ovulatory and fertility challenges of their own kind;
2. The electromagnetic waves emitted by these devices has a direct, physical, oxidative impact on the cells in close proximity to the radiating device.[10]

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).

The radiation source of the cellular phone can be modelled by an equivalent dipole antenna. After obtaining the induced electric field by the FDTD method, the local SAR in W/Kg for:

$$SAR(i,j,k) = (\sigma(i,j,k)|E(i,j,k)|^2)/\rho(i,j,k)$$

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
 $SAR = c_p dT/dt$

Where c is specific heat, dT is rise in temperature, and dt 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 radiotelephone antenna. So the tissues around the nearby cellphone devices are more exposed compared to the tissues which are far away from the radiating cellphone antenna.

REPRODUCTIVE SYSTEMS AND MALE SPERM FERTILITY

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 2°C lower than body temperature for optimal spermatogenesis and an elevation of testicular temperature may be reversible detrimental factor to sperm production[11]

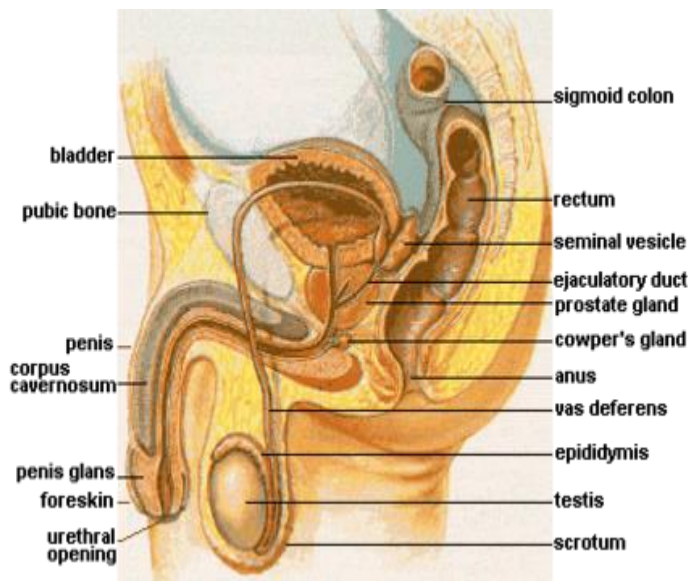


Figure 5: The human male reproductive system[12]

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).

Spermatozoa 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.

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.[13]

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 bioelectromagnetic modelling, experimental (*in vivo* and *in vitro*) investigations and epidemiological studies.

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[9].

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.

Also various frequencies for GSM (from 900MHz and 1800MHz) have been used in simulating the results to find the SAR, Electric field and Magnetic field variation with the mentioned frequencies and fixed transmit power using FEKO simulation software or tool.

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, antennas, etc.). [9]

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.[14] 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

We do assume 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 our case we assumed that the tissue present in testes are the investigative parts which can give us the required simulated results.

IV. RESULTS AND DISCUSSIONS

After going through the methodologies above, analysis has been done on the experimental values obtained through the use of FEKO software at GSM frequencies of 900MHz and 1800MHz at a distance of 10cm from where the cell phones was situated in relation to the position of the testes.

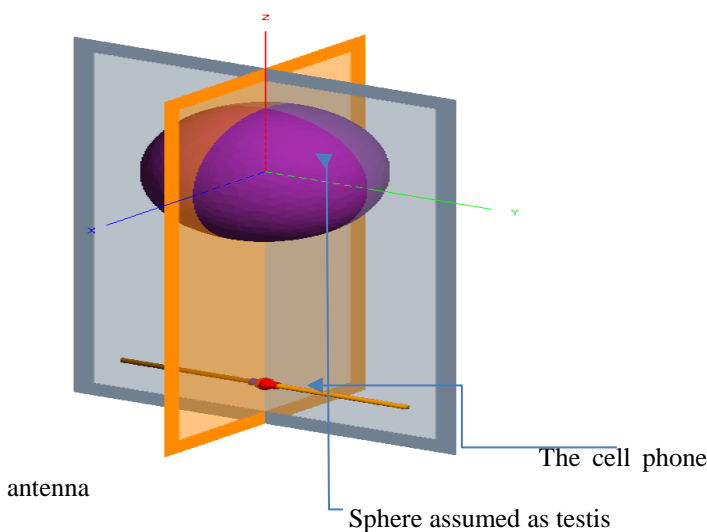


Figure 6: Showing the setup of the experiment analysis of the radiation effects on testis

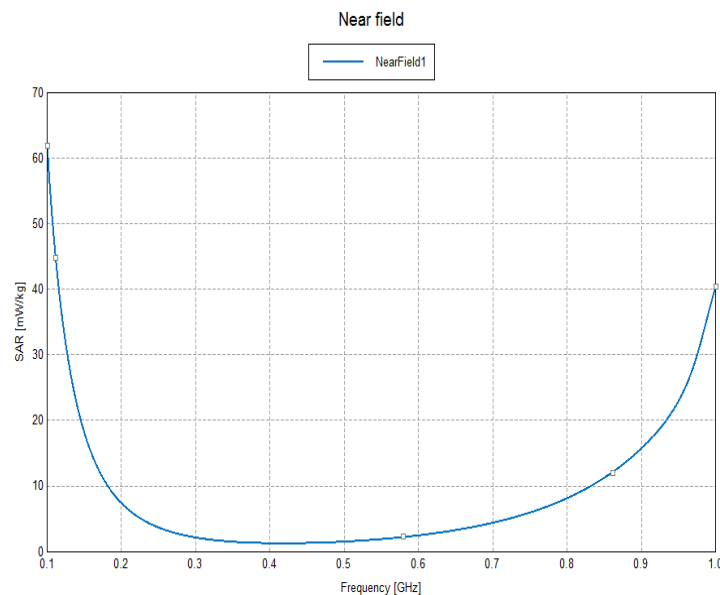


Figure 7: Showing the simulated results of SAR against operational frequency of 900MHz.

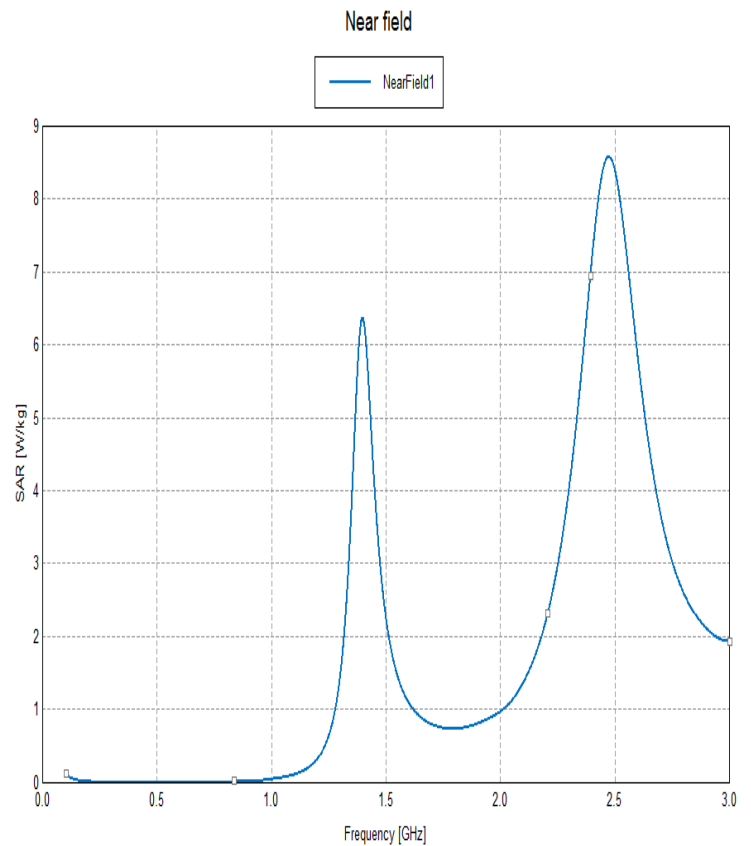


Figure 8: Showing the simulated results of SAR against operational frequency of 1800MHz.

From the simulation results above we can discuss on the values of SAR at different frequencies used by GSM cellular phones where for 900MHz the SAR values was approximately 17mW/kg as it can be seen from the graph when the maximum transmit power from the cellular phone antenna was limited to 2Watts while for 1800MHz, the SAR value was approximately 0.8W/kg as seen from its graph when the maximum transmit power from the cellular phone was limited to 1Watt.

V. CONCLUSION

Since there is energy absorbed by testis tissues during radiation, this electromagnetic energy is easily converted to thermal 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.

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

So keeping cell phone in trouser pocket can lead to male sperm infertility because it will be nearby the reproductive organs specifically testes where sperms are produced and stored there.

RECOMMENDATIONS

From this study, we recommend that storage of mobile phone in a trouser when it is on should be abandoned, also the use headphones while talking and at the same time the phone is situated nearby male reproductive organs should be strictly avoided, and if it is impossible for the two cases above then try to make the call as short as possible (avoiding to make a long call which for example can last for let say 30minutes).

ACKNOWLEDGMENT

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