Behavioural Change on EM Exposure and its Modelling

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Abstract: This paper presents the ill-effects of EM exposure through experiment, simulation and modelling using COMSOL Multiphysics (COMSOL). Bio-logical Effects of microwave radiations on living creatures are studied supported with the practical results. When a microwave beam impinges on a target, any one or combination of three interactions may occur: beam may be reflected; may be absorbed; may pass through the target. Only the absorbed fraction is potentially harmful. There is change in the behaviour of living organisms on exposure to microwaves at constant low power level at operating frequency of 9.45 GHz for fixed time at temperature of 29°C. EM endurance is different for different creatures. The main focus is to find out the behavioural fluctuations using 3D Model. This approach with Comsol Software helps in finding inner truth biologically. Relevant data, photographs with timings and experimental results are reported.

Keywords: Microwave bench, organism, radiation, heat, electrical stimulation.

1. Introduction

Microwave frequency ranges from 3 to 300GHz. Microwave can produce thermal and non-thermal effects in biological systems. Biological tissues can easily absorbs the radiations in the range from 300 MHz to 10 GHz. The heating of tissues as a result of absorption of microwave mainly occurs due to ionic conduction and vibration of dipole molecules of water and proteins present in the body. Amount of rise in temperature of the tissues mainly depends upon frequency and power of the radiation. Temperature crossing the limits of the thermoregulatory capability of the body or parts of the body results in tissue damage and death. If the absorbed energy increases due to the prolonged exposure or increase in power of radiation, the protecting mechanism of heat control breaks down, resulting in uncontrolled rise in body temperature. Frequency and power level of microwave radiation decides the rise in temperature of the body tissues of living organism. Effect of radiation on target may be reflected if it is metal, pass through if it is non-conductor and absorbed if it contains water. molecules. Exposed insects will absorb the microwave energy.

Heating of tissues due to exposure for a long period of time, increases the absorption of energy leading to break down of protecting mechanism of heat control. Thus damaging the tissues and death can result. In case of human-being, at low power of radiation, symptoms are headache, vomiting, intraocular pain, fatigue, nervousness, awareness of buzzing vibrations or pulsations and sensation of warmth. Most of these effects are not permanent.

Localized heating, or “hot spots,” may lead to heat damage and burns to internal tissues. Hot spots can be caused by non-uniform fields, by reflection and refraction of RF/MW fields inside the body, or by the interaction of the fields with metallic implants. There is a higher risk of heat damage with organs which have poor temperature control, such as the lens of the eye and the testes. Other than cancer which comes in long term many other problems comes first: neurological, reproductive, and cardiac. Problems with severe headaches sleep disturbances, memory loss, learning disabilities, attention deficit disorder, and infertility show up long before cancer. When cancer does appear, it’s typically brain tumors, leukemia, and lymphoma. Firstenberg describes in number of studies on microwave radiation and blood cells found that white blood cell phagocytosis was stimulated by chronic exposure to the lowest intensities of radio waves and inhibited, sometimes severely, by higher intensities. Here exposure levels ranged from 0–4 mW/cm^2 to 120 mW/cm^2. The weakest fields, according to

various studies, are the biologically most effective, poses a major problem.

When the nervous system or the brain is disturbed, by radiations, morphological, electrophysiological, and chemical changes can occur. A significant change in these functions will inevitably lead to a change in behaviour. Indeed, neurological effects of radiations include changes in blood-brain-barrier,morphology,electrophysiology,calcium efflux, neurotransmitter functions, cellular metabolism, etc. According to previous studies conducted on rats it was found that, due to long exposure, cumulative damages in DNA may in turn affect cell functions. DNA damage that accumulates in cells over a period of time may be the cause of slow onset diseases, such as cancer. DNA damaging agents in this case radiations induce mutations in DNA, leading to expression of certain genes and suppression of other genes resulting in uncontrolled cell growth. Thus, damage to cellular DNA or lack of its repair could be an initial event in developing a tumour. However, when too much DNA damage is accumulated over time, the cell will die. Cumulative damage in DNA in cells also has been shown during aging. Particularly, cumulative DNA damage in nerve cells of the brain has been associated with neurodegenerative diseases, such as Alzheimer's, Huntington's, and Parkinson's diseases. Since nerve cells do not divide and are not likely to become cancerous, more likely consequences of DNA damage in nerve cells are changes in functions and cell death, which could either lead to or accelerate the development of neurodegenerative diseases.In case of insects, to determine the effect and behaviour of insects on exposure at low power radiation and 9.45 GHz frequency for fixed span of time, power level is 5.472W.

2. EXPERIMENTAL RESULTS

The experiment was performed on two insects one thin and one fat placed in polythene transparent bag of 10 micron thick, for exposure with small opening on the top and small pin holes pierced in the bag providing enough air. Here Reflex Klystron is used as microwave source. As the experiment is conducted for low power level so it is best suited for this experiment. Experiment was started at 1:15 PM and lasted till 02.30 PM at power of 5.472 W at temperature of 29^{o} C. Various photographs taken at different timing are:

I. Start Time: 1.15 PM

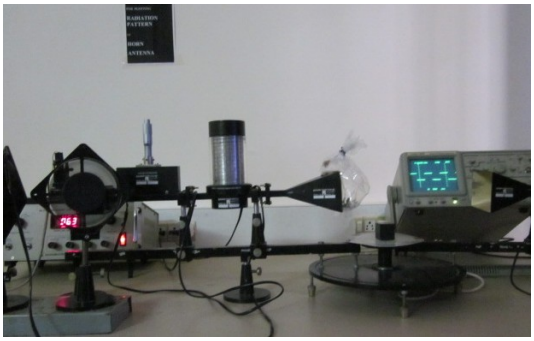

Fig.1: Experimental Setup.

Figure 1 shows the experimental setup which consists of Reflex Klystron, Isolator, Attenuator (precision type rotary attenuator), Waveguide (rectangular), Horn antenna pair, Klystron power supply, Stand for hanging polybeg, cooling fans required for cooling purpose of Reflex Klystron.

a) At 1:15pm: On striking the polythene by fingers , they respond quickly, showing their repellent behaviour and are active.

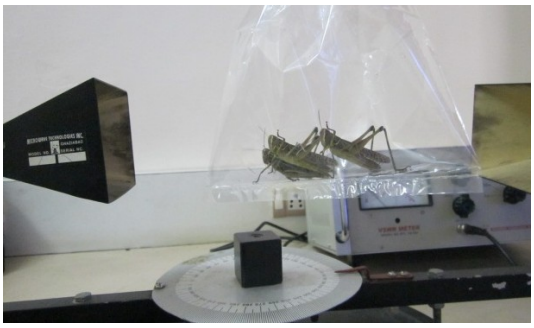

Fig. 2: Three grasshoppers between pair of horn antenna.

b) At 1:30 pm: There is some sort of laziness and dullness in their behaviour but still sometimes they show opposition.

c) At 2:00 pm: They become lazy and turned inactive. Behaviour of opposition reduces continuously.

d) At 2:15 pm: On striking with pointed pen they jump slightly to show their response but their energy level reduces drastically. They are trying to move away from the vicinity of EM exposure.

Fig. 3: A trail to escape.

Fig. 4: Close view

e) At 2:30 pm: Itching on their body was observed. They folded their legs and nostrils become stable and did not show any motion. There was no movement found during this time as if they are unconscious. But on striking the bag with fingers, movement appears in both of them like moving their leg up and down or just changing their position little bit. Means stringent movement was found at this level and time of exposure. At this time they become quite lazy and each movement is stable for a noticeable time.

f) Effect of radiation is more is younger insect than the elder one. Two insects of were the most susceptible to microwave energy and adults were the least susceptible. There was a significant decrease in the movement with an increase exposure time. Capacity of speed of their movement was decreased with an increase in exposure time.

3. Correlation with COMSOL

SAR (specific absorption rate) is used to determine the amount of radiation that human tissue absorbs. This measurement is especially important for mobile telephones, which radiate close to the brain. The model studies how a human head absorbs a radiated wave from an antenna, and the temperature increase that the absorbed radiation causes. SAR can be calculated as-

$$E_{SAR} = \sigma|E|^2 / \rho$$

Where,
σ is the conductivity of human brain tissue,
ρ is the density, and
|E| is the norm of the electric field.

The SAR value is an average over a region of either 10 g or 1 g of brain tissue, depending on national rules. This model does not calculate the average value and so it refers to the local SAR value. The maximum local SAR value is always higher than the maximum SAR value.

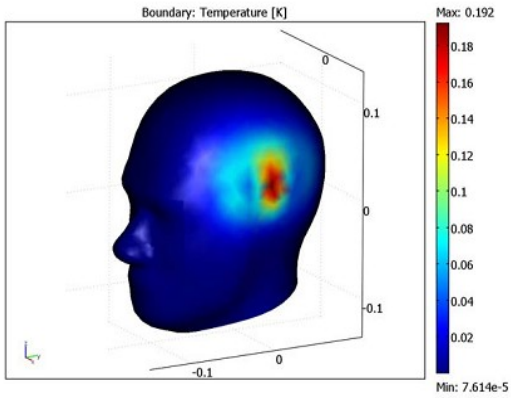

Fig.5: The local increase in temperature on head surface.

The perfusion rate varies significantly in different parts of the human body, and the table below presents the values used here.

Table 1. Perfusion rate of different parts

Part	Perfusion Rate
Brain	2×10^{-3}(ml/s)/ml
Bone	3×10^{-4}(ml/s)/ml
Skin	3×10^{-4}(ml/s)/ml

4. Absorption of energy from electromagnetic fields

Exposure to low-frequency electric and magnetic fields normally results in negligible energy absorption and no measurable temperature rise in the body. However, exposure to electromagnetic fields at frequencies above about 100 kHz can lead to significant absorption of energy and temperature increases. In general, exposure to a uniform (plane-wave) electromagnetic field results in a highly non-uniform deposition and distribution of energy within the body, which must be assessed by

dosimetric measurement and calculation. As regards absorption of energy by the human body, electromagnetic fields can be divided into four ranges:

- Range from 100 kHz to less than about 20 MHz, at which absorption in the trunk decreases rapidly with decreasing frequency, and significant absorption may occur in the neck and legs
- 20 MHz to 300 MHz, at which relatively high absorption can occur in the whole body, and to even higher values if partial body (e.g., head) resonances are observed
- frequencies in the range from about 300 MHz to several GHz, at which significant local, non-uniform absorption occurs; and
- frequencies above about 10 GHz, at which energy absorption occurs primarily at the body surface.

5. EM Effects on Humans

The effect is observed more in the cortical tissue as compare to skin, bone etc. due to microwave radiations.

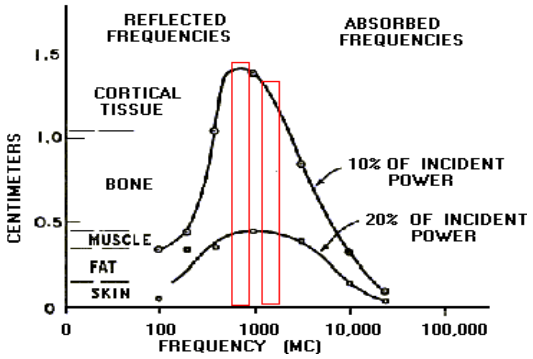

Fig.6: Microwave power distribution in the forehead model neglecting resonance effects and considering only first reflections.

There is change in behavioral and physiological responses of laboratory animals, insects, birds to thermal interactions of EMF at frequencies above 10 MHz.

Some people show "hypersensitivity" to electric or magnetic fields. Symptoms are aches and pains, headaches, depression, lethargy, sleeping disorders, and even convulsions and epileptic seizures on electromagnetic field exposure. There is little scientific evidence to support the idea of electromagnetic hypersensitivity. There is no accepted biological mechanism to explain hypersensitivity. Research on this subject is difficult because many other subjective responses may be involved, apart from direct effects of fields themselves.

Thermosensitivity and thermoregulatory responses are associated both with the hypothalamus and with thermal receptors located in the skin and in internal parts of the body. Afferent signals reflecting temperature change converge in the central nervous system and modify the activity of the major neuroendocrine control systems, triggering the physiological and behavioral responses necessary for the maintenance of homeostasis.

Fig.5. shows increase in temperature in human brain. Heat dissipation is not uniform. Tissues which are more heated, their function are more affected by the thermal energy. Brain is the control system of the whole body. Thermoregulatory function hampers due to radiation. When the nerves and blood are heated then the transmission of signals from brain to the rest part of the body is disturbed. It reduces the capacity of living being to respond to any stimuli. By radiation, one experiences laziness, headache, arrogant behavior, heating of skin tissues causing damage and itching, loss of memory leading to change in behaviour.

In Brain, Hippocampus is understood to be responsible for learning and memory. In order to confirm this, we have carried out investigations on the whole brain, hippocampus, and remaining brain. This was undertaken to determine the possible site of the Electromagnetic Field (EMF) biointeraction. These radiations may damage our nervous system especially memory. This has been done by protein kinase C activity and DNA strand break, which has been affected electromagnetic radiations.

6. Conclusion

There are different effects of microwave radiation on different living beings including insects, humans, animals and also birds when exposed for long duration. The behavioral changes in insect on exposure show the effect of radiations like rubbing, laziness etc. As per as India is concern there must be some limits of exposure time and power density. Also there must be some guideline for installations

surveyed to get desired and safe microwave radiation levels.

7. References

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9. Acknowledgements

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