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Microwave (1GHz-30GHz) and Terahertz Radiation (3THz-30THz) Effecting the Sensory System for the Sense of Taste: The Gustatory Delights gets effected

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Abstract: **-** Non-Ionized electromagnetic radiation possessing inspite of low energy demonstrating to be very hazardous at long exposure. The topical expansion on mobile communication has drawn attention towards how these radiation effects the human beings particularly depending on the position of phones. Biological effect resulting from microwave or terahertzradiation exposure are primarily a thermal response produced by the absorption of the energy. Depth of penetration of microwave energy or terahertz energy which is a function of frequency totally depends on the type of tissue they are fronting. The lower the frequency the depth of tissue penetration being more.
This paper is an attempt to elucidate the electromagnetic radiation (Radiofrequency, Microwaves and Terahertz) might also effect the gustatory system which is a sensory system of taste of human beings just located below the human head. The paper also highlights the modalities of interaction of these radiation with the ion channels formed at the specific taste cells.

Keywords: *- Non-ionized radiation, Radiofrequency, Microwave, Terahertz, Gustatory, Ion channels*

I. INTRODUCTION

Electromagnetic radiation propagates and travel through space carrying energy at a speed of $3*10^8$ m/s being electromagnetic in nature that is both the electric and magnetic field components oscillates in a fixed relationship perpendicular to each other and perpendicular to the direction of wave propagation. Electromagnetic radiation is defined by its frequency and its wavelength [2], [5]. The electromagnetic spectrum is shown in Figure. 1 demonstrating the lower and higher frequency end. Higher frequency corresponds to proportionately more energy carried by a photon (photon of a visible light carries less energy incomparison with an UV photon).The energy being directly proportional to the frequency.
The energy E of a photon is given by relation

$$E = h\nu = \frac{hc}{\lambda} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where$h$-Planck constant
c - Velocity of light
λ - Wavelength of light

II. IONIZING AND NON-IONIZING RADIATION

Electromagnetic radiation are of two types ionizing and non-ionizing radiations. Non-ionizing radiations are responsible for some twist and turns in the bond resulting in thermal effects.
Ionizing radiation depends on the capability that they are strong enough to detach the electron or ionize the atom and thus breaking the covalent bond.
Ultraviolet, X-ray radiation and higher frequencies on the electromagnetic spectrum chart are ionizing radiation but nonionizing radiation such as microwaves, radio waves or terahertz radiation (lying in the range between the

infrared and microwave) having lower frequencies too potentially responsible for biological hazards (effecting the living cells and tissues in the human body) [1]-[7].
A special branch of science Bio -electromagnetics which basically deals with the interaction of oscillating electromagnetic fields with biological entities or more precisely can be said like studying the responses of living cells and tissues when exposed to electromagnetic spectrum.

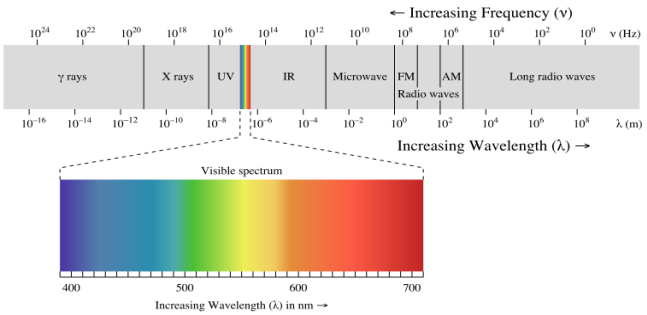

Figure. 1 Electromagnetic Spectrum

Human body comprises of 65% -70% of water, ions and electrolytes. Recent studies and advancements in research shows how electromagnetic radiation generated from mobile communication effects the human beings. The cell phone industries claims the safe levels of radiation exposure but a greater community of doctors, physicists and health officials who strongly disagree these safe levels. Long radiation exposures if effecting the human head which is the most protective part of the human body below which is the gustatory system.Long radiation exposures can surely effect the gustatory system, which is a sensory system for taste.

2.1 Discussion

Gustatory The sensory system in humans which senses the taste.

Sensitivity of a taste

Sensitivity of a taste depends on the quantity and solubility of a substance present at the taste pore. Gustatory system makes human to distinguish between the salt, sour, bitter and sweet. It also allows to distinguish between the safe and poisonous food.

2.2 Gustatory function

Any stimulus given to the body bring about physiological and psychological changes. Stimulus can be external or internal. Sensory receptors present in the human body responds to both the stimulus. Neurons being the most important component of the nervous system which sends the signalsfrom sensory to all over the body. Sensory receptors for taste in the mouth are the taste cells and they are in bundles called taste buds which are contained in the raised areas known as papillae that are found across the tongue.

Cells which are derived from epithelium rather than from neural precursors. The taste cells are capable of firing action potential either spontaneously or in response to some stimulus (electrical or chemical).Three types of taste cells are there Type 1 ,Type 2 and Type 3 out of which Type 2 & Type 3 are capable of observing action potential responds to bitterness, sweetness, acids and sourness. Each taste receptor acts differently and interprets the taste by first detecting the presence of the chemical followed by action potential and finally leaving brain to decide the taste. Recent studies shows that radiation in the microwave frequency range emitted by the communicating system like mobile phones, transmitting station and the receiving stations effects the human body (the cells or tissues). A long and continuous exposures of these radiation might also cause severe effects to the gustatory system also.

2.3 Sensory Stimulus

Sensation for the taste depends on the diverse taste solutes. Membranes at the taste cell change include depolarization followed by hyperpolarization due to ion channels formed or we can say membrane potential changes. Action potential developed at the membrane of the cell can easily get effected by the microwave or terahertz radiation. Microwave in the range of 1GHz -30GHz approximating to the energy of $E = 4.13 * 10^{-6}\ ev$ to $E = 12.39 * 10^{-5} ev$ and terahertz radiation ranging from 3THz -30 THz approximating to the energy of $E = 12.39 * 10^{-3} ev$ to$E = 12.39 * 10^{-2} ev$.
As the action potential at the cell membrane of the taste cell is $\mathbf{61.7 \pm 15mV}$ Developed will be effected by both the microwave as well as terahertz radiation.

III. ACTION POTENTIAL

How the action potential are observed at the cell membrane and gets effected when exposed to radiations?

Considering a small part of a membrane spherical in shape so that a potential isuniform or iso-potential at the surface. When a current is injected through a cell there is a voltage change but a voltage change does not seen like I but it grows with respect to t (response inside the cell) as shown in Fig.2

The cell cannot be represented by a mere resistance (V = IR). The voltage inside the cell grows with respect to time therefore does not look like a square waveform. With an input of a square current the voltage grows with respect to t but stopping a current the voltage come back to its original zero value. The change in the voltage is with growing positive current is depolarization or the change in voltage with growing negative current is hyperpolarization. The change in the current is not like a resistive circuit only as shown in Fig.3.

The behaviour of the cell is like an electrical circuit so it is not only a resistive circuit. The first approximation that a cell can be represented as a RC circuit. The behaviour of any membrane can be defined electrically by RC circuit.

The injected current I can be written as

$$C\frac{dV}{dt}+\frac{V}{R}=I \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

3.1 Depolarization and Hyperpolarization

Injected current should be equal to the summation of resistive current and capacitive current according to KCL, where C, V and I are constant. The voltage developed across the two ends can be calculated by solving linear differential equation (2)

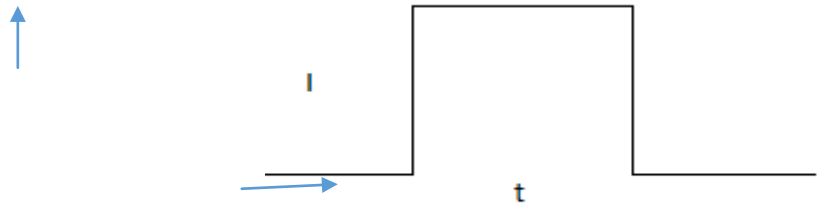

Figure. 2 Response ofinjected Current for a cell Behavingas resistive circuit.

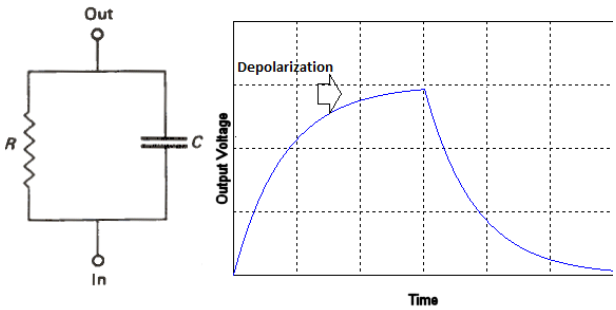

Figure. 3 Electrical Behaviour of the Membrane as RC Circuit

A positive current when injected makes the cell more positive inside as compare to outside which is defined as a state of depolarization .A negative current when injected makes the cell more negative inside as compare to outside which is defined as a state of depolarization.

A negative current when injected makes the cell more negative inside as compare to outside which is defined as a state of hyperpolarization. These membranes or cells always sits at a resting potential or always have a reference potential of -61.70mV. The cell always waits for a change from its reference resting potential of -61.70mV.

These membranes are passive membranes. Each passive membrane has a time constant which may be less or more depending upon how leaky the resistor is?

3.2 Synapse

A synapse being an electrical device or a kind of a chemical interaction which takes place at a cell membrane (transmitter acts with a receptor) then few ion channels get opened at the cell membrane that enables the flow of the current. In a simple RC circuit of a cell a new path of the current can also be demonstrated.

As these synaptic channels are the special channels which enables the flow of ions inside or outside.

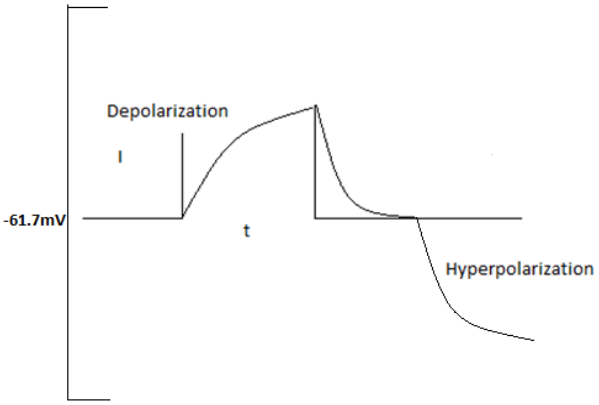

Figure. 4 Responses inside the cell forbehaving as RC circuit (Depolarization and Hyperpolarization)

The membrane at the cell wall behaves like a kind of a passive membrane which is showing the cell is more negative inside as compared to outside. Cell always sits at rest and therefore the resting potential is defined at the cell membrane due to the opening of the channels where the concentration of ions becomes equal inside and outside and sets the gradient as shown in Fig.5.

The cell is ready to change from its rest state or reference potential. If a positive current is injected then depolarization or hyperpolarization of a cell takes place.

A chemical interaction that is between the transmitter and receptor (taste cells) allows new channels to be opened at the membrane of the cell and decides the new path for the current or conductance as shown in Fig.6

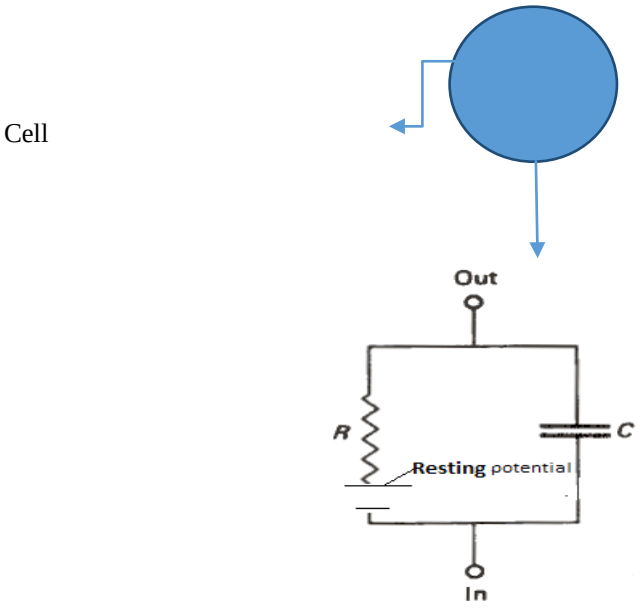

Figure.5 Rest state of the cell

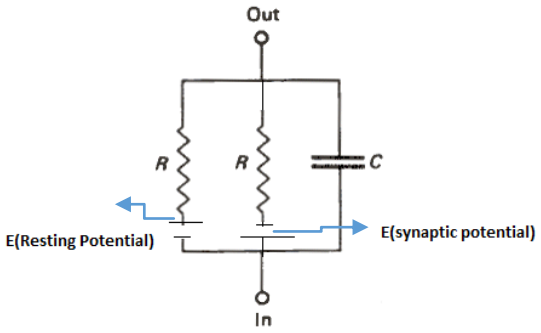

Figure.6 State of a cell after receiving stimulus

At the taste bud the membrane or the taste cell have a resting potential of $\mathbf{61.7 \pm 15}\boldsymbol{mV}$. . The ion channels formed at walls of the taste cell allowing some specific ions to flow and blocking the others thus depolarizing the cells and resulting in taste like saltiness, sourness, sweetness or bitterness. The influx and efflux of an ions at the membrane decides the taste. The channels which gets opened at the membrane allows the flow of ions now if these taste cells continuously exposed through microwave or terahertz radiation the resting potential of the cell will always be in fluctuating state which in turn change the concentration of the ion at the membrane of the cell.. As ion channels gets exposedby the electromagnetic radiation continuously will surely effect the flow off ions which in turn effect the taste.

IV. CONCLUSION

In conclusion, electromagnetic radiation like microwaves and terahertz interacting with the biological system [1], [3] and [5] of human beings at tissues and bio molecular levels then surely the effect has to be observed at the gustatory system or the sensory system of taste.

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