Journal of Public Health and Pharmacy
2775-4952 (Online - Elektronik)
Research Articles Open Access

Bioeffects of EM Radiation on Human Skin Health: A Theoretical SAR Analysis

Rockey Choudhary[1]*, Vijay Kumar[2], Soni Mishra[3]
[1]Research Scholar, Graphic Era Hill University, Dehradun, India
[2]Professor, Dhanauri P G College Haridwar, India
[3]Associate Professor, Graphic Era Hill University, Dehradun, India

***Corresponding Author: E-mail:** rockeychoudhary87@gmail.com

ARTICLE INFO

Manuscript Received: 5 Mar, 2024
Revised: 8 Jan, 2025
Accepted: 10 Feb, 2025
Date of publication: 12 Feb, 2025
Volume: 5
Issue: 1
DOI: 10.56338/jphp.v5i1.5068

KEYWORDS

Electromagnetic Waves;
Transmission Tower;
Electric Field;
SAR

ABSTRACT

Introduction: In this modern era, electromagnetic waves are playing a crucial role in our lives. An electric field is generated around the source of electromagnetic waves like mobile phone transmission towers, radio towers, TV towers, etc., which affects human beings living around them. The sources are increasing as we are regularly using devices that emit EM waves.
Methods: to study the effects of non-ionizing EM radiation on the skin of human being, the electric field around the transmiison tower is calculated. When this external electric field incident on the body of human being, it penetrates inside the skin of human being. The penetrated electric field is calculated at different depth inside the skin. With the help of this penetrated electric field, the specif
ic absorption rate inside the skin is also calculated for various height of transmission tower. The impact of non-ionizing EM radiation on the skin is predominantly associated with thermal effects. The extent of these effects depends on the intensity, duration, and proximity of the exposure.
Results: In this manuscript, the specific absorption rate (SAR) is calculated inside the skin at the variable depth of the epidermis layer of human beings. The transmission towers of EM waves are taken at different heights. It is observed that the tower that has the minimum height produces more electric field inside the skin as compared to the longer-height tower.
Conclusion: The amount of energy absorption by the tissues of the skin is higher for the transmission tower of 50 m height. The energy absorption by the tissues may become harmful for the health of the skin.

Publisher: Pusat Pengembangan Teknologi Informasi dan Jurnal Universitas Muhammadiyah Palu

INTRODUCTION

Human skin is the outer most layer or we can say the covering of the body, it saves the body from bacteria's and germs which are present in the environment. Just as in the case of humans, the skin also serves as a protective shield against the forces of nature such as sun, rain and radiations (1). Initially, the impact of the radiations is felt first by the skin and after that, the radiation penetrates inside the skin when the radiations fall on the body of humans. It impacts the internal organs and tissues (2). To avoid these potential threats, regulatory agencies, such as the Federal Communications Commission (FCC), International Agency for Research on Cancer (IARC), and (ICNRP), set forth guidelines and safety limits for exposure to non-ionizing radiation (3,4,5). Understanding these recommendations will help you minimize any risk from non-ionizing EM radiation while still taking advantage of the benefits of devices emitting it. Non-ionizing EM radiation: An area of research that requires more scrutiny as wireless technologies proliferate; health impacts of non-ionizing EM radiation require further investigation.

Human skin which is composed of three layers of the tissues that can be classified into epidermis, dermis and hypodermis. This three-layered structure comprises the epidermis, the outer layer; dermis, the middle layer; and hypodermis, the bottom layer of skin. This layer makes up the epidermis layer which we can see and feel, and this layer contains a protein called keratin. The epidermis layer is also important for producing new cells, since this layer contains the pigment melanin which gives the skin its color. The langerhans cells present in epidermis layer of the skin also aids the skin to deal with germs and infections. The 90% thickness of the skin is located in between the outer layer epidermis and middle layer dermis of the skin. Proteins called elastin and collagen found in the dermis layer of skin make the skin cells strong and flexible. Hair follicles grow from the dermis skin layer. The dermis layer of skin also senses things, like when you touch something that is hot or cold, the nerves in the dermis enable us to feel it. When something is itchy, hard or soft, the nerve receptors provide us with the ability to feel it. Oil keeps the skin soft and supple, and your oil glands located inside the dermis layer. The dermis layer which aids in the process of removing toxins from the body is additionally with the sweat gland which also helps in keeping the body temperature stable. It also includes the dermal layer tissues which can give blood vessels to the epidermis layer skin. Hypodermis is the fat layer present in the bottom which may protect the bones and the ligaments from any injury made in any unfortunate accident. This layer of skin connects the skin to the muscles and bones. As stated above, EM waves may have an affect on normal function of both dermis, epidermis and hypodermis layers (6). The same is true for thermal effect and non - thermal effect as skin due to direct expose to EM radiation is relatively much more sensitive. But there is little research on the specific absorption rate (SAR) in the skin layers.

The skin is the largest organ of the human body and serves several essential functions, including protection, sensation, and temperature regulation. When electromagnetic waves impose on the body of human being, the first organ is skin which comes in contact with these waves. In 1887 Heinrich Hertz a German Physicist discovered artificial EMFs (7). After the advancement in communication technologies, it has become a necessary part of our life. On the basis of frequency range, electromagnetic waves are divided into ELF (extremely low frequency), RF (Radio Frequency) and MW (microwave Radiation). The frequency ranges from 3 KHz to 300 GHz is used in radio frequency. The human beings have a great probability to come in the influence of RF waves via mobile phones, mobile phone transmission tower, WiFi etc. Currently the industries are using sub-THz (90-300 GHz) frequency range for the faster data speed. Now the fifth-generation network is also launched in which frequency range 28 GHz to 60 GHz is used (8,9). The telecommunication industries must think about the health risk in human beings due to the advancement in the network technologies. They must concern about the non-thermal impacts of electromagnetic waves on the human beings (10,11). Some research has been suggested that the extended application in the network technologies must have a limitation. As the technology is increasing, the ways of interacting of EM waves with the body of human being is also increased. Therefore, research on the impacts of electromagnetic waves on human health is a topic to concern (12,13,14). According to the previous research, electromagnetic waves have many negative effects on the body of human being like kidney damage, leukaemia, immune disorder, reproductive disorder etc. The skin is a great prevention from harmful radiation to the body since it is the outer layer of the body. Any type of harmful radiation strike on the skin before penetrates into the other organs of the body. Skin is the organ which expose primarily to the physical stimuli, heat, cold, and harmful radiations etc. Skin reacts as a result of wrinkles, skin irritation, losing moisture, pigmentation on it after the exposure of harmful non-ionizing radiations such as UV-A, UV-B, IR and blue light (15,16).

It is very evident that there are more possibilities for people come into contact with radiation like when walk on the road, sitting in front of TV, using mobile phone, using electronic equipment in kitchen or in other works, in many medical devices etc. It is impossible to avoid the exposure of electromagnetic radiation completely but it can be reduced. There are many harmful impacts of EM radiation on living beings (17,18,19). The guidelines published by ICNIRP and WHO must be followed strictly. The telecommunication agencies do not follow the guidelines sincerely. We know that it is impossible to reduce the usage of mobile phones in our daily basis because we all have become fully dependent on the mobile phones and other electronic devices but we can reduce the usage time of mobile phones. By reducing the usage time of mobile phones, we can decrease the harmful effects of electromagnetic radiations. In this manuscript we will discuss about the harmful effects of EM radiation on human beings.

There are some evidences to suggest that exposure to high levels of electromagnetic radiation can have biological effects on the human body (20,21). However, the effects and severity of these effects depend on several factors, including the frequency, intensity, and duration of exposure, as well as the individual's age, health status, and sensitivity to electromagnetic radiation (22). The effects of electromagnetic radiation on the brain, heart, and pregnant women are also found in some researches, while some studies have suggested an increased risk of cancer is also there with high levels of exposure to electromagnetic radiation. However, it is widely accepted that exposure to high levels of ionizing radiation, such as that experienced in the Bhopal Gas Tragedy, can cause genetic damage that may be irreversible and can affect future generations (23). Therefore, it is important to limit exposure to electromagnetic radiation as much as possible and to take appropriate precautions when working or living in environments with high levels of electromagnetic radiation. Electromagnetic waves including microwaves are a form of non-ionizing radiation. Non-ionizing radiation is generally considered to have insufficient energy to break chemical bonds or directly damage DNA, which is typically associated with harmful effects on cells and organisms (24,25).

A cross-sectional study showed the perception of increased risk associated with the deployment of fifth-generation (5G) networks among Korean adults. The analysis revealed that the gender was one of the most important variables with females having greater risk perception than males. The study showed greater concerns about possible health effects due to EM waves of the 5G networks. In addition, those who had a high degree of perceived exposure to EM waves had a higher degree of perception of risk, indicating that subjects who apprehended more exposure to EM waves had a higher risk apprehension to the agents of EM waves (26). Most studies related to EM radiation are limited to body-wide exposure or hold back on internal organs, ignoring the uniqueness of skin that is headed towards the move in terms of EM waves interaction. This study addresses this gap by estimating SAR values in the epidermis layer at various depths. This study also investigates the effect of both transmission tower height and frequency. This research suggests the possible dangers EM radiation poses to the skin.

METHOD

Choice of the height of the tower, power required for transmission and tower frequency

Tower heights: The tower heights chosen in this paper are 50m, 100m and 200m, which is frequently used in practice when evaluating mobile communication communication transmission towers and broadcast transmission towers. Shorter towers (i.e. 50 m) are placed in city or densely populated areas requiring high user densities to be close to transmission sources. In adding more access points, taller towers (e.g., 100 m and 200 m) are often used in these more peripheral, suburban, or rural areas to extend coverage (4). The te study seeks to examine how the SAR scales with respect to distance and exposure level, both of which are influenced by the height of the tower, so the selected these heights.

The frequency range chosen includes bands used in modern (5G - e.g. 3.5 GHz) and future spectrum communication technologies. It direrects with present progress in telecommunication and brings that the study results to the point of relevant to the wireless technologies together with the related health hazards.

The transmission power 120 W was chosen for its widespread use in the mobile phone transmission towers. This allows for results that are applicable to exposure levels typical of everyday life.

These were chosen based on scientific rigour whilst retaining practical applicability. This allows performing a wide-scale analysis of SAR changes in realistic environmental and technical conditions. This track contributes to the relevance and impact of the study.

Determination of electric field around the transmission tower: The rapid increase in the usage of wireless communication and the growing number of transmission towers have significantly amplified the probability of human

beings being exposed to EM waves in their daily activities. This heightened exposure is largely due to the widespread use of wireless devices in the new generation. An electric field is produced around the transmission tower. The produced electric field is given by where P denotes the power of the mobile phone of the transmission tower. Here we are calculating the external electric field for the power of 120W. After solving it, the electric field around the tower becomes.

$$E_0 = 7.746\frac{\sqrt{P}}{r} \quad (1)$$

$$E_0 = \frac{84.853}{r} \quad (2)$$

Determination of electric field inside the human beings' skin: When the electric field generated around the transmission tower is incident on the human beings, its penetrated inside the body. The penetrated electric field inside the epidermis layer of skin of human beings become.

$$E_Z = E_0 e^{(-Z/\delta)} \quad (3)$$

Where δ is the skin depth it is a frequency-dependent parameter. z is the penetration depth and $\mathbf{E_Z}$ is penetrated electric field inside the skin.

Determination of SAR: The Specific absorption rate inside the skin of human beings at a depth is given by Where $\boldsymbol{\sigma}$ and md represents the conductivity and mass density of human's skin respectively.

$$SAR = \frac{\sigma E_0^2}{m_d} \quad (4)$$

RESULTS

When the high frequency electromagnetic waves incident on the skin of human beings, the electric field is induced inside the skin. The penetration depth of an electric field depends on the conductivity and dielectric properties of the tissues of skin. The strength of an electric field decreases with distance from the source. If the frequency and intensity of the electric fields are high, the induced electric field can penetrate deep inside the epidermis layer of skin. The induced electric field's strength would depend on the tissue's conductivity and dielectric properties of the body. In this manuscript, the impact of electric field on the epidermis layer of human skin is observed around the transmission tower. The SAR value inside the skin of human beings is determined for various heights of transmission towers. The frequencies of electromagnetic radiations emitted from the transmission tower are selected from 3.5 GHz to 8.0 GHz. The selected frequencies of EM waves are most useful in today's scenario. The penetrated electric field is computed inside the epidermis layer of human beings at variable depth of skin. It is observed that its value decreases with the height of transmission tower. When the height of transmission tower is 50 m, the intensity of EM waves is highest and for 200m it is lowest. However, for the height of 100m the impact of EM radiation is medium.

Descriptive Statistics

In general, the height of the tower may be varied from 50m to 200m depends upon the requirement of the region. The less height of the tower may be selected for high altitude area like hill area and more heights may select for the plane area of a city or village. The observations have been made from 1m to 10 m distance from the towers. Table 1, 2 and 3 represent the penetrated electric field and specific absorption rate (SAR) by skin of human beings for the 50m 100m and 200m height of transmission tower.

Primary Outcome Measures

Electric field and SAR have been computed from 1 μm to 3 μm depth inside the skin. When EMW penetrated inside the skin, the electric field decreases by 0.037%, 0.043%, 0.049%, 0.057%, 0.064%, 0.073%, 0.082%, 0.091%,

0.10% and 0.11% for the frequencies 3.5GHz, 4.0 GHz, 4.5GHz, 5.0GHz, 5.5GHz, 6.0GHz, 6.5GHz, 7.0GHz, 7.5GHz and 8.0 GHz respectively in penetration of 1 μm to 3 μm depth inside the skin.

Secondary Outcome Measures

During this penetration, the energy is absorbed 0.062 %, 0.072 %, 0.083 %, 0.095%, 0.10%, 0.12%, 0.13%, 0.15%, 0,16% and 0.18% by the skin tissues of human beings for the frequencies 3.5GHz, 4.0 GHz, 4.5GHz, 5.0GHz, 5.5GHz, 6.0GHz, 6.5GHz, 7.0GHz, 7.5GHz and 8.0 GHz respectively. The above observations are taken for 50m, 100m and 200m height of the towers.

Subgroup Analysis

Figure 1, 2, 3 show the variation between the percentage of SAR Vs frequency of radiation at the depth with respect to the distance from the tower at the depth of 1μm, 2μm & 3μm inside the skin respectively. For 50m height of the tower, the variation in SAR is decreased by 3.8% for all selected frequencies of EMW. The variation in SAR for the height of tower 100m is nearly 1% for all selected frequencies. For 200m height of the transmission tower and at 1μm depth inside the skin, the maximum and minimum variation in SAR is 0.45% and 0.15% respectively. The percentage change in SAR for height 200m of tower, is varied continuously at various distance from the tower. It is also concluded that for 50m and 100m tower, the nature of the variation of results are same for all frequencies of EMW.

From figure 2, it is observed that for 50m and 100 m tower, the variation in SAR value is nearly same for all selected frequencies. For the height of 200m, the maximum variation of 0.32% and minimum variation of 0.17 % are observed in SAR value for the frequencies of 8 GHz and 5.5 GHz respectively.

It is also observed from figure3 that the variation in percentage of SAR at the depth of 3μm is changing randomly for 200m height of the tower. However, for 100m and 50m height of tower, the variation is almost same for all selected range of frequencies. The maximum variation in percentage of SAR for 200m height of the tower is 0.36% for the frequencies of 5.5GHz.

In figure 4, for the frequencies of 6.5 GHz to 8 GHz, the variation in percentage of the SAR value inside the skin is in the same phase for 50m and 100m height of transmission towers. For the frequencies of radiation are 3.5 GHz to 4.0 GHz, the SAR is first increasing, and then decreasing for tower height 200m. For the frequency of 5.5 GHz, there is no variation in SAR values inside the skin. At the frequency of 6.0 GHz, the variation is increased by 0.15%. For the frequencies 6.5 GHz to 7.0 GHz, it is decreasing up to 0.12%. For 7.5 GHz and 8 GHz, it starts to increase up to 0.23% and then decrease up to 0.10% respectively. This variation is represented for 200m height of transmission tower by a red line.

SAR is decreased by 75% if the height of the transmission tower changes from 50m to 100m or 100m to 200m at a depth of 1 μm and at a distance of 1m from the transmission tower. When height of transmission tower is changed from 50 to 100m and 100 to 200 m, SAR decreases by 74.26% and 74.8% respectively. The observation is taken at 1μm depth inside the skin and at 10m distance from the tower.

Table 1. SAR of skin of Human being (height of the tower is 50 m)

Frequency (GHz)	**External Electric field(E0) V/m**	**Distance from the tower(m)**	**Penetrated electric field (V/m) inside the epidermis layer of skin of human beings at the depth**			**SAR Value inside the skin of human being (Watt/Kg)**		
			1μm	**2μm**	**3μm**	**1μm**	**2μm**	**3μm**
			Max-Min	Max-Min	Max-Min	Max-Min	Max-Min	Max-Min
3.5	1.696755-1.664111	1-10	1.69665-1.66401	1.69644-1.66380	1.69612-1.66349	0.0052433-0.0050435	0.0052420-0.0050422	0.0052400-0.0050403
4.0	1.696755-1.664111	1-10	1.69663-1.66399	1.69639-1.66375	1.69602-1.66339	0.006074-0.005842	0.006072-0.005841	0.006069-0.005838
4.5	1.696755-1.664111	1-10	1.69661-1.66397	1.69633-1.66369	1.69591-1.66328	0.006982-0.006716	0.00698-0.006714	0.006976-0.00671
5.0	1.696755-1.664111	1-10	1.69659-1.66395	1.69627-1.66364	1.69579-1.66316	0.007942-0.00764	0.007939-0.007637	0.007935-0.007632
5.5	1.696755-1.664111	1-10	1.69667-1.66393	1.69620-1.66357	1.69565-1.66303	0.00898-0.008638	0.008976-0.008634	0.008971-0.008629

Frequency (GHz)	**External Electric field(E0) V/m**	**Distance from the tower(m)**	**Penetrated electric field (V/m) inside the epidermis layer of skin of human beings at the depth**			**SAR Value inside the skin of human being (Watt/Kg)**		
			1µm	**2µm**	**3µm**	**1µm**	**2µm**	**3µm**
6.0	1.696755-1.664111	1-10	1.69655-1.66391	1.69613-1.66350	1.69551-1.66289	0.010096-0.009711	0.010091-0.009707	0.010084-0.009699
6.5	1.696755-1.664111	1-10	1.69652-1.66388	1.69606-1.66343	1.69536-1.66274	0.011264-0.010834	0.011257-0.010828	0.011248-0.01082
7.0	1.696755-1.664111	1-10	1.69650-1.66386	1.69598-1.66335	1.69520-1.66258	0.012509-0.012032	0.012501-0.012025	0.01249-0.012014
7.5	1.696755-1.664111	1-10	1.69647-1.66383	1.69589-1.66326	1.69503-1.66242	0.01378-0.013255	0.013771-0.013246	0.013757-0.013233
8.0	1.696755-1.664111	1-10	1.69644-1.66380	1.6580-1.66318	1.69485-1.66225	0.015103-0.014528	0.015092-0.014517	0.015075-0.0145

Table 2. SAR of skin of Human being (height of the tower is 100 m)

Frequency (GHz)	**External Electric field(E0) V/m**	**Distance from the tower(m)**	**Penetrated electric field (V/m) inside the epidermis layer of skin of human beings at the depth**			**SAR Value inside the skin of human being (Watt/Kg)**		
			1µm	**2µm**	**3µm**	**1µm**	**2µm**	**3µm**
			Max-Min	Max-Min	Max-Min	Max-Min	Max-Min	Max-Min
3.5	0.848496-0.844325	1-10	0.84844-0.84427	0.84834-0.84417	0.84818-0.84401	0.001311-0.001298	0.001311-0.001298	0.00131-0.001298
4.0	0.848496-0.844325	1-10	0.84843-0.84426	0.84831-0.84414	0.84813-0.84396	0.001519-0.001504	0.001518-0.001504	0.001518-0.001503
4.5	0.848496-0.844325	1-10	0.84843-0.8443	0.84828-0.8441	0.84807-0.8439	0.001746-0.001729	0.001745-0.001728	0.001745-0.001727
5.0	0.848496-0.844325	1-10	0.84842-0.84424	0.84825-0.84408	0.84801-0.84384	0.001986-0.001967	0.001985-0.001966	0.001984-0.001965
5.5	0.848496-0.844325	1-10	0.84840-0.84423	0.84822-0.84405	0.84794-0.84378	0.002246-0.002224	0.002245-0.002223	0.002243-0.002221
6.0	0.848496-0.844325	1-10	0.84839-0.84422	0.84818-0.84402	0.84787-0.84371	0.002525-0.0025	0.002523-0.002499	0.002522-0.002497
6.5	0.848496-0.844325	1-10	0.84838-0.84421	0.84815-0.84398	0.84780-0.84367	0.002817-0.002789	0.002815-0.002788	0.002813-0.002785
7.0	0.848496-0.844325	1-10	0.84837-0.84420	0.84811-0.84394	0.84772-0.84355	0.003128-0.003097	0.003126-0.003096	0.003123-0.003093
7.5	0.848496-0.844325	1-10	0.84835-0.84418	0.84806-0.84390	0.84763-0.84347	0.003446-0.003412	0.003444-0.003410	0.00344-0.003406
8.0	0.848496-0.844325	1-10	0.84834-0.84417	0.84802-0.84385	0.84755-0.84338	0.003777-0.00374	0.003774-0.003737	0.00377-0.003733

Table 3. SAR of skin of Human being (height of the tower is 200 m)

Frequency (GHz)	**External Electric field(E0) V/m**	**Distance from the tower(m)**	**Penetrated electric field (V/m) inside the epidermis layer of skin of human beings at the depth**			**SAR Value inside the skin of human being (Watt/Kg)**		
			1µm	**2µm**	**3µm**	**1µm**	**2µm**	**3µm**
			Max-Min	Max-Min	Max-Min	Max-Min	Max-Min	Max-Min
3.5	0.424265-0.423735	1-10	0.42424-0.42371	0.42419-0.42366	0.42411-0.42358	0.000327-0.0003270	0.000327-0.0003269	0.000327-0.0003268
4.0	0.424265-0.423735	1-10	0.42423-0.42370	0.42417-0.42364	0.42408-0.42355	0.00038-0.000379	0.00038-0.000379	0.000379-0.000379

Frequency (GHz)	External Electric field(E0) V/m	Distance from the tower(m)	Penetrated electric field (V/m) inside the epidermis layer of skin of human beings at the depth			SAR Value inside the skin of human being (Watt/Kg)		
			1µm	2µm	3µm	1µm	2µm	3µm
4.5	0.424265-0.423735	1-10	0.42423-0.42370	0.42416-0.42363	0.42405-0.42352	0.000437-0.000435	0.000436-0.000435	0.000436-0.000435
5.0	0.424265-0.423735	1-10	0.42422-0.42369	0.42414-0.42361	0.42403-0.42349	0.000497-0.000495	0.000496-0.000495	0.000496-0.000495
5.5	0.424265-0.423735	1-10	0.42422-0.42369	0.42413-0.42360	0.42399-0.42346	0.000561-0.00056	0.000561-0.00056	0.000561-0.000559
6.0	0.424265-0.423735	1-10	0.42421-0.42368	0.42411-0.42358	0.42395-0.42342	0.000631-0.00063	0.000631-0.000629	0.00063-0.000629
6,5	0.424265-0.423735	1-10	0.42421-0.42368	0.42409-0.42356	0.42392-0.42339	0.000704-0.000702	0.000704-0.000702	0.000703-0.000702
7.0	0.424265-0.423735	1-10	0.42420-0.42367	0.42407-0.42354	0.42388-0.42335	0.000782-0.00078	0.000782-0.000780	0.000781-0.000779
7.5	0.424265-0.423735	1-10	0.42419-0.42366	0.42405-0.42352	0.42383-0.42330	0.000862-0.000859	0.000861-0.000859	0.000860-0.000858
8.0	0.424265-0.423735	1-10	0.42419-0.42366	0.42403-0.42350	0.42379-0.42326	0.000944-0.000942	0.000944-0.000941	0.000943-0.000940

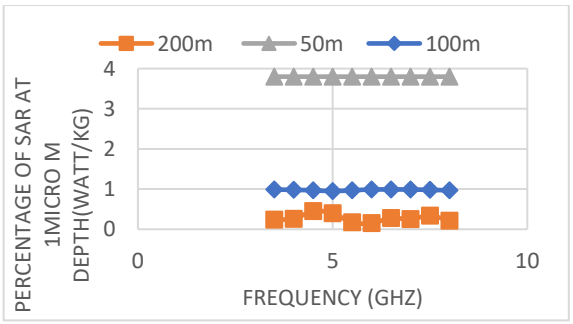

Figure 1. Percentage of SAR at 1 µm depth with varying distance from the tower

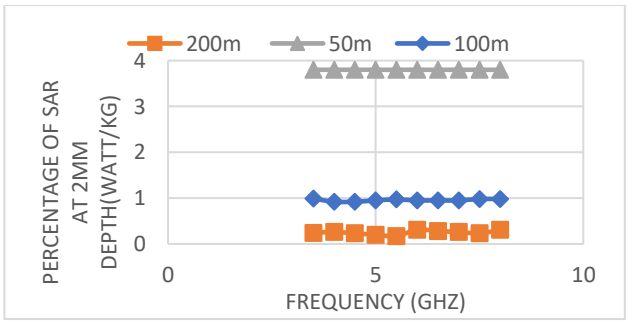

Figure 2. Percentage of SAR at 2 µm depth with varying distance from the tower

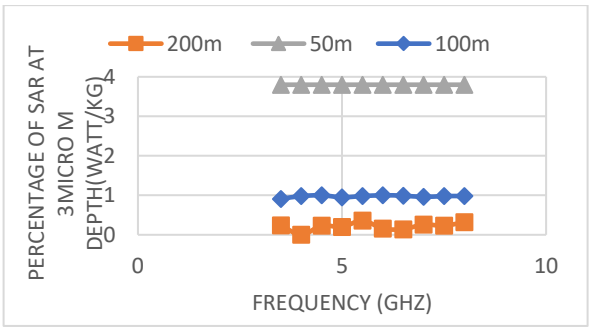

Figure 3. Percentage of SAR at 3 µm depth with varying distance from the tower

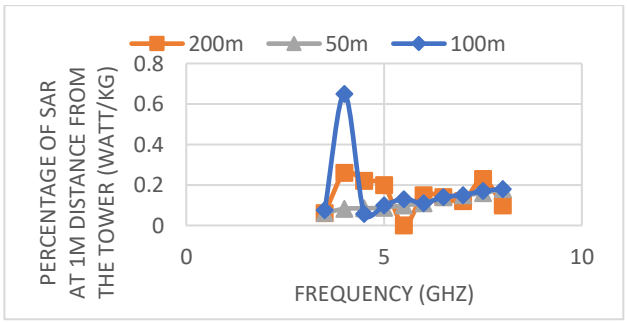

Figure 4. Percentage of SAR at 1m distance from the tower with varying depth inside the skin

DISCUSSION

Interpretation of Key Findings

In today's scenario the sources of electromagnetic waves are increasing rapidly due to which the impact of electromagnetic waves is also increasing. When the EM waves incident on the skin of human being, the electric field induced around the transmission tower penetrate inside the epidermis layer of skin at various depth. In this study the penetrated electric field and specific absorption rate inside the of human being is calculated for various height of transmission tower.

Comparison with Previous Studies

The previous studies, the effects of electromagnetic (EM) radiation on human beings were investigated. In this study the focus was on computing the penetrated electric field and Specific Absorption Rate (SAR). Additionally, a comparison of SAR inside the body was conducted for varying heights of transmission towers. The study aimed to explore the impact of different tower heights on the electromagnetic exposure experienced by individuals (4, 12).

Implications for Public Health

In our study, the effects of EM radiation on the skin health of the human being is calculated. This study shows the variation of SAR inside the skin of human being at different distance from the transmission tower and for various height of transmission tower. It is observed from the above analysis that the impact of EM radiation is decreasing as the height of transmission tower and distance from the transmission tower aremincreasing. For the shake of public health, this study recommends that the residence must be away from the transmission and height of the transmission tower should be long. The calculated SAR value is with in the safety limit but prolonged exposure of EM radiation near the 50 m height tower may have skin health hazards.

Limitations and Cautions

In this investigation, the impact of electromagnetic (EM) radiation within the human skin was assessed, specifically focusing on the influence of a singular transmission tower. However, it is crucial to acknowledge that in practical scenarios, various other sources of EM radiation surrounding individuals may also contribute to effects on human health. The current study does not encompass an examination of the effects of these additional sources. The observations from this study suggest that, as a precautionary measure, transmission towers should be situated at a considerable distance from residential areas. Furthermore, the findings indicate that taller tower structures may be preferable for minimizing potential impacts."

Recommendations for Future Research

To safeguard human health, this study strongly recommends additional research in the realm of electromagnetic (EM) radiation. Prolonged exposure to such radiation has the potential to impact human well-being adversely. It is advised that government authorities allocate spectrum to telecom companies only after a meticulous comparison with safety guidelines provided by pertinent agencies. This careful approach ensures that the electromagnetic spectrum allocated for communication purposes aligns with established safety standards, prioritizing the health and safety of individuals exposed to these radiations.

CONCLUSION

When electromagnetic waves of frequency 3.5 GHz to 8.0 GHz incident, the electric field is varied from 1.69665 V/m to 1.66318 V/m and SAR is varied from 0.00524 W/Kg to 0.0145 W/Kg for 50 m height of the tower. It is observed that the electric field and SAR are proportionally decreased as the height of the tower is increased. Low value of energy absorption represents the less harmful effect on internal organs of human beings. The long transmission tower will be less harmful for the human skin health. The electric field and SAR are also less if the distance from the tower is more. Then from the above discussion it is concluded that residence near to the short heighted towers are harmful for human skin health. Thus, residence should be away from the tower and tower should be as long as possible.

In the end of conclusion, the continuous exposure of electromagnetic radiation on the skin of human beings may be harmful for the skin and it may cause of skin cancer in human body.

AUTHOR'S CONTRIBUTION STATEMENT

Authors explicitly outline and describe their individual contributions to the research and the development of the manuscript. This statement is intended to provide transparency and clarity regarding each author's role in the project. It helps readers and reviewers understand the specific contributions of each author to the research process

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interests.

SOURCE OF FUNDING STATEMENTS

We are not using any type of funding by any organisation.

ACKNOWLEDGMENTS

This section devotes to acknowledge the supports by Graphic Era Hill University and the authors whose references are used in this manuscript.

BIBLIOGRAPHY

1. Schommer NN, Gallo RL. Structure and function of the human skin microbiome. Trends in microbiology. 2013 Dec 1;21(12):660-8. doi: 10.1016/j.tim.2013.10.001
2. Panagopoulos DJ, Karabarbounis A, Margaritis LH. Mechanism for action of electromagnetic fields on cells. Biochemical and biophysical research communications. 2002 Oct 18;298(1):95-102. https://doi.org/10.1016/S0006-291X(02)02393-8
3. International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). Health physics. 2020 May 1;118(5):483-524. doi: 10.1097/HP.0000000000001210
4. Tyrakis C, Gourzoulidis GA, Kiouvrekis Y, Alexias A, Alkhorayef M, Sulieman A, Kappas C. Radiofrequency exposure in schools' environment reveals spectrum characteristics: The role of public information. Bioelectromagnetics. 2020 Oct;41(7):558-64. https://doi.org/10.1002/bem.22286
5. Monadizadeh S, Kibert CJ, Li J, Woo J, Asutosh A, Roostaie S, Kouhirostami M. A review of protocols and guidelines addressing the exposure of occupants to electromagnetic field radiation (EMFr) in buildings. Journal of Green Building. 2021 Mar 1;16(2):55-81. https://doi.org/10.3992/jgb.16.2.55
6. Cork MJ. The importance of skin barrier function. Journal of Dermatological Treatment. 1997 Jan 1;8(sup1):S7-13. https://doi.org/10.3109/09546639709160948
7. Buchwald J, Yeang CP, Stemeroff N, Barton J, Harrington Q. What Heinrich Hertz discovered about electric waves in 1887–1888. Archive for History of Exact Sciences. 2021 Mar;75:125-71. https://doi.org/10.1007/s00407-020-00267-8
8. Li QC, Niu H, Papathanassiou AT, Wu G. 5G network capacity: Key elements and technologies. IEEE Vehicular Technology Magazine. 2014 Jan 31;9(1):71-8. doi: 10.1109/MVT.2013.2295070
9. Kowall B, Breckenkamp J, Blettner M, Schlehofer B, Schüz J, Berg-Beckhoff G. Determinants and stability over time of perception of health risks related to mobile phone base stations. International journal of public health. 2012 Aug;57:735-43. https://doi.org/10.1007/s00038-011-0310-4
10. Azpilicueta L, Lopez-Iturri P, Zuñiga-Mejia J, Celaya-Echarri M, Rodríguez-Corbo FA, Vargas-Rosales C, Aguirre E, Michelson DG, Falcone F. Fifth-generation (5G) mmwave spatial channel characterization for urban environments' system analysis. Sensors. 2020 Sep 18;20(18):5360. https://doi.org/10.3390/s20185360
11. Yaekashiwa N, Otsuki S, Hayashi SI, Kawase K. Investigation of the non-thermal effects of exposing cells to 70–300 GHz irradiation using a widely tunable source. Journal of radiation research. 2018 Mar 1;59(2):116-21. https://doi.org/10.1093/jrr/rrx075
12 Simkó M, Mattsson MO. 5G wireless communication and health effects—A pragmatic review based on available studies regarding 6 to 100 GHz. International journal of environmental research and public health. 2019 Sep;16(18):3406. https://doi.org/10.3390/ijerph16183406

13. Zeni O, Scarfì MR. Experimental requirements for in vitro studies aimed to evaluate the biological effects of radiofrequency radiation. Microwave Materials Characterization; InTech: Rijeka, Croatia. 2012 Nov 14:121-38.
14. Cousin ME, Siegrist M. Cell phones and health concerns: Impact of knowledge and voluntary precautionary recommendations. Risk Analysis: An International Journal. 2011 Feb;31(2):301-11. https://doi.org/10.1111/j.1539-6924.2010.01498.x
15. D'Orazio J, Jarrett S, Amaro-Ortiz A, Scott T. UV radiation and the skin. International journal of molecular sciences. 2013 Jun 7;14(6):12222-48. https://doi.org/10.3390/ijms140612222
16. Nestle FO, Di Meglio P, Qin JZ, Nickoloff BJ. Skin immune sentinels in health and disease. Nature Reviews Immunology. 2009 Oct;9(10):679-91. https://doi.org/10.1038/nri2622
17. Chiaramello E, Bonato M, Fiocchi S, Tognola G, Parazzini M, Ravazzani P, Wiart J. Radio frequency electromagnetic fields exposure assessment in indoor environments: a review. International journal of environmental research and public health. 2019 Mar;16(6):955. https://doi.org/10.3390/ijerph16060955
18. Kim K, Lee YS, Kim N, Choi HD, Kang DJ, Kim HR, Lim KM. Effects of electromagnetic waves with LTE and 5g bandwidth on the skin pigmentation in vitro. International Journal of Molecular Sciences. 2021 Jan;22(1):170. https://doi.org/10.3390/ijms22010170
19. Verloock L, Joseph W, Goeminne F, Martens L, Verlaek M, Constandt K. Temporal 24-hour assessment of radio frequency exposure in schools and homes. Measurement. 2014 Oct 1;56:50-7. https://doi.org/10.1016/j.measurement.2014.06.012
20. Saliev T, Begimbetova D, Masoud AR, Matkarimov B. Biological effects of non-ionizing electromagnetic fields: Two sides of a coin. Progress in Biophysics and Molecular Biology. 2019 Jan 1;141:25-36. https://doi.org/10.1016/j.pbiomolbio.2018.07.009
21 ICNIRP (International Commission for Non-Ionizing Radiation Protection) Standing Committee on Epidemiology:, Ahlbom A, Green A, Kheifets L, Savitz D, Swerdlow A. Epidemiology of health effects of radiofrequency exposure. Environmental health perspectives. 2004 Dec;112(17):1741-54. https://doi.org/10.1289/ehp.7306
22. Tesselaar E, Macková P, Pagonis C, Saers S, Ahle M, Sandborg M. Measurement of Skin Dose and Radiation-Induced Changes in Skin Microcirculation in Chronic Total Occlusion Percutaneous Cardiac Interventions (Cto-Pci). Radiation Protection Dosimetry. 2021 Oct;195(3-4):257-63. https://doi.org/10.1093/rpd/ncab024
23. Dhara R. Health effects of the Bhopal gas leak: A review. NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy. 1994 Nov;4(3):35-48. https://doi.org/10.2190/NS4.3.g
24. Caraglia M, Marra M, Mancinelli F, D'ambrosio G, Massa R, Giordano A, Budillon A, Abbruzzese A, Bismuto E. Electromagnetic fields at mobile phone frequency induce apoptosis and inactivation of the multi-chaperone complex in human epidermoid cancer cells. Journal of cellular physiology. 2005 Aug;204(2):539-48. https://doi.org/10.1002/jcp.20327
25. Colombi D, Thors B, TöRnevik C, Balzano Q. RF energy absorption by biological tissues in close proximity to millimeter-wave 5G wireless equipment. IEEE Access. 2018 Jan 5;6:4974-81. doi: 10.1109/ACCESS.2018.2790038
26. Koh TH, Choi JW, Seo M, Choi HD, Kim K. Factors affecting risk perception of electromagnetic waves from 5G network base stations. Bioelectromagnetics. 2020 Oct;41(7):491-9. https://doi.org/10.1002/bem.22290
27. Mortazavi SA, Megha K, Shams SF, Mohammadi S, Mortazavi SM. Radiation from mobile phones and cell towers, risks, and protection. An Introduction to Non-Ionizing Radiation. 2023 Nov 13;292. doi: 10.2174/9789815136890123010013