

## 5G

# 5G – Effects on Health and Environment

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**Abstract**—This paper mainly targets on how the implementation of the 5G radio frequency (RF) fields in the close proximity of the human environment will affect the human health and the environment. Previous research on human exposure to Radio Frequency fields in a wireless network communications system has been mainly priorities on uploading of data only as the device was more in the radius of the human body. However my paper points out how it is very necessary of a full in-depth investigation of radio frequency directly transmitting on the human body by these antennas, as mobile systems implemented in millimeter wave bands will lead to the following:- (i) installation of more antennas as they have smaller cell size and (ii) more concentration of radio frequency transmitted on human body using a more directional antennas. In this research paper, I explain how exposure to different levels of radio frequency in downlink of 5G Wireless system will affect the human body. The research result shows that the downlink of the transmission of 5G will increase in generating a very higher specific absorption rate (SAR) and power density (PD). With the help of this paper we can also determine that we should consider SAR being a huge part in determining human radio frequency exposure in the mmW downlink.

**Index Terms**— *Human RF exposure; 5G; PD; mmW; Uplink; Downlink; SAR.*

## I. INTRODUCTION

It is proven that exposure to radio frequency has more adverse impact on the health of human and the birds, bees and other animals. The rapid increase in the number of mobile telecommunications has appeared among controversy over the technology poses risk to the human health. Millimeter Wave frequencies is where it is highly possible that the future mobile telecommunication system is going to operate, there are going to be two changes that is definitely going to happen which are the biggest concern of increasing the exposure level on humans to radio frequency fields. The first thing is that number of transmitters which will operate are going to increase exponentially. The number of base station (BSs) that are going to be installed due to propagation of small cell towers and mobile devices appropriately. This is going to lead to the chance of increasing of radio frequency exposure to humans. Second, the beams which are going to be used for transmitting the signals are going to be narrower as a solution for the higher depletion of the higher frequency bands. Very small wavelengths of mmW signals combined with advances in RF circuits enable very large numbers of miniaturized antennas. These multiple antenna systems can be used to form very high gains. Such higher concentration of RF energy will increase the potential to more deeply penetrate into a human body.

## II. WHAT IS 5G ?

5G means “5th generation” wireless technology. The capacity to transmit will be higher and much faster due to high bandwidth. The things which are going to be included are Internet of Things (IoT), faster video streaming, driverless cars and much more.

Due to 5G we are going to notice a huge escalation in the millimeter and microwave radiation in our surrounding and environment. It is also going to be use a completely new frequencies which have not been completely examined by experts who have no relations with the industries.

5G is going to use a technology which were first being used by the military for controlling crowds. It is very difficult for these millimeter waves to propagate through the walls so the distance between the transmission antenna is going to be very less and are going to be placed near our surrounding in the form of “small cell”.

The intention of these wireless industries is to place these so called “small cell” in every lamp post or access point around the whole country. These cells are going to be near our homes, office premises, schools etc. emitting these kinds of dangerous radiations for all the time of the year 365 days and 24/7.

5G radiation is going to be emitted from advanced transmitters, in the shape of phased arrays, that emits the millimeter and/or microwaves in narrow waves, a technology which was originally used by the military as a weapon against the enemy. This will drastically increase the exposure of these hazardous waves to the human body. These dangerous waves are going to be everywhere.

### A. Related Works

This research paper points out the facts that there have been very few research papers focusing on the fact of how 5G affects the human body.

**1) Measurement of Human RF Exposure:** *All of us are well informed about the health hazards because to electromagnetic (EM) emissions in mmW spectrum, international health organization such as the Federal Communications Commission (FCC) or the ICNIRP have decide how much of the the human body can absorb without showing any abnormalities to the human body or can lead to a major health problems. It has been reported that there's been very a high chances of cancer due to emissions of higher RF frequency by the communication transmitter. The electromagnetic exposure leads to the*

heating which is absorbed by the first few millimeters inside the human skin; for example, the generated heat which is emitted at 42.5GHz can be absorbed upto 0.41mm inside the skin. The mmW waves which are being transmitted on the body of the human can lead to be regular burn on the skin which occurs when coming in a contact of a hot object as reported in "Safe for the the generations which will come : The millimeter wave in the wireless communications needs to be accurately checked for all considerations of safety" by T. Wu, C. Collins, and T. Rappaport. The normal temperature for the skin outer surface is typically around 30 to 35°C. A human body can tolerate upto 43°C if the temperature rises above that limit that can lead to permanent damage to the skin.

**2) Reduction of Human RF Exposure:** There have been very few studies before which has paid attention to the effect of the RF exposure on human in communication system. It's characteristics of spreading at different mmW and heating effects were checked for debate on health effects of Radio Frequency exposure in millimeter wave radiation by IEEE standard for safety at standards to human body in different levels 1992. The Scheme and model of Emission reduction for SAR in the exposure parameters are Explained in recent paper of IEEE regulations for protection levels w.r.t. human exposure 2005 and "The millimeterwave wireless communication systems and human body: interplay and implications".

### III. SYSTEM MODEL

This part of the paper explains how the setup of the whole network is done and how it will affect human RF exposure. Let us consider the frequency spectrum used for 5G is 28 GHz (28 GHz to 100 GHz) as it is the best candidate for 5G, I will use a similar report that was released by the 3GPP. This paper will also compare the exposure of Radio frequency on human of 5G system to a older version of the

system in cellular communications system. For pointing out the amount of how much SAR level can increased I will compare its data with the Release 9. The parameters for comparing are mentioned in the Table I.

#### A. 5G

**1) Path Loss:** The Model for 5G System is demonstrated in the Fig.1. It includes of 19 areas each consisting of 3 sectors. The distance between each site is 200 meters and each sector can have number of users or user equipments(UEs) upto 30. The table 1 also defines the propagation of the network between access point and user equipments, the retinue 3 path loss system models are pretended: Urban Macro (UMa), Rural Macro (RMa) and Urban Micro (UMi) [20].

**2) Pattern to Antenna Beam:** In case of a 5G Access Point, the weakening model of an element in antenna on the rise and plane of azimuth are provided by [20]

$$A_a(\phi) = \min \left\{ 12 \left( \frac{\phi}{\phi_{3db}} \right)^2, A_m \right\} \text{ [dB]} \quad (1)$$

$$A_e(\theta) = \min \left\{ 12 \left( \frac{\theta - 90^\circ}{\theta_{3db}} \right)^2, A_m \right\} \text{ [dB]} \quad (2)$$

where  $\phi$  and  $\theta$  are angles of a beam on the azimuth and elevation plane, respectively;  $(\cdot)_{3db}$  means the angle of where it is displayed a loss occurs of 3-dB. Afterwards the pattern of antenna elements which are combined into two planes is produced by

$$A(\theta, \phi) = \min (A_a(\phi) + A_e(\theta), A_m) \text{ [dB]} \quad (3)$$

where  $A_m$  is a maximum loss (front-to-back ratio). It is defined  $A_m = 30$  dB in [20], but it could be more higher in practical implementation. Eventually, an antenna gain that is derivated into a formula as

TABLE I  
PARAMETERS FOR 5G AND RELEASE 9

Parameter	Value	
	5G	Release 9
Carrier frequency	28 GHz	1.9 GHz
System layout	RMa, UMa, UMi [18]	SMa, UMa, UMi [21]
Inter-site distance (ISD)	200 m	1,000 m
Cell sectorization	3 sectors/site	6 sectors/site
Bandwidth	850 MHz	20 MHz
Max antenna gain	5 dBi per element	17 dBi
Transmit power	21 dBm per element	43 dBm
AP's number of antennas ( $\lambda/2$ array)	$8 \times 8$ and $16 \times 16$	$4 \times 4$
AP antenna height	10 m	32 m
Duplexing	Time-division duplexing (TDD)	
Transmission scheme	Singler-user (SU)-MIMO	
UE noise figure	7 dB	
Temperature	290 K	

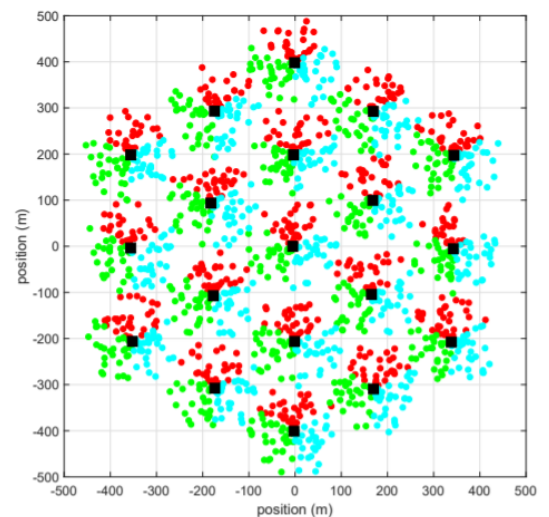


Fig. 1. A snapshot of one "drop" of 5G topology (19 sites, 3 sectors per site, and 30 UEs per sector)

$$G(\phi, \theta) = G_{max} - A(\phi, \theta) \text{ [dB]} \quad (4)$$

where  $G_{max}$  is the maximum limit of antenna gain.

### B. Release 9

1) **Path Loss** : The mobile network which operates on the current Release 9 is to create a radius of cell of 500m, which can result in the ISD of around 1,000m. The power received in a downlink of the transmission is calculated in this paper, after following the current path loss models provided in the paper no [21]- Urban Macro (UMa), Urban Micro (UMi) and Suburban Macro (SMa).

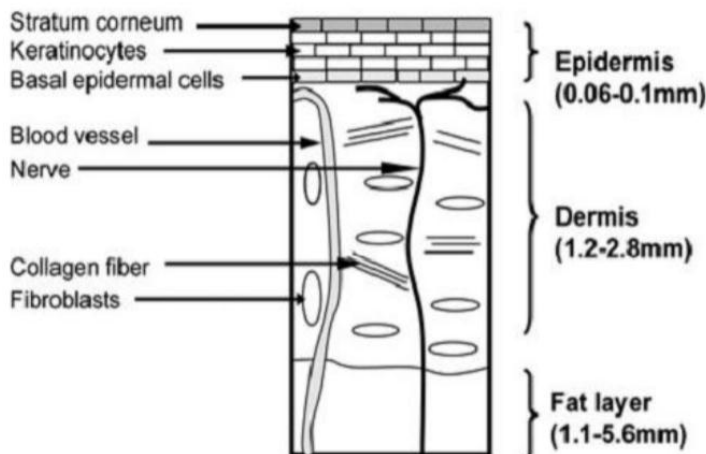
2) **Antenna Beam Pattern**: The radiation pattern for antenna of the release 9 basestation is also defined in the equation (1) and (2). However, not like at a 5G Access Point,  $\theta_{3db}$  and  $A_m$  for a Release 9 Base Station are probably given as  $35^\circ$  and 23 dB, respectively.

### IV. BODY PARTS MOST VULNERABLE

The primary biological target of the radiation are eyes and skin.

a) **Eye**: The cornea of eyes are characterized by water consisting of around 75% of free water and has a thickness of around 0.5 mm so it leads to the absorption of electromagnetic waves energy easily. The Ocular redness or swelling have been occurred after high intensity exposure to the eye. However no physiological modification have been found, indicating the EM waves act on the cornea as dose-dependent manner i.e., the effect stays until it is exposed on the and reverts back when no exposure.

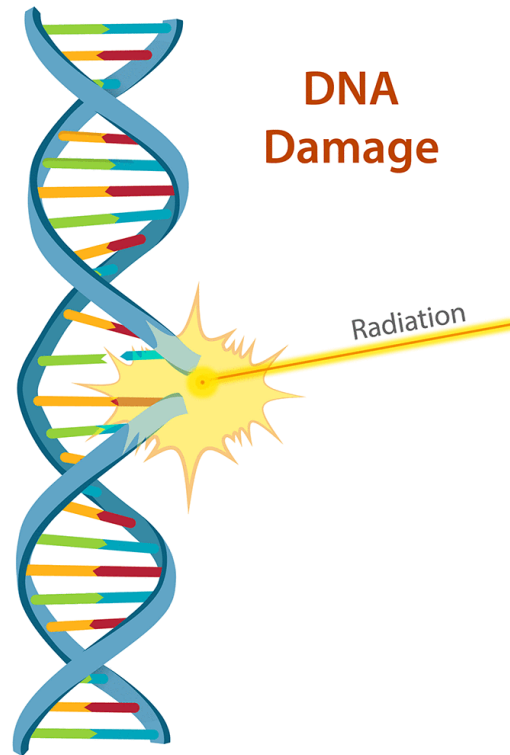
b) **Skin**: The skin contains 95% of the human body. From the perspective of EM, the skin can considered anisotropic (value can be different as per the different test) the structure of multilayer dispersive consists of 3 different layers, namely, subcutaneous fat layer, dermis and epidermis.



Human skin structure

c) **DNA STRAND BREAK**: There has been a research which tested EM waves on DNA. The EM waves which were way below safety level still the waves made damaged the DNA strands. Although the damages can be recovered after few medication but the waves were emitted only for small

amount of time. If EM waves are emitted for much longer time it can reach a non recoverable stage. A point to be noted is that the EM waves were emitted on the subject were low (60 Hz) as compared to the current emissions by the network cell towers (800 Hz-3.4 GHz). The breakage can cause to either cell dead or can result into the mutation of the cell which is a major cause of the cancer.



### V. CONCLUSIONS

The technology of Electromagnetic Waves has been with us from a long time and we have become dependent on its technological applications, so it is impossible for us to just remove from the system. But it is our responsibility for us to use the technology with precautions as 5G is a completely new territory and there have been very few or no major research on this technology and its effect on the human health. So, we first delay this technology until we have a further concrete evidence of its effects. For the time period we should focus on finding alternative of using this technology which can decrease the negative points of the current. Currently we do not need this technological advancement as we are still able to use current technology much efficiently. So, my thoughts we don't need at least for now as we are losing more than we are gaining in the long run.

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