

Mitigation of the Excessive Non-ionized Radiation of Base Transceiver in Developing Countries

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ABSTRACT

The use of mobile phone is increasing day by day both in urban and rural areas in developing countries. As a result, there has been a corresponding rise in transmitting antenna radiated power. The aim of this paper is to describe the detection of this radiation and minimizing that excessive radiation using some techniques according to ITU (International Telecommunication Union) recommendation K70.

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1. INTRODUCTION

Base Transceiver Stations (BTS) commonly known as 'base stations' emit radio frequency/electromagnetic energy (RF/EME), which is a form of radiation technically referred to as non-ionizing radiation (NIR). People produces this non-ionizing radiation through Mobile-phones and BTS, remote control devices, broadcast transmitters, electric and electronic devices. The main source of RF energy in a cell-phone is its antenna, which is contained within the handset. Since the handset is typically held to the side of the head while the phone is in use, the closer the antenna is to the head, the greater the exposure to RF/EME. The amount of exposure to RF energy to which a cell-phone user is exposed depends on the number and duration of calls made, the amount of cellular telephone traffic at any given time, the distance of the user from the nearest BTS, the quality of the transmission, how far the antenna is extended, and the size of the handset. According to latest World Health Organization [1] (WHO) and 13 countries Interphone [2] study researches mobile phones can contribute to health deficiency, including the increased risk of brain tumors, eye cancer, salivary glands tumors, testicular cancer, non-Hodgkin's lymphoma and leukemia [3].

In developing countries just scarce or no research on non-ionizing radiation is performed. The telecommunication regulator and the mobile operators must take in account the recommendations released by international entities in order to comply with human exposure levels, it means protect human against non-ionizing radiation [4]. The main source of NIR in developing countries is BTS transmitter antenna radiation. Setting up a huge number of BTS in a small area without any planning is causing this NIR. The NIR level is much more in urban areas than rural areas as the number of mobile user is much more in urban areas. New operators are coming and setting up their new BTS and the NIR is getting increased.

In this situation government must force them to share infrastructure to minimize the number of BTS. Otherwise the intensity of NIR will increase day by day.

ITU-T Recommendation K.70 [5] defines techniques which may be used by telecommunication to identify the main source of radiation. It offers guidance on mitigation methods which allow reduction of radiation level in order to comply with exposure limits. It also provides guidance on procedures necessary in the environment in which, in most cases, there is a simultaneous exposure to multiple frequencies from many different sources. For rural base station, the power density levels may be more significant because of the higher cellular radius coverage but still lower than the standard threshold power density levels [6]. A new type of coupler (which is applicable to low leakage two-dimensional communication (2DC) sheets) is used to evaluate the safeness in terms of localized specific absorption rate (SAR), according to the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Safety Guidelines [7]. An evaluation of the radiation (RFR) from transmitting devices in the VHF/UHF band. The readings of the radiation are then verified with the guidelines made by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) which was recommended by the International Telecommunication Union (ITU) [8]. A paper by Allam Mousa studied the main sources of EMF radiation at the vicinity of the university and then checked if the combined exposure rates meet the international standards in the concerned area. The dominant EMF sources were the BTS and FM (Frequency Modulation) transmitter [9].

First, the main methods used to evaluate the exposure levels are met with an especial focus on the point source method which is chosen for this study.

2. SOURCE OF RADIATION AND EXPOSURE LIMITS

The real source of intentional EMF is the transmitting antenna – not the transmitter itself, because the transmitting antenna is the main source that determines EMF distribution in the vicinity of a transmitting station. The EMF distribution does not depend on the type of the transmitter used if the same type of a signal and the same output power is applied to the input of the antenna (more exactly, the input of the feeding system). In most cases the distance between a transmitter and a transmitting antenna is rather big (around 30 m to 100 m in radio communication and around 200 m to 1500 m in broadcasting). The radiation emitted by the transmitter enclosure is unintentional radiation and is not considered in this recommendation. The radiation emitted by the transmitting antenna is the intentional radiation which is most important from the point of view of the exposure assessment and determines radiation levels in areas accessible to people.

Table 1. different international organizations for the frequency band 900 MHz and 1800 MHz [10].

Country or Organization	Document	900 MHz		1800 MHz	
		Electric field (V/m)	Power density W/m ²	Electric field (V/m)	Power density W/m ²
International health based guidelines					
International commission of non ionizing radiation protection	ICNIRP 1998	41.25	4.5	58.3	9.0
International/ Institute of Electrical and Electronics Engineer	IEEE,1999 USA	47.6	6.0	67.3	12
European/ European Committee for Electro technical Standardization (Technical committee)	CENELEC,1995	41.1	4.5	58.1	9.0

The most important step in the exposure assessment is the evaluation of radiation levels in the considered area. In typical transmitting and base stations, many operating frequencies are used, so the cumulative exposure assessment is required. Depending on the accessible data, models and methods used for the evaluation, the results have a lower or higher accuracy. In general, more detailed information concerning the radiation sources and more sophisticated methods and models lead to higher accuracy. In some cases, the accuracy of the evaluation is limited because of the lack of appropriate data concerning transmitting equipment (antennas). The radiation exposure depends on the below things:

- Frequency / wavelength of RF signal being transmitted;
- Operating power of transmitting stations;
- Radio Frequency Power radiated from the antenna;
- Time of Exposure of RF signal at a given distance from the antenna ;
- Exposure from other antennas located in the area;
- Over powering of amplifier for better reception quality, signal strength and more coverage;
- Duration/ frequency of recurrent exposure;
- Temperature and humidity;

In the table 1, we shown the exposure limit which is set by different international organizations for the frequency band 900 MHz and 1800 MHz [10].

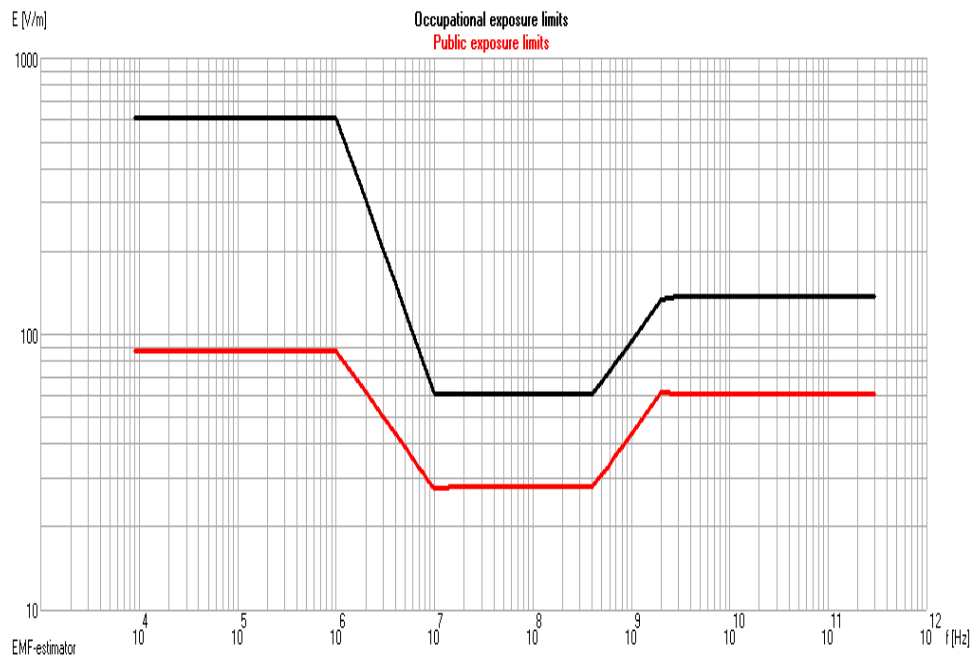


Figure 1. ICNIRP (International Commission on Non-Ionizing Radiation Protection) Limits

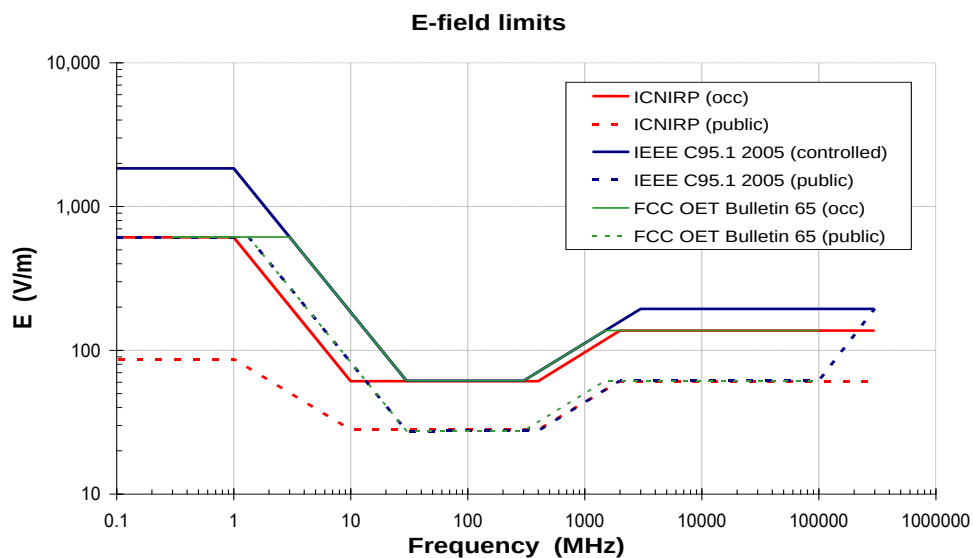


Figure 2. Comparison between the ICNIRP and IEEE (Institute of Electrical and Electronics Engineers) standards

In Bangladesh, only in Gulshan area has a large number of BTS. The exact numbers are below. The total number of base station in this area is 526. A large number of base station in this small area is alarming and these base stations cumulative exposure is huge. As this is in the heart of the city, so the harm caused by these radiations is also huge.

Table-2: BTS Statistics

Operator name	Banglalink	Grameen Phone	Robi	Airtel
Number of BTS	173	117	128	108

3. METHODS TO CALCULATE THE RADIATION

3.1. Full Wave Methods:

The highest accuracy of calculation of the reference levels will be achieved by the numerical modeling using one of the full-wave methods based on solving Maxwell's equations in frequency or time domain. It includes the method of moments (MoM), finite-difference time domain (FDTD) and many others. Such methods of calculation may be used for any region of the EMF. They use detailed-segmented models of systems – the more detailed-segmented model is used, the better accuracy of the evaluated field distribution is achieved.

A typical transmitting station or base station consists of many transmitting antennas. The area required for consideration is usually big and inhomogeneous. In such a case, the MoM is more effective than other methods.

3.2. Synthetic Model:

In the synthetic model each antenna is considered to be a set of elementary sources which have identical parameters. Such an approach is natural, for example, for broadcast antennas which usually contain sets (up to 64) of identical panels operating as one transmitting antenna. In the case of GSM (Global System for Mobile Communication) panels (or similar antennas), they can be divided into "patches" (usually containing one dipole with a screen) and each of them may be considered as a separate radiating source. This model may be employed for distances beyond the near-field distance calculated with respect to the maximum size of an elementary radiating source (patch in GSM, panel in broadcasting). The model leads to very accurate results, but the accuracy is lower than in numerical modeling because the coupling between radiating sources is neglected. In many cases (for example, for all the broadcasting antennas) this assumption is well fulfilled. A disadvantage of this model is that exact information concerning the feeding arrangements of the system containing many radiating sources is required.

3.3. Point Source Model:

The point source model is a simple but very effective model which may be used in calculating the reference levels. It is assumed that the transmitting antenna is represented only by one point source, situated in the antenna electric centre and having a radiation pattern of the considered transmitting antenna. The accuracy of this model depends on the field region and on the antenna gain. The boundaries of the field regions are defined according to slightly different criteria. This model is fully applicable in the far-field region which can be represented as

$$d_r = \max\left(3\lambda, \frac{2D^2}{\lambda}\right) \quad (1)$$

Where,

d_r is the distance between the transmitting antenna and the point of investigation

D is the maximum size of the antenna

λ is the wavelength

A disadvantage of this model is in the immediate vicinity of the antenna, where the dimension of the antenna needs to be taken into account in the exposure assessment.

4. CUMULATIVE SOURCE RATIO IN MULTIPLE SOURCE ENVIRONMENT AND ANALYSIS

In most cases, a typical transmitting station contains many transmitting systems operating on many frequencies. In this case, in the area around the antenna tower, the electromagnetic field has a complex structure with many components of different frequencies and different field strengths, varying from point to point. For example, a typical cellular base station contains transmitting antennas of two frequency ranges (e.g., 900 MHz and 1800 MHz), operating on many radio carriers and is frequently shared by several operators, which involves the presence of additional transmitting antennas and radio carriers. The cellular base stations are often mounted on broadcast antenna towers which usually contain transmitting equipment for the FM (Frequency Modulation), VHF (Very High Frequency) and UHF (Ultra High Frequency) bands. In such multiple sources environments, the human body is exposed to radiation emitted simultaneously by all the radiating sources.

For the frequency range above 100 kHz, in which the thermal effect is dominating the cumulative exposure, the coefficient W_t has the form (for the electric field strength) shown in equation below

$$W_t = \sum_{i=100 \text{ kHz}}^{300 \text{ GHz}} \left(\frac{E_i}{E_{l,i}} \right)^2 \leq 1 \quad (2)$$

where,

E_i is the electric field strength at frequency i

$E_{l,i}$ is the reference limit at frequency i .

For the induced current density and electrical stimulation effect, relevant up to 10 MHz, and electric field strength as the reference level, the coefficient is shown in equation below,

$$W_t = \sum_{i=1 \text{ Hz}}^{10 \text{ MHz}} \frac{E_i}{E_{l,i}} \leq 1 \quad (3)$$

For compliance with the regulations, both coefficients W_t of the cumulative exposure should be less than 1.

5. MITIGATION OF EXCESSIVE RADIATION TECHNIQUES

5.1. Minimizing the transmit Power:

The simplest and the easiest way to mitigate the radiation is to minimizing the transmit power of the BTS antennas. Because in this case electric field strength and power density value becomes less. But in this case the coverage area also becomes less as the power travels to less distance. So, this method is only used if the other methods get failed.

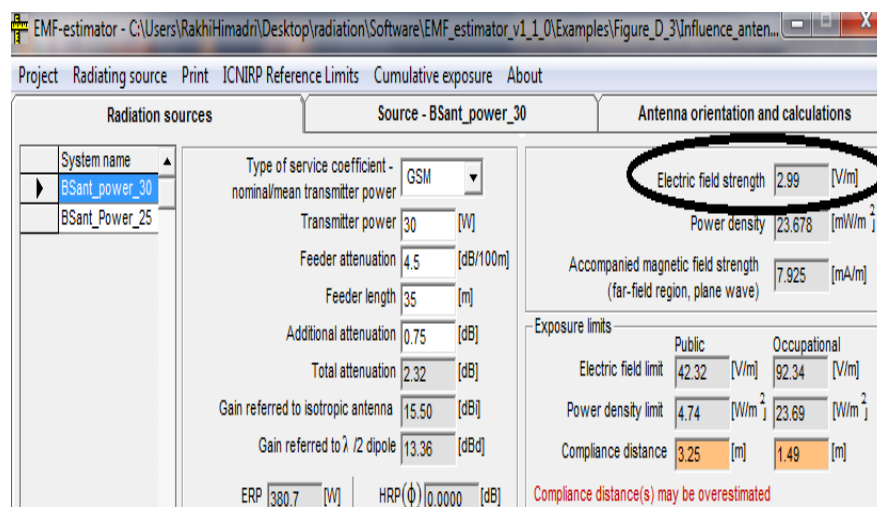


Figure 3. For Transmitter Power 30W

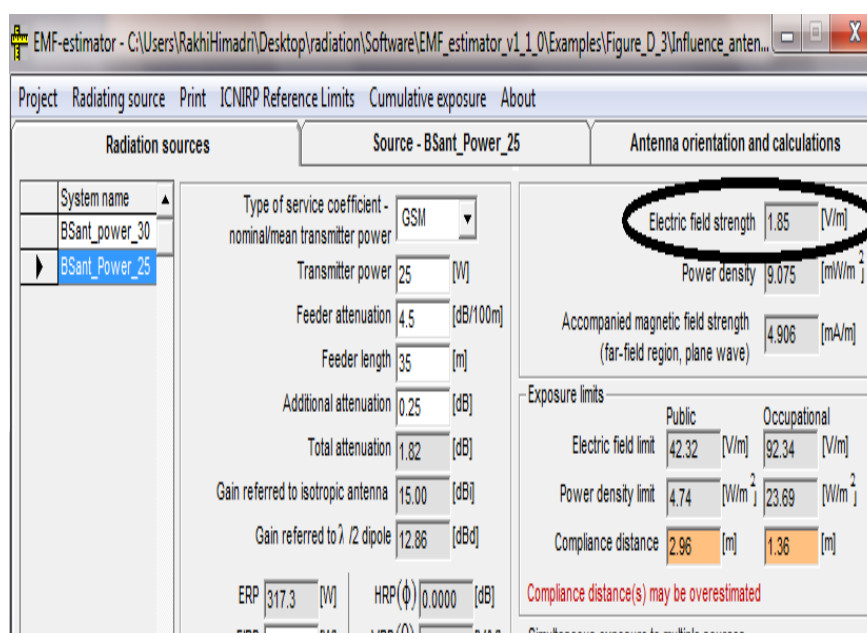


Figure 4. For Transmitter Power 25W

So, from figure 3 and figure 4 this is clear that if we minimize the transmit power then the electric field strength becomes less which cause less radiation exposure.

5.2. Increasing the Antenna Height:

Increasing the antenna height is another method cause in this method the points of investigation gets shifted to larger distance. Also the elevation angle of the considered area moves to another part of the vertical radiation patter. But this process is only applied if there is any scope to increase the antenna height.

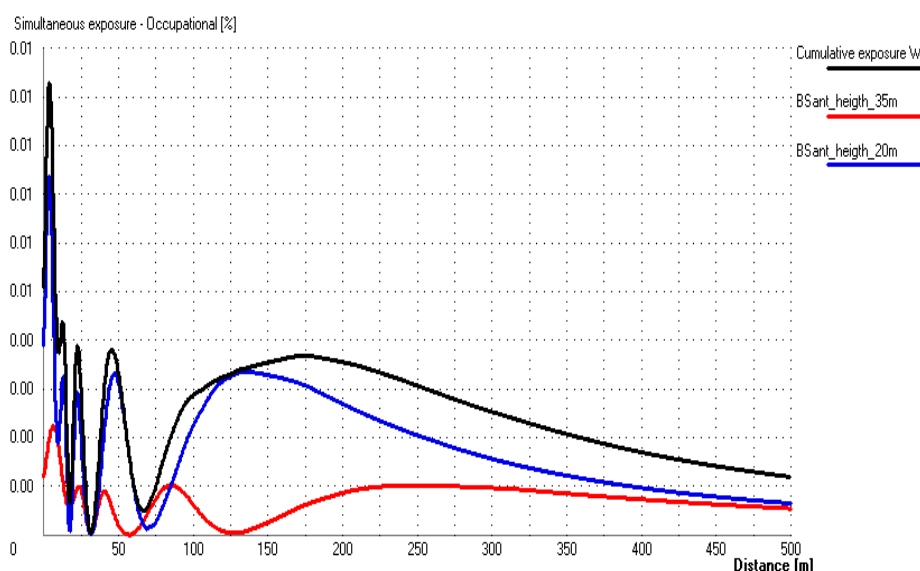


Figure 5. Antenna Height vs. Exposure

From Fig 5 we can see that the exposure is higher for the antenna height 20m than the antenna height 25m.

5.3. Decreasing the VRP (Vertical Radiation Pattern) down tilt:

The main beam tilt of the VRP of the transmitting antennas is frequently used for performance service reasons. This is because, in the first approximation, in a line-of-sight mode, all the energy radiated

above the horizontal plane is lost. This loss can be reduced by narrowing the vertical radiation pattern of the antenna system and tilting the beam downward. In the cellular base stations, the downtilt is also used to limit the coverage area, which increases the possibility of the frequency reuse.

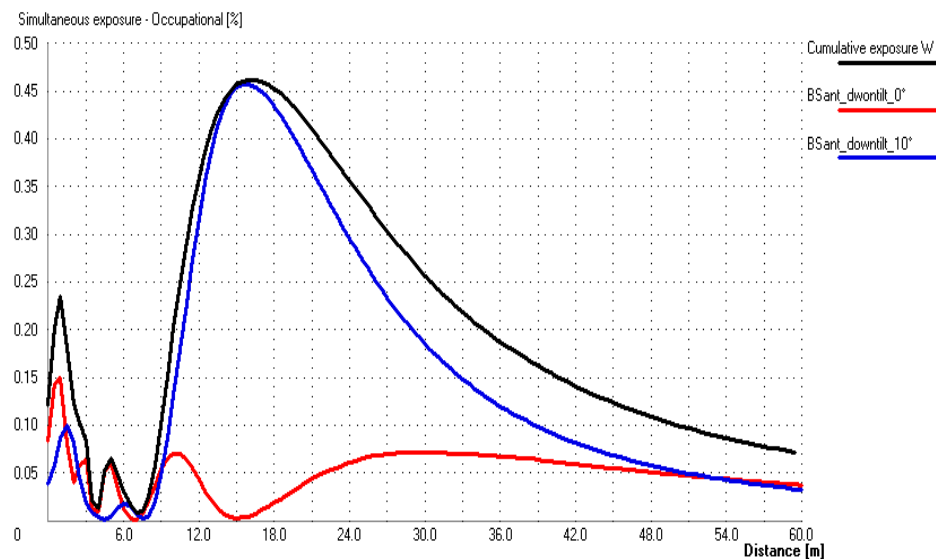


Figure 6. Antenna down tilts vs Exposure

Main beam tilt has also an influence on the radiation level in the proximity of the transmitting antenna. It can be generally stated that bigger downtilt gives bigger radiation levels in the proximity of the transmitting antenna. From Fig 6 we can see the exposure is much higher when the down tilt is 10 degree. But if we decrease the down tilt then the exposure becomes lesser.

5.4. Increasing the Antenna Gain:

Antenna gain is another technique to minimize the radiation cause if we increase the antenna gain, the effective radiation increases in the desired direction and the loss of radiation is minimized. Which in a result minimizes the radiation exposure. This can be done by proper antenna directivity.

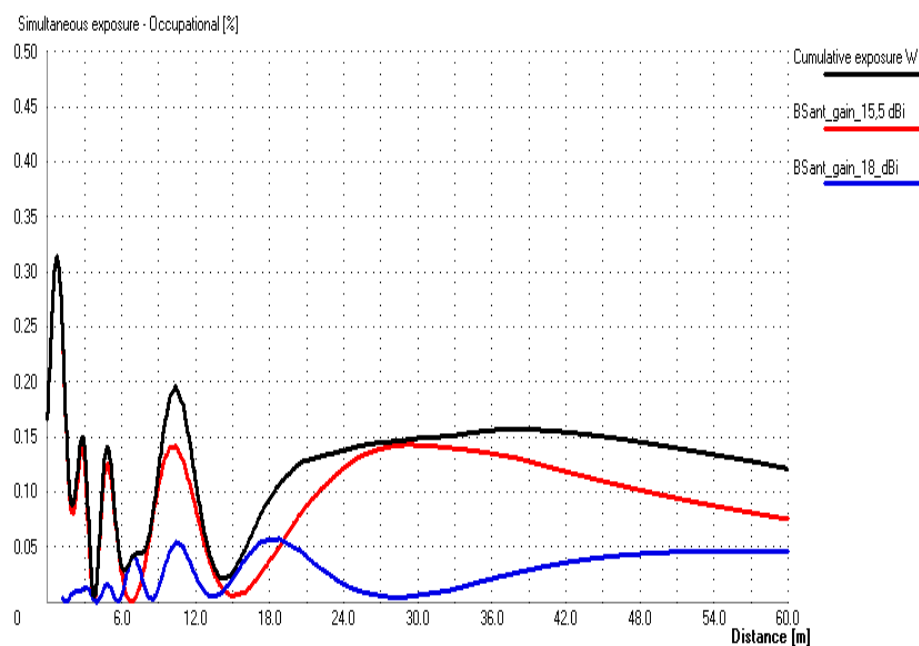


Figure 7. Gain vs. Exposure

From the above figure this is visible that if we increase the antenna gain from 15.5 dBi to 18 dBi then the exposure gets mitigated.

5.5. Changing the HRP (Horizontal Radiation Pattern):

There is very less scope to control the excessive the radiation by changing the HRP. For cellular base stations, it is possible to reduce the level by replacing panels with a wide horizontal beam by one with a narrower horizontal beam.

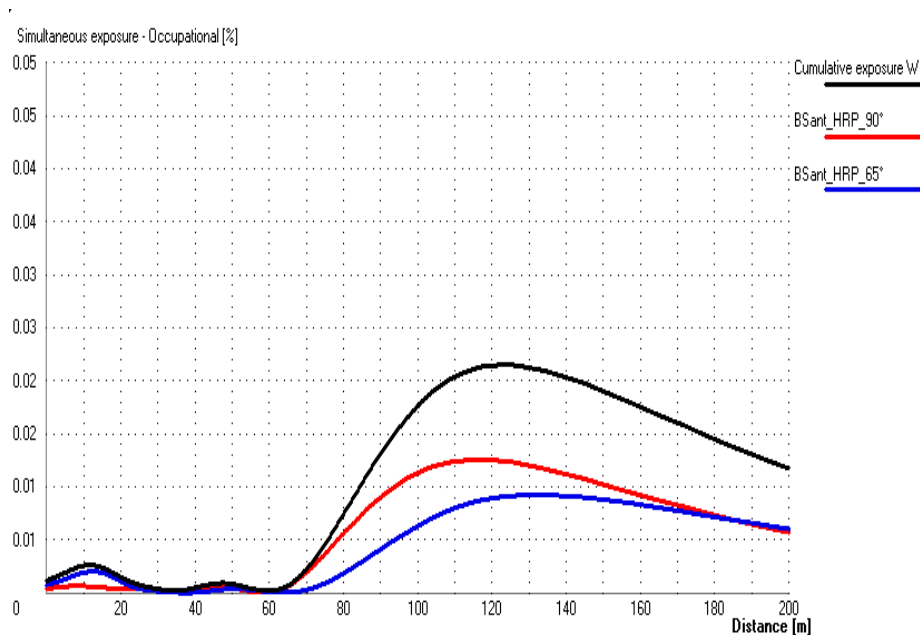


Figure 8. HRP vs. Exposure

From the above figure this is visible that when the HRP is changed from 90 degree to 65 degree then the exposure gets minimized.

5.6. Applying Multiple Methods:

As the above methods are independent to one another, in some cases the above methods can be applied together to get the desired radiation and to control the excessive radiation.

6. CONCLUSION

Because of the rapid growth of mobile technology in the developing countries, the cumulative exposure of radiation is getting serious day by day. The operators who are providing the cellular services are also not following the guidelines of ITU. But to stop the excessive radiation the operators surely follow the recommendations. They can use the techniques which are stated and analyzed in this paper to meet the ITU guidelines. The possible realistic proposal to control the excessive radiation is infrastructure sharing between different operators. Otherwise the cumulative exposure will get higher and higher. The government of developing country should also emphasis on this topic and should encourage proper installation of base station with controlled non-ionized radiation. The future work of this paper could be searching for some key parameters which can mitigate the non-ionized radiation.

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Rakhi Roy has completed her graduation in Electrical and Electronics Engineering from American International University-Bangladesh. She has completed her first Masters from American International University-Bangladesh in Telecommunication Engineering. She served American International University-Bangladesh as a faculty member in the department of Electrical and Electronics Engineering. Right now she is continuing her second M Sc. in Communication Engineering in National Taipei University, Taiwan. Her research interests are in MIMO (Multiple-Input Multiple-Output), OFDM (Orthogonal Frequency Division Multiplexing), Network Coding, Fading Channels, Renewable Energy, Power Efficiency etc.



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