

Effect of Electromagnetic Radiations Emitted By Mobile Towers On Survival of *E.coli*

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Abstract: In Indian urban set up, mobile phone towers are a major source of electromagnetic radiations, which can be mutagenic. India's permissible limit for radiation levels from mobile phone towers is 900 times higher than the safe limit. High environmental concentration of radio frequency radiations may place biological systems under high risk of hazardous radiation effects. The present study focuses on determination of effect of electromagnetic radiations emitted by mobile towers on *E. coli*. Different locations in a Residential complex with three mobile towers installed in vicinity were selected as sites for exposure. Log phase culture of laboratory strain of *E. coli* (OD = 0.1) was prepared and exposed at the selected sites for maximum period of 30 hours and checked for viability and phenotypic mutations at different time intervals. The unexposed culture kept at a site with very low EMR was used as control. Significant reduction in the cell viability was observed for the culture exposed to mobile tower radiations. Surprisingly, this reduction in cell viability was observed on exposure to site with EMR within the safe limits. Thus, the present study showed lethal effect of EMR emitted by mobile towers on microbial culture even when the radiation was within safe limits.

Key words: Mobile tower, EMR, *E.coli*, viability

I. Introduction

Wireless technology has several advantages and has grown rapidly in the last decade. All over the globe, dramatic haphazard increase is witnessed in the number of wireless devices and supporting infrastructure in the form of cell towers due to immense growth in communication industry. Worldwide, people are debating about associated health risks due to electromagnetic radiations from mobiles and mobile phone towers.

Radiation effects are divided into thermal and non-thermal effects. Non-thermal effects are not well defined and there are plenty of controversial findings, but generally, it has been reported that non-thermal effects are a few times more harmful than thermal effects (1). The biological effects of radio-frequency electromagnetic field (RF-EMF) at molecular level induce thermal and non-thermal damage, which may be due to dielectric heating leading to protein denaturation, polar molecular agitation, cellular response through molecular cascades and heat shock proteins, and changes in enzyme kinetics in cells (2).

Mobile phones use ultra high frequency range and according to the International Commission of Non-Ionizing Radiation Protection, the limit of emission of non ionizing radiation is 2 milliwatts. However, it is observed that this limit is often surpassed. According to an article published in reputed newspaper, India's permissible limit for radiation levels from mobile phone towers is 900 times higher than the safe limit of 0.5 milliwatts per square meter, suggested by global report on health risks from exposure to wireless technology radiation (3).

The hot tropical climate of the country, low body mass index [BMI], low fat content of an average Indian as compared to European countries and high environmental concentration of radio frequency radiation may place Indians under high risk of radio frequency radiation effects and the level of susceptibility of an average Indian may be different (1).

With more than 5.4 lakh towers installed to cater the needs of 800 + million mobile holders, the hazard associated with RF EMR increases several fold and the issue needs to be given a top priority.

Various studies have shown the ill-effects of radio-frequency electromagnetic field (RF-EMF) on bees, fruit flies, frogs, birds, bats, and humans, but the long-term studies of such exposures are inconclusive and scarce, and almost non-existent in India (MOEF, 2010; DoT, 2010). International Agency for Research on Cancer (IARC), part of WHO, designated RF-EMF from cell phones as a "possible human carcinogen" Class 2B (WHO, 2011). (2)

According to a review on 919 research studies related to effect of EMR, it is stated that 593 studies report impact; 130 studies reveal EMR has no influence on the biological system that are used in the studies; 196 remain inconclusive (2).

Bacteria have also been used in the studies to check impact of Extreme Low Frequency Electromagnetic Fields (ELF-EMF) (4). In particular, it has been demonstrated that ELF-EMF can negatively or

positively affect functional parameters (cell growth and viability) and bacterial antibiotic sensitivity. It depends on physical parameters of the electromagnetic field (frequency and magnetic flux density) applied, the time of the exposure, and/or the type of bacteria cells used (5).

However, limited literature is available on impact assessment of EMR by giving onsite exposure to representative bacterial systems, especially with respect to mutagenicity.

II. Material and methods

Screening of sites for the study:

Since the present study involved assessment of effects of EMR generated by mobile towers on microbial systems, different locations were screened and evaluated based on the EMR values using an RF measurement App. Different locations representing Low, Moderate and High EMR prevalence were selected, so that varying EMR exposures and the effects of the same would possibly be correlated.

Along with sites with differing EMR levels that were used as 'test sites', site with practically unavailable mobile network and showing minimum EMR power levels was selected as 'control sites'. Measure was taken to select the control site which was in the vicinity of the test sites to rule out the effects of other environmental factors like temperature, humidity etc. on the bacterial culture.

The sites finally selected for exposure were as follows:

Site 1: Terrace (radiation detected of -60 dBm)

Site 2: 6th floor residence (radiation detected of -57 dBm),

Site 3: Parking lot (radiation detected of -95dBm)

Selected sites were such that the culture was exposed at different angles from the tower.

Assessment RF measurement using online apps:

RF measurement at was done using Online app 'open signal'.

Selection and maintenance of bacterial culture as a model system for the study:

Culture: Laboratory strain of *E.coli* having O. D of 0.1 was used as the representative microbial culture. It was cultured in nutrient broth at 37°C was washed with sterile saline twice. The culture suspension prepared in saline (OD= 0.1) was distributed in sterile tubes and then taken for exposure.

Exposure of the culture at selected sites with simultaneous EMR recordings:

Culture of the selected laboratory strain of *E.coli* was exposed at the pre determined test and control sites for varying time periods and simultaneously the EMR value at the respective sites was determined. Effects of short exposure times of as less as few hours to long exposure periods in terms of days was analyzed.

Analysis of the effects of EMR on bacterial system:

Screening for morphological and biochemical changes: In the present study, the possibility of morphological changes in the bacterial cells was analyzed by performing Gram staining before and after exposure. Conversion of the lactose fermenting strain of *E. coli* to lactose non-fermenters due to mutagenesis was also analyzed on MacConkeys agar.

Viability Assay:

10ml of the culture was exposed in different test tubes, for different time intervals i.e. 1hr, 4hrs, 24hrs, 30hrs. The exposed cultures were collected at their specified time intervals, plated on MacConkey's agar medium using spread plate technique and incubated at 37°C for 24 hours.

III. Results and Discussion

Antennas on Cell tower transmit in the frequency range of 869 - 890 MHz (CDMA), 935 - 960 MHz (GSM900), 1805 - 1880 MHz (GSM1800), 2110 - 2170 MHz (3G). People living within 50 to 300 meter radius are in the high radiation zone (dark blue) and are known to be more prone to ill-effects of electromagnetic radiation. The location selected for the study had three mobile towers within 200 meter radius. The sites of exposure, site 1 and site 2, represented maximum radiation zone. The selected sites also were studied regarding any known ill effects of high EMR in the selected regions on humans, e.g., increased cases of cancer, increased cardiac problems etc. Noteworthy, three cases of cancer were reported within a span of three years at the site selected for exposure.

Bacteria are simple and widely used models for examination of mutagenesis and DNA repair processes. The advantages of bacterial systems are their availability, ease of cultivation, short life cycle, and haploidy. Many DNA damaging agents and/or mutator genes cause mutations that are readily and clearly observed as

changes in phenotype. Bacteria are also been used as model system to analyze effect of low intensity EMR in number of studies (6, 7). Hence, *E. coli* was used in this study to monitor the effects of EMR.

Earlier studies have indicated that low level EMR induce morphological and biochemical changes in the bacterial cells. Along with studying the phenotypic effects of the mutagen, additional observations like analysis of bacterial survival after treatment with mutagenic agent and microscopic examination of bacterial cells can provide a simple, rapid and highly informative characterization of the overall effect of mutagenic agent. Hence *E. coli* was selected as experimental system.

In the present study, MacConkey's agar, a selective medium for enteric bacteria, was used for the viability assay. The Medium is also a differential medium that differentiates between lactose fermenters and lactose non fermenters. No visible effect of mutation was observed that would convert lactose fermenting *E. coli* to non fermenter phenotype. Also, no morphological changes were noted while observing Gram Staining slides before and after exposure.

It is well known that mutagens cause changes to the DNA that can affect the transcription and replication of the DNA, which in severe cases can lead to cell death. Radiation from cell phone is known to produce DNA breaks in sperm cells that can mutate and cause cancer. Hence, cell viability was another criteria used in this study to determine effects of EMR exposure.

Cells exposed on terrace (site 1) and 6th floor residence (site 2) with radiation levels of -57 dBm and -60 dBm respectively, showed remarkable decrease in cell number within first four hours of exposure to radiations. On the contrary, sustenance and minor increase in number of organisms was observed in parking lot (site 3) having minimum recorded radiations of -125 dBm.

After 30 hours of exposure, complete cell kill was observed in case of cells at site 1 and site 2, while cell number was sustained for cells in the parking lot. Loss of cell viability was observed to be proportionate to the extent of radiations.

It is a known fact that at low doses, mutagens exhibit mutagenic effects, while lead to cell kill at high doses. This can be observed in UV exposure of bacteria. Since no visible mutagenic effects of EMR were observed, it needs to be confirmed whether these effects are not seen because a culture meant for such study, e. g., Ames' test cultures was not used; or because the EMR levels are so toxic that rather than mutagenesis they are resulting in massive cell kill. Ames test has been widely used to screen chemicals for their potential mutagenicity and genotoxicity. It is used routinely as a screening assay to predict animal carcinogens. In future, Ames' test would be performed to study effects of EMR in a similar manner.

Online available app 'open signal' was used for RF measurement. Though the apps do provide an idea about the extent of radiations in terms of power level in dBm, the basic use of the same is to map the cellular coverage, the signal readings and help locate nearest cell towers, and not really RF measurement. Use of these apps has shown correlation of cell viability and extent of radiation in our previous studies on effects of EMR on *Escherichia coli*. Lethal effect of EMR emitted by mobile towers was observed on microbial culture, even when the exposure was within safe limits. Thus, it needs to be further determined whether the massive cell kill observed was because measurement by this app is not very accurate, or the permissible value in India further needs to be reduced.

IV. Conclusion

Our study thus indicates that a simple bacterial system can be used to monitor the level of EMR in a particular area and observe its effects on cellular system. Although no phenotypic changes were observed in the culture as result of EMR exposure, massive cell kill was noted. Thus, the present study showed lethal effect of EMR emitted by mobile towers on microbial culture even when the radiation was within safe limits.

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Table-1: Results of cell viability Assay

Exposure time Interval	Cell density in CFU /ml		
	Site 1 Terrace	Site 2 6th floor residence	Site 3 Parking lot
0 Hr	7.0 X 10 ⁶		
1 Hr	9.5 X 10 ⁸	2.8 X 10 ⁸	1.68 X 10 ⁶
4 Hr	7.0 X 10 ⁴	7.2 X 10 ⁴	1.6 X 10 ⁷
24 hr	5.0 X 10 ²	4.5 X 10 ⁵	1.8 X 10 ⁷
30 Hr	Zero	Zero	5.21 x 10 ⁷