

Study and Analysis of 4G-5G Spectrum Mobile Signals on Germination Seed and Further Growth

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Abstract—Day by day the number of Radio Frequency Transmitting User Devices (RUD), mobile or static, are getting increased in and around living objects (LO). The near exposure of these Radio Frequencies Radiations to a specific LO, at a given place, under given environmental conditions, at unscheduled time of intervals, may affect its growth and survival, positively or negatively, as compared to the growth and survival of LO without presence or far presence of these RUDs is subject of study. The impact of effect will depend on the surface of exposure, field strength of signal at the surface of exposure, both these factors depend on Frequency, distance and radius of first Fresnel zone. Considering commonness of 800/1700/1800 MHz frequency band for 4 G & 5G communication system, the impact of RUD radiations in this band have been planned, the uplink and down link RF radiation pattern studied and accordingly test set-up has been designed and first experiment conducted on Butter Bean seeds and observed the impact on the biochemistry parameters after two to three weeks of exposure at regular interval during germination and growth. The first set of readings exhibit low values as compared to control.

Index Terms: 4G, 4GLTE, 5G, Living objects, Radio Frequency Transmitting User Devices, Butter Bean, RF, Mobile handset, smart phones, Biochemistry, FSL, Fresnel Zone.

I. INTRODUCTION:

The behavioral pattern of electromagnetic waves (EMW) of various frequency bands are getting revealed as their usage is proposed for a typical RUD application along with time period of radiation, power of radiation and number of RUDs and number frequency bands deployed together at a given place.

The RUDs under the name Zigbee, Bluetooth, LPWAN, Wi-Fi, GSM, CDMA, 3G, 4G, 5G, having radio frequencies ranging between 400MHz to 5200MHz are getting populated in and around LOs. The transmit power output of these devices range between 0dBm to +23dBm, and the gap between the transmitter and the living object may range between a Milli-meter or a Centi-meter. For such a minimal distance the free space RF signal power loss (FSL) is calculated using formula:

$$FSL = 32.45 + 20\log F + 20\log D \text{ in dBm,}$$

Where:

D is the distance in KM and

F is in Giga-Hertz.

The 4G & 5G broadband cellular technology is capable of delivering mobile web access, IP telephony, gaming services,

high-definition mobile TV, video conferencing, 3D-Television, Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (WiMAX), and Evolved High Speed Packet Access (HSPA+). The 4G technology is having peak data rates of up to approximately 100 Mbit/s and for high mobility up to approximately 1 Gbit/s, whereas, 5G broadband cellular network technology the peak data rate will be 10 times more than of 4G.

To cater ever-growing demand of higher volume of data communication, at the highest speed, new RF bands are being explored along with appropriate power of transmission, keeping in view the pre-defined Specific Energy Absorption Rate (SAR) from one RUD and internationally recognized EMW exposure limit of less than or equal to 6 minutes [1].

The FSL shall be very low, for a distance of 1Cms, which means, the receive strength (RS) of RF at the surface of LO will be almost same as transmitted by the RUD. The energy radiated by the RUD and absorbed by the LO may change the heat balance in the LO at the surface of exposure [3] depending upon the total time of RF exposure, RS of RF power at LO surface and pattern of exposure such as continuous and constant power or in intervals with or without variation in RF power radiation. Any change in the heat balance due to this new RF source may further change the bio-chemical transformation process during growth and survival of LO.

The exposure of 900 and 1800 MHz EMW radiations for a period of 2 h, and 4 h on Allium cepa (onion) root meristematic cells in terms of mitotic index (MI), chromosomal aberrations (CAs) and single cell gel electrophoresis (comet assay), has been observed adversely affecting on growth, more pronounced at 1800 MHz than that at 900 MHz [2].

The exposure of 2G mobile phone (850- 1850 MHz band) and 3G mobile phone (900- 1900MHz band) for different time $\frac{1}{2}$ hour, 1 hour, 2 hours, 4 hours and 8 hours adversely impacted the germination and growth parameters of soybean seeds band [5]. The radiations interfere with morphological and biochemical process and affect the growth of seeds of Pea and Fenugreek and nodule formation in the plants. [4].

Before germination, 48 hours exposure of 1800MHz mobile phone having 1 mW output power 2.2 Cms distance from the seeds of Lens Culinaris Medic seeds (Lentil), affects seeds in the state of dormancy rather than the state of germination [6].

In this work we designed an experiment set-up to study the impact of 4 G & 5G (800/1700/1800 MHz band) mobile hand set on the germination of Butter Bean seeds as living object to access the impact of average weight of leaf, Chlorophyll, Carbohydrates and Protein.

II. THE EXPERIMENTATION SET-UP:

Criteria and impacting parameters:

A. 4G Mobile handset:

TABLE I. FUNCTIONAL SPECIFICATIONS

Techno-logy	Multi-plexing	Peak Data rate	Switching	Frequency Band
LTE WiMAX	MC-CDMA/ OFDM	1Gbps	Packet	0.7 to 8 GHz

B. The parameters considered:

- Distance between living object (LO) and Transmitter from highest and lowest Signal strength perspective.
- The radius of first Fresnel Zone creating area of exposure at LO.

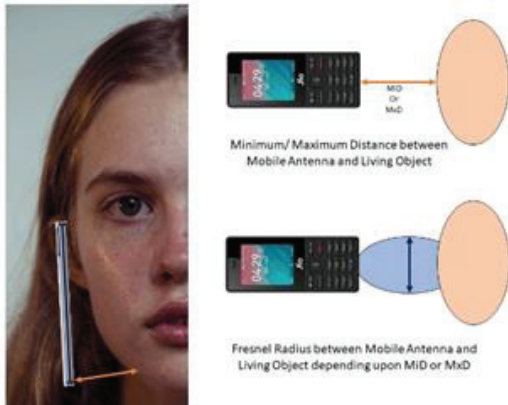


Fig. 1. Distance between RUD & LO and diameter of first Fresnel Zone

C. Specifications of Selected Mobile hand set for the experimentation:

- Model LYF -LF-2403N
- Head SAR :0.516 W/Kg
- Body SAR :1.154 W/Kg
- RF power output: +5dBm(max)
- Service provider: Jio
- Technology: 4G
- Uplink Frequency: 824-844Mhz /1710-1765MHz
- Down Link Frequency: 869-889 MHz/1805-1860MHz

D. Reasons to select this frequency band of mobile handset:

- JIO is using for their 4G communication bands: 800MHz and 1700/1800MHz. Whereas 800MHz and 1800MHz bands will reused under 5G

communication. Therefore, using Jio Handset and network shall remain advantageous from 4G and 5G perspective.

- At 800MHz Power Radiation Characteristics:
 - Mobile Handset Transmit Power +5dBm (3.1628 mW) reduces to +4.88dBm at a distance of 2.9 Centimeter (MiD) from the antenna of mobile handset considering free space loss of 0.12dBm. Therefore, any object within 2.9 Centimeter shall experience EMF of +5dBm during transmission time.
 - The radius of first Fresnel Zone at MiD shall remain 7.11 Centimeters which is sizable large as compared to higher frequency Bands.
 - The Maximum distance (MxD) for this frequency band will be 904 Centimeters and radius of first Fresnel Zone shall be 90.16 Centimeters considering 50dBm path loss for signal radiated, means at +5dBm transmitted power the signal strength at 1032 Cms shall remain as -45dBm (0.000032mW).
- At 1700MHz Power Radiation Characteristics:
 - Mobile Handset Transmit Power +5dBm (3.1628 mW) reduces to +4.83dBm at a distance of 1.4 Centimeter (MiD) from the antenna of mobile handset considering free space loss of 0.17dBm. Therefore, any object within 1.4 Centimeter shall experience EMF of +5dBm during uplink time.
 - The radius of first Fresnel Zone at MiD shall remain 2.46 Centimeters which is sizable low as compared to 800MHz frequency Bands.
 - The Maximum distance (MxD) for this frequency band will be 434 Centimeters and radius of first Fresnel Zone shall be 43.28 Centimeters considering 50dBm path loss for signal radiated, means at +5dBm transmitted power the signal strength at 434 Cms shall remain as -45dBm (0.000032mW).

The 800/1700MHz band considered for study being used for uplink (Transmit) purpose only being EMW strength of transmitter is more impacting on the LO as compared to receive strength.

For selection of these parameters the general habits of users are also considered:



Fig. 2. RUD and its holding position by user

- The transmitter antenna of Handset, will be very close to face of the user, which is even less than MiD calculated at that frequency.
- Users keeping mobile handset away from the body in hand is also not more than MxD calculated considering the distant signal level as -45 dBm.

E. Study of Handset uplink and downlink radio frequency and power of radiation:

With the help of RF Signal Strength Meter, the 4G antenna location in the handset have been identified:

- It is observed that the handset is having antenna on the bottom side of the handset and the maximum power output is +5dBm.



Fig. 3. RF strength measurement

- It is also observed that the frequency during call transmission does not remain constant and also not having constant trans power as + 5dBm but keeps on varying and hence it is decided not keep a fix frequency and fix power for experimentation but decided to use working handsets for experiencing actual mobile user condition of RF exposure.

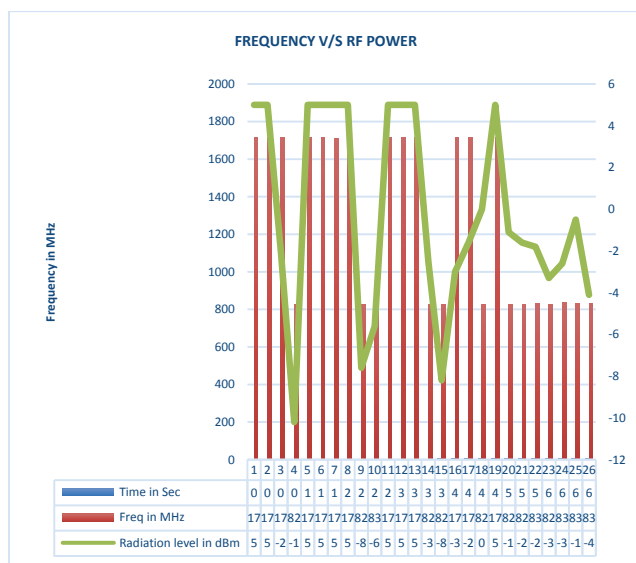


Fig. 4. Call transmitting mode Frequency V/S RF Power

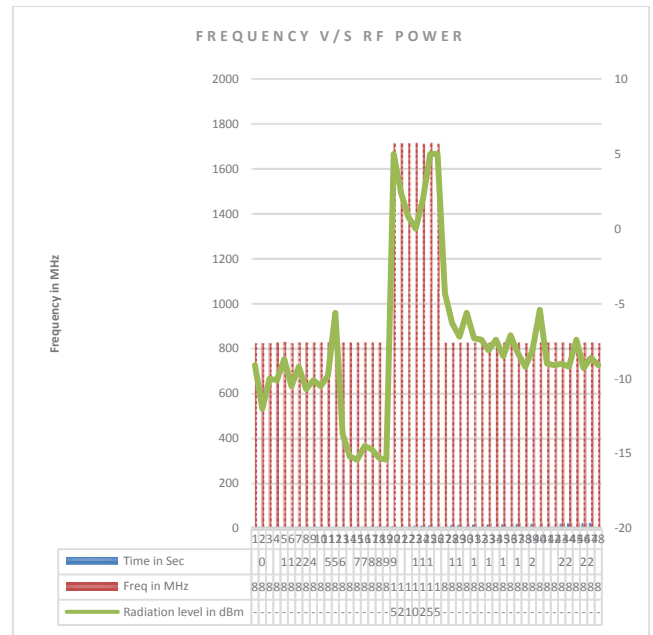


Fig. 5. Call receiving mode Frequency V/S RF Power

This study of handset revealed that the RF is not radiating at its maximum power all the time but fluctuating between -10dBm to +5dBm throughout the time of call transmitting mode while during call receiving mode it fluctuate between -16dBm to +5 dBms but the interval between two +5dBm pulse is more than the uplink mode.

This means, The RF frequency is not radiated continuously with constant RF Power but it is radiated in intermittent or pulse manner. This pattern of RF transmission and its impact on LO is a distinguished criterion than earlier studies where the continuous RF transmission with constant RF Power for a fixed time like 1 Hour or 4 Hour was the important consideration.

F. Selection of Butter Bean as LO for conducting RF impact study:

A nutritional powerhouse chock-full of protein, fiber, and trace minerals, lima beans grow on bushes or vines just like common beans (*Phaseolus vulgaris*). The seed is selected for experimentation considering the less time for germination and faster growth of saplings up to a height of 25-30 Cms in almost 2-3 weeks with number of leaves 5 to 9. The nutritional values of Butter Bean seed:

TABLE II.

Nutritional value per 100 g (3.5 oz)	
Energy	482 kJ (115 kcal)
Carbohydrates	20.88 g
Sugars	2.9 g
Dietary fiber	7 g
Fat	0.38 g
Protein	7.8 g



Fig. 6. The Butter Bean Seeds

G. RF test setup planned:

Plastic boxes selected to germinate and grow the seed in water so that the seed can be exposed to RF radiation of the mobile hand set easily and with minimum path loss.



Fig. 7. Seeds in plastic box.

The environment for experimentation to have same light, temperature, humidity and less than -45 dBm RF signal from the nearest mobile tower for control and exposed seeds. When one box is exposed others will receive less than or equal to -45dBm signal will be ensured. The control shall be kept on top of the rack to have always natural environmental RF radiation condition at this location when there is no mobile nearby or to say better than -45dBm.



Fig. 8. Placement arrangement for Control and to be exposed boxes.

Measurement of RF Strength before the seeds are exposed to mobile hand set.



Fig. 9. Testing of RF receive signal strength.

The Seeds shall be exposed to RF radiations of Mobile handset to experience +5dBm signal strength for given time of exposure. The gap between the seed and antenna of mobile is between 5mm to 15 mm.



Fig. 10. Mobile hand set position with respect to Seeds

The same arrangement shall be used under uplink and downlink condition of mobile operation.

To experience the transmit and receive condition of mobile the call will be established between a third party (external) mobile (minimum 5 meter away from the testing location)

Under the call receive condition, the third-party mobile will play an audio or musical recorded information for 10 minutes period and the receiving mobile radiations at that time will as experienced by seeds in the plastic box as shown in the Fig-10 above.

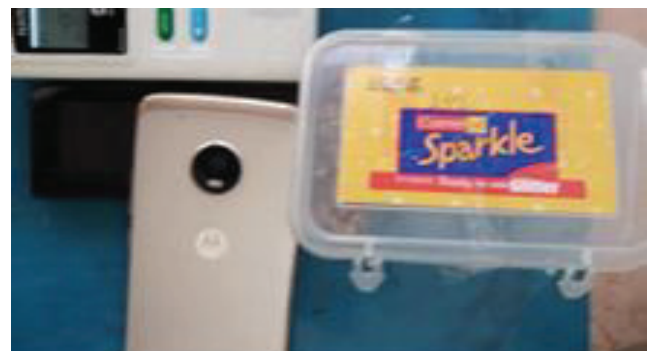


Fig. 11. The arrangement during call in transmit mode.

To experience radiations from the mobile during its transmission period of 10 minutes similar audio or musical recorded information shall be played from the mobile kept near the seeds as exhibited in the following figure. To transmit the audio or musical information a second handset

will be used having already recorded or down loaded files. This mobile will not have sim or wifi or Bluetooth under "ON" condition to avoid interference or influence of other frequencies at the spot. The receive strength meter is kept nearby to measure the radiation level of RF from the mobile.

This procedure will be followed for 2 to 3 weeks till the saplings grows up to a height of 20 to 25 centimeters.

Every day morning and evening the procedure will be repeated i.e. establishing a call with external mobile.

Transmit of Information: 10 minutes.

Receive of Information : 10 minutes.

Municipal Tap water will be added in the box from day one in incremental quantity to keep the seeds just under soaked condition because the growth is totally dependent on water, air, humidity, light and seed's own storage of energy.

Once the saplings are grown, the following biochemical analysis will be carried out in respect of control and exposed seeds:

1. Average weight of leaf
2. Chlorophyll-a
3. Chlorophyll-b
4. Total Chlorophyll
5. Total Protein
6. Total Carbohydrates

And the results of exposed will be compared with reference to values observed for control.

Every box will have 20 seeds and there will be one box for control and 6 boxes to expose RF radiations.

III. EXPERIMENTATION:

As planned 1 box for control and 6 boxes for experimentation have been prepared and kept at the location.

After 14 days of RF exposure of 10 Minutes trans and 10 minutes receive every day in morning and evening the growth is observed as follows:

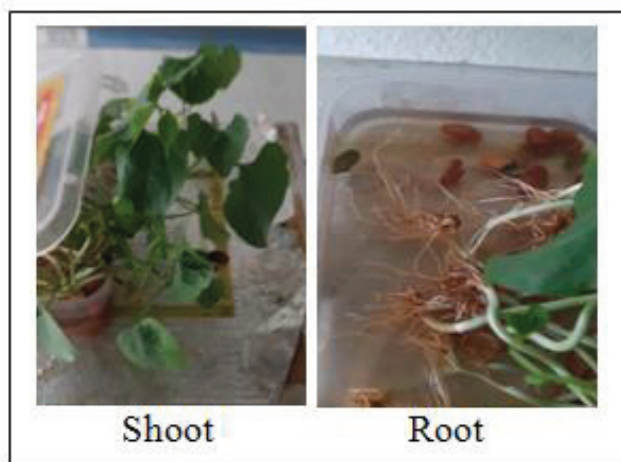


Fig. 12. Growth -Control Box, after 14th day

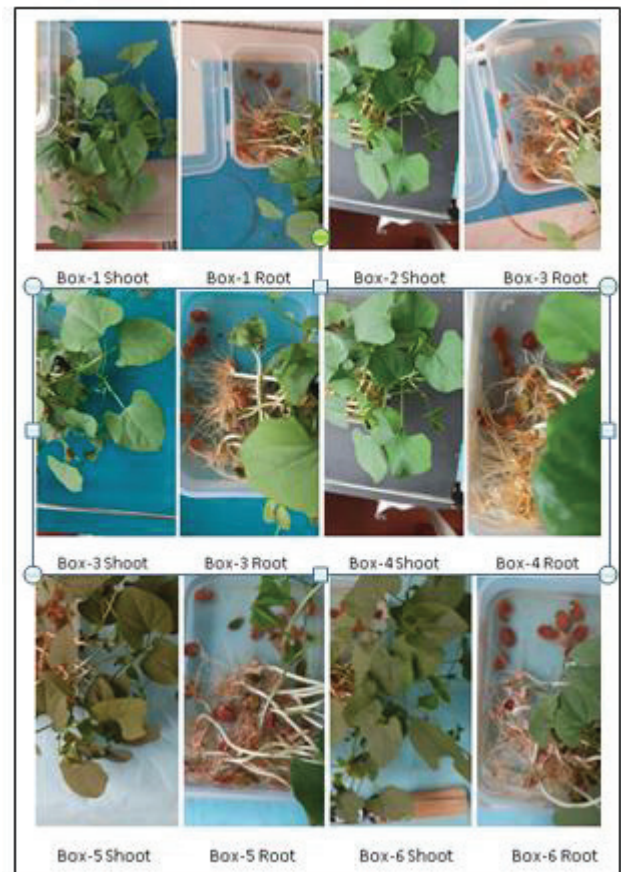


Fig. 13. Growth -Exposed Boxes, after 14th day Biochemistry analysis report:

Average weight:

TABLE III.

Sample Code	No. of Saplings	Total No. of Leaves	Biomass (g)	Average leaf wt (g)	Sample Code
Box-C	16	93	19.93	0.21	Box-C
Box-1	14	106	20.41	0.19	Box-1
Box-2	15	112	19.36	0.17	Box-2
Box-3	16	119	24.36	0.20	Box-3
Box-4	3	23	3.89	0.17	Box-4
Box-5	17	125	20.37	0.16	Box-5
Box-6	13	96	16.12	0.17	Box-6

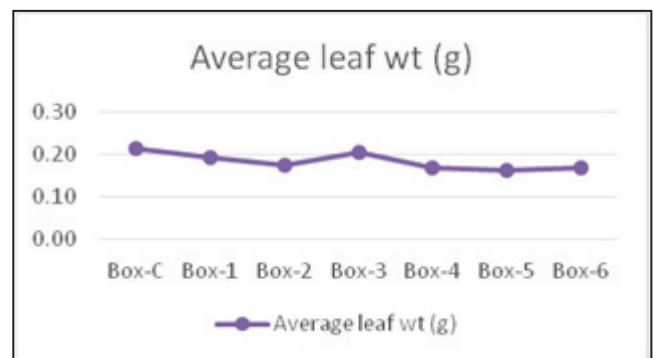


Fig. 14. Average leaf weight in grams.

Chlorophyll :

TABLE IV.

Sample Code	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)
Box-C	3.04	1.89	5.07
Box-1	2.17	1.00	3.05
Box-2	2.66	1.74	4.31
Box-3	2.22	1.25	3.48
Box-4	1.91	1.07	2.91
Box-5	2.37	1.36	3.71
Box-6	2.04	1.08	3.12

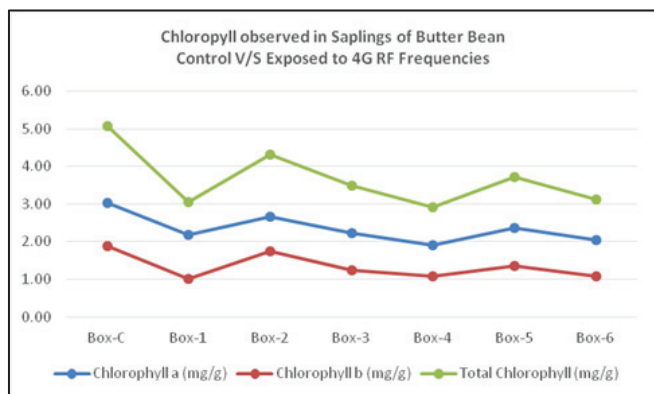


Fig. 15. Chlorophyll-a, Chlorophyll-b, Total Chlorophyll in mg/g

Total Protein:

TABLE V.

Sample Code	Total Protein mg/g
Box-C	3.75
Box-1	1.15
Box-2	2.10
Box-3	2.35
Box-4	1.15
Box-5	1.40
Box-6	2.10

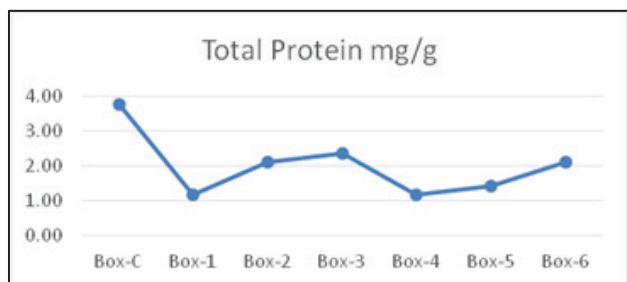


Fig. 16. Total Protein in mg/g

Total Carbohydrates:

TABLE VI.

Sample Code	Total Carbohydrate mg/g
Box-C	0.140
Box-1	0.035
Box-2	0.045
Box-3	0.045
Box-4	0.045
Box-5	0.060
Box-6	0.140

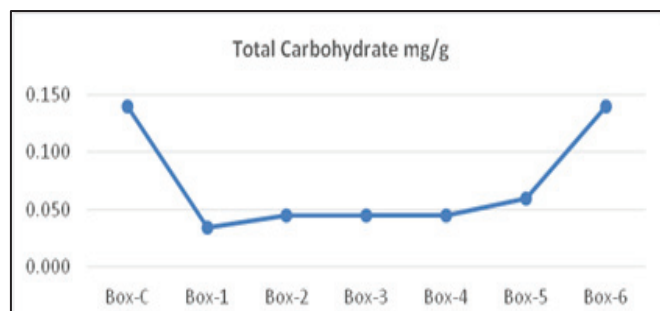


Fig. 17. Total Carbohydrate in mg/g

Observations:

1. One uses mobile handset for just listing the voice call at that time also the mobile handset transmits the +5dB signal in the environment. Even when some one is not using mobile for communication; the mobile communicates with the base station for up-gradation of apps and other processes.
2. Under the biochemistry analysis of all the saplings the values obtained for control box in respect of: Average Leaf Weight, Chlorophyll-a, Chlorophyll-b, Total Chlorophyll, Total Protein and Total Carbohydrates found to be higher than the saplings in the boxes exposed to EMW (RF) of mobile handset.

IV. CONCLUSION:

The increase of EMW radiation in the band of 800/1700/1800 from User Devices (RUD) at a given place may affect negatively, the bio-chemical strengths of the plants, can be seen from the results obtained. Particularly, the area of dense population. It is observed that, though some one is not using mobile for communication the RUD still continues radiating signals of +5dB strength.

The biochemical analysis observations clearly indicate that there is impact of EMW on the seed's germination and growth processes. The growth in population of 5 G RUDs just started in India and with additional population of RUDs at a given place, a big impact is expected to happen on living objects, hence there is great scope for further studies and research.

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