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# EMF Energy Radiation Trends and Analysis Due to Cellular Mobiles for 2050 at 900 MHz

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**Abstract**

In this article Electromagnetic Field (EMF) Radiations by cellular mobiles were experimentally determined at 900 MHz using Selective radiation meter, SRM-3006. These experiments were conducted using 30 cellular mobiles in four different modes of operation, namely ON (Sleep/Idle), Search, Transmit and Receive modes of operation. In this research work number of cellular mobiles available at present and projections for India, China, USA and Entire world for 2020, 2030, 2040 and 2050 are included. The alarming trends of EMF radiations by India, China, USA and Entire world at present and for 2020, 2030, 2040 and 2050 are also included. These EMF power levels entering in to environment were analysed and discussed.

**Keywords**: Electromagnetic Field (EMF) Radiation; Radiation Survey meter ; Mobile Telephony ; Environmental EMF exposures, International Commission on Non-Ionizing Radiation Protection(ICNIRP)

## 1. Introduction

Today the most invisible environmental pollution in industrialized as well as developing countries is the Electro Magnetic Fields (EMF) exposures created by the vast array of wireless technologies. The EMF radiation pervading the environment is now increasingly realised and this has added to a new pollutant to the list of pollutants into the environment which is invisible and insidious. Man made Electro-magnetic pollution has assumed prominent importance which is in limelight in recent times for all negative reasons. There has been unprecedented growth in the communication

industry in recent past causing a dramatic increase in a number of communication towers and more and more towers are being erected each year. Data demands have increased on mobile network and are fast expanding from cities to towns and to villages. Further with increased affordability, reduced costs their uses have increased dramatically and the overall exposure of the population as a whole to EMF due to cell phones have increased drastically. Electromagnetic radiations are not easily recognised and detectable. However their impacts are being felt on human beings[1-3, environment[4], wildlife including Bees and Birds[5]

## 2. Brief Historical Background and Necessity

WHO has conducted study in 13 countries and has reported 5117 brain tumour cases[6]. Professor Girish Kumar of IIT, Bombay has in his research quoted saying there are 200 research papers contributing to effects of EMF radiation on human health problems [7-8]. The impact of EMF radiation on environment further escalates on forests, birds, bees and wildlife[9]. The effects of human exposure to Wireless technology including EMF exposures from cell phones and whole body exposure to RF transmissions from cell tower antenna is simply not known yet with certainty. Scientific studies as yet have not been able to confirm a cause-and - effect relationship.

WHO[10] reported that considering the very low exposure levels and research results collected, there is no convincing scientific evidence that weak RF signals from cell phone towers and wireless networks cause adverse effects. However a number of studies have reported the link between exposure to radio EMF radiation and occurrence of heath disorders i.e. effect on cell growth, cell differentiation, DNA, immune system, hormonal effects, reproduction, neurological, cardiovascular systems, blood brain barrier, skin, sleep disorders etc. As these studies were not well designed and the number was not statistically significant, these observations have not been considered conclusive. Recently the EMFs from mobile phones and other sources have been classified as “possibly carcinogenic to human”by the WHO’s International Agency for Research on Cancer (IARC). The US Government Accountability Office also opined in 2012 that exposure and testing requirements for mobile phones should be reassessed[11].

Thus the conflict among designers, telecommunication equipment manufacturers, corporate, distributers, government and consumers need to be controlled and resolved. In such a situation there is a great demand and necessity for determination of quantum of EMF radiation into environment and society. In view of exponential growth of population, urbanization, ever increasing consumer electronics products, concern for environment and human health hazards is growing throughout the world. There is a great necessity from across the world including medical agencies to know what the EMF emissions into environment by cell phones are. Hence, measurement and estimation of EMF emissions into environment and society are required to be determined through experiments.

Every year, hundreds of thousands of new cell phones are introduced into market. Mobile telecom revolution in the modern world has triggered not only the growth of world economy but has changed the life style of millions of people. Mobile telephony is growing exponentially in India and across the world. At present there are about 800 million mobile subscribers in India and over 6 billion in the world.

The population projections for India [12], China [13], USA [14] and the entire world [15-18] are as shown in the table.1 below till 2050.

**Table 1**: Population Projections of India, China, USA and World for 2050

| **Country** | **2012 Population (Billions)** | **2020 Population (Billions)** | **2030 Population (Billions)** | **2040 Population (Billions)** | **2050 Population (Billions)** |
|---|---|---|---|---|---|
| India | 1.240 | 1.326 | 1.460 | 1.571 | 1.657 |
| China | 1.339 | 1.423 | 1.454 | 1.376 | 1.320 |
| USA | 0.304 | 0.325 | 0.351 | 0.392 | 0.438 |
| World | 7.060 | 7.900 | 8.800 | 9.800 | 10.60 |

The growth of cell phone numbers and their estimated projections for India, China, USA and the entire world[19] for 2050 are as shown in the table 2 below.

**Table 2**: Cell Phones Projections India, China, USA and World for 2050.

| **Country** | **2012 mobiles (Millions)** | **2020 mobiles (Millions)** | **2030 mobiles (Millions)** | **2040** | **2050** |
|---|---|---|---|---|---|
| India | 908 | 994.5 | 1095 | 1178 | 1242 |
| China | 1046 | 1071.8 | 1105 | 1045 | 1003 |
| USA | 316 | 338 | 361 | 408 | 456 |
| World | 6000 | 6873 | 7656 | 8526 | 9222 |

## 3. Experimental Methodology

In spite of the recent studies indicating possible harmful impact of EMF on several species, there are no long-term data available on the environmental impacts of EMF radiations as of now. Studies on impact of cell phones and cell phone towers and EMF radiations on birds and other wildlife are almost non-existent in India. Moreover pollution from EMF radiations relatively is a new environmental issue. In this research work EMF radiations of 30 randomly selected cell phones and their EMF emissions were experimentally measured using NARDAs Selective radiation meter SRM-3006.

Selective Radiation meter SRM-3006 from Narda safety test solutions combines the analysis of features of spectrum analyser with simple application of a wide band

measuring set. This provides users with application oriented operating modes for measuring separate transmission channels and services including mobile phones of GSM,UMTS, LTE, WLAN and WIMAX. Here for this research work GSM mobile phones EMF radiations were experimentally determined using SRM-3006.

**3.1. Salient features of SRM-3006 [20]are as stated below.**

- It makes accurate professional EMF measurements easy.
- It performs time averaged measurements over the standard time period up to 6 minutes.
- It can perform spatial averaging over several measurement points.
- It is suitable for usage of isotropic antenna, thus doing away with direction of radiated field.
- This can set up measurement routines and save them.
- Easy to operate and is a hand held device.
- This can record the date, time & GPS coordinates, display in units or graphical form and snap shots can be taken.
- Measurements possible from long wave up to the latest generation of mobile frequencies.
- Results can be displayed in physical units, electric field strength in V/m, magnetic field strength in A/m and power density in $w/m^2$
- Frequency coverage is from 27MHz-3GHz.
- Minimum power that can be measured is 106.101 pico watts/$m^2$ .

**3.2 Modes of operation of mobiles**

EMF Radiation of 30 mobiles carried out with SRM-3006 along with 3axis E-field P/N -350/03(S/N) K-0487 Antenna . The Measurements carried out at four modes of operations and graphical snap shots taken and stored .The four modes of operation are

- ON(Sleep/Idle) mode of Operation
- Search Mode of Operation
- Transmit Mode of Operation
- Receive Mode of Operation

**3.3. Experimental Procedure**

The experimental Procedure followed for this research is as illustrated below.

- Identify a suitable lab /Room Where EMF Radiations are minimal
- Connect the antenna with SRM-3006.
- Switch on the SRM-3006 , wait for inbuilt calibration & background settlement.
- Select the test frequency of 900MHz.
- Read the background EMF Radiation and store the Display the snap shot.
- Switch on the mobile, place it close to the antenna and read the EMF level and take a snap shot of graphical display and store it.

- Dial a mobile number and read the EMF level take a display snap shot and store it in a PC during only Search mode .
- Read the EMF level, take a display snap shot and store it during only Tx mode
- Read the EMF level, take a display snap shot and store it during only Rx/Ringing mode .
- Repeat the above procedure for 30 different mobiles samples.
- Tabulate the EMF levels during ON,Search,Tx and Rx modes of mobiles operations.
- Select the appropriate EMF power density settings depending upon the maximum density level of mobile Phone in various modes of operations.
- The EMF levels measured in graphical display form for one mobile sample are shown in Figures 2 to 5.

**Fig. 1**: Selective Radiation Meter SRM-3006.

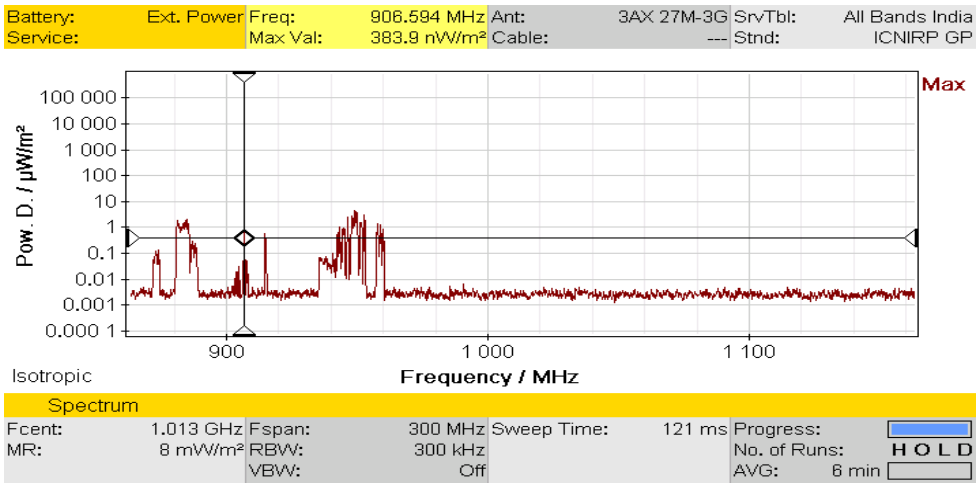


**Fig. 2**: EMF Radiation from Nokia 2600 During ON (sleep) mode.

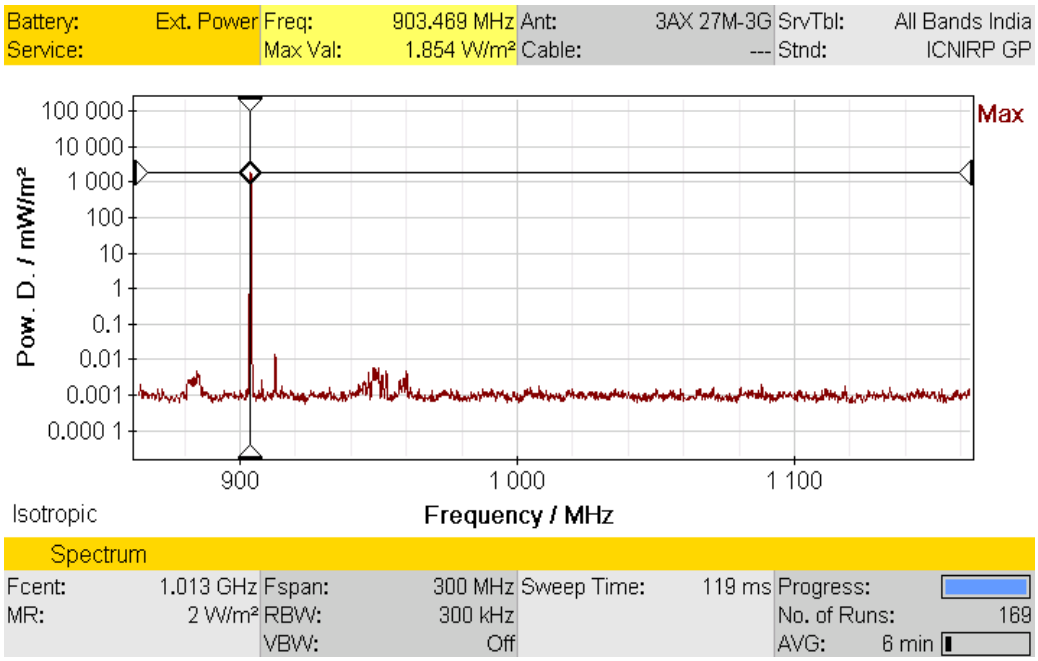


**Fig. 3**: EMF Radiation from Nokia 2600 During Search mode.

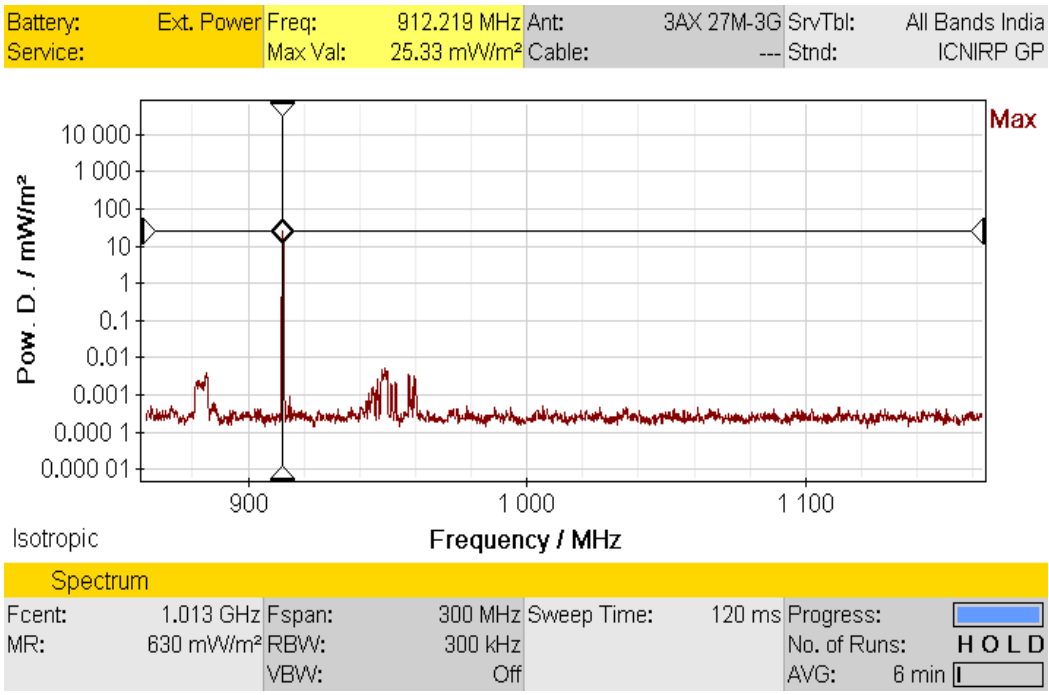


**Fig. 4**: EMF Radiation from Nokia 2600 During transmit mode.

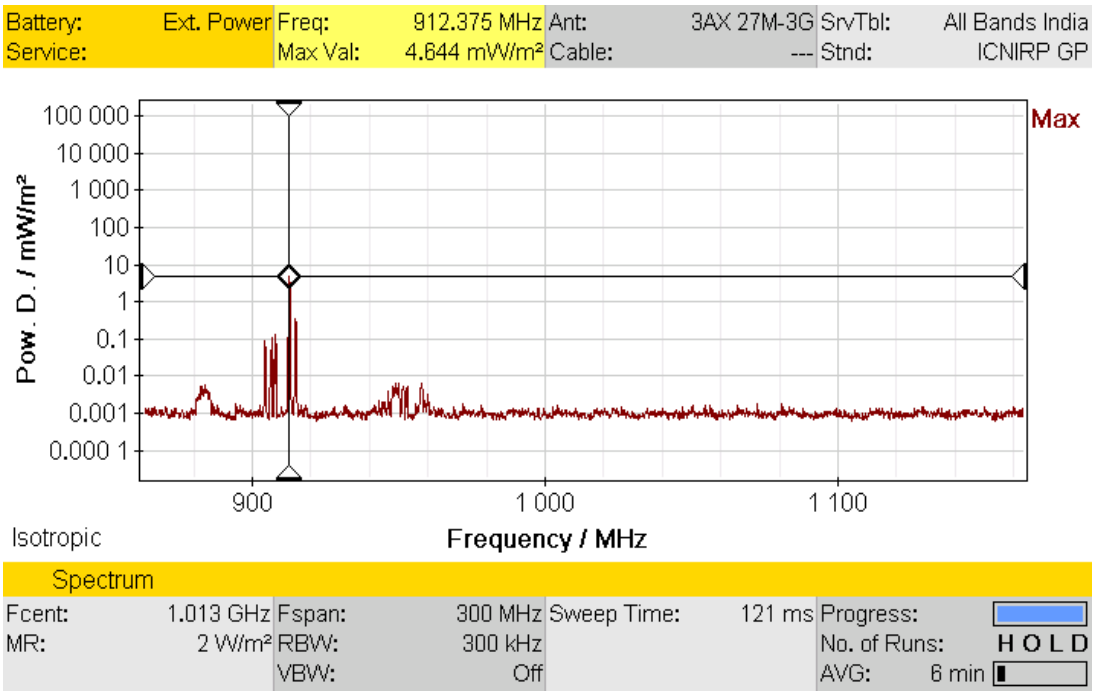


**Fig. 5**: EMF Radiation from Nokia 2600During Receive mode.

## 4. Results, Analysis and Discussions

The Fig. 1 shows the photograph of SRM-3006, the test equipment used for EMF density measurements of cell phones for this research work. From the figures 2 to 5 it is clearly seen that the EMF power density values measured are 383.9mw/$m^2$ , 1.854w/$m^2$ , 25.33mw/$m^2$ and 4.844mw/$m^2$ in ON(sleep), search, transmit and receive modes of operation of a Nokia mobile. Similar measurements were carried out with snapshots taken for 30 mobiles in four modes of operation. The average values of power density obtained are 0.00004202w/$m^2$ , 1.5334w/$m^2$ , 0.0842w/$m^2$, and 0.0182w/$m^2$ in ON(sleep), search, transmit and receive modes of operation respectively at 900MHz. The experimental Values of EMF radiation were determined for India China USA and the World at 900 MHz. These results are shown in the tables 3 to 7 and in figures 6 to 10 in bar charts for better appreciation and understanding. The total power transmitted in to environment is calculated from the measured power density using the following equation.

$$P_d = \frac{P_t G_t}{4\pi r^2}$$

Where $P_{d=}$ power density

$P_t$=transited power

$G_t$=Antenna Gain of mobile phone

r = radius (distance = 1cm)

In addition, to calculate total EMF energy in a day the following assumption were made.

- A mobile is in ON (sleep) mode for a duration of 19 hrs in a day
- A mobile is in search mode for a duration of 1 hrs in a day
- A mobile is in Tx mode and receive mode of operation for each in a day

**Table 3**: EMF Radiation By Mobiles in India at 900MHz.

| INDIA | 2013 Million Watts | 2020 Million Watts | 2030 Million Watts | 2040 Million Watts | 2050 Million Watts |
|---|---|---|---|---|---|
| On mode | 4.795E-06 | 5.252E-06 | 5.783E-06 | 6.221E-06 | 6.559E-06 |
| Sx mode | 0.1749877 | 0.1916578 | 0.2110259 | 0.2270215 | 0.2393554 |
| Tx mode | 0.0048043 | 0.005262 | 0.0057938 | 0.0062329 | 0.0065716 |
| Rx mode | 0.0010385 | 0.0011374 | 0.0012523 | 0.0013473 | 0.0014205 |

**Table 4**: EMF Radiation By Mobiles in China at 900MHz

| CHINA | 2013 Million Watts | 2020 Million Watts | 2030 Million Watts | 2040 Million Watts | 2050 Million Watts |
|---|---|---|---|---|---|
| On mode | 5.524E-06 | 5.66E-06 | 5.836E-06 | 5.519E-06 | 5.297E-06 |
| Sx mode | 0.2015827 | 0.2065548 | 0.2129531 | 0.20139 | 0.1932959 |
| Tx mode | 0.0055345 | 0.005671 | 0.0058467 | 0.0055292 | 0.005307 |
| Rx mode | 0.0011963 | 0.0012258 | 0.0012638 | 0.0011952 | 0.0011471 |

**Table 5**: EMF Radiation By Mobiles in USA at 900MHz.

| USA | 2013 Million Watts | 2020 Million Watts | 2030 Million Watts | 2040 Million Watts | 2050 Million Watts |
|---|---|---|---|---|---|
| ON mode | 1.669E-06 | 1.785E-06 | 1.906E-06 | 2.155E-06 | 2.408E-06 |
| Sx mode | 0.0608988 | 0.0651386 | 0.0695711 | 0.0786288 | 0.0878793 |
| Tx mode | 0.001672 | 0.0017884 | 0.0019101 | 0.0021588 | 0.0024128 |
| Rx mode | 0.0003614 | 0.0003866 | 0.0004129 | 0.0004666 | 0.0005215 |

**Table 6**: EMF Radiation By Mobiles in World at 900MHz.

| World | 2013 Million Watts | 2020 Million Watts | 2030 Million Watts | 2040 Million Watts | 2050 Million Watts |
|---|---|---|---|---|---|
| ON mode | 3.169E-05 | 3.63E-05 | 4.043E-05 | 4.503E-05 | 4.87E-05 |
| Sx mode | 1.1563063 | 1.3245488 | 1.4754468 | 1.6431112 | 1.7772427 |
| Tx mode | 0.0317468 | 0.0363659 | 0.0405089 | 0.0451122 | 0.0487948 |
| Rx mode | 0.0068621 | 0.0078606 | 0.0087561 | 0.0097511 | 0.0105471 |

**Table 7**: EMF Radiation By Mobiles Per Day at 900MHz.

| | **2013 (Million W-Sec)** | **2020 (Million W-Sec)** | **2030 (Million W-Sec)** | **2040 (Million W-Sec)** | **2050 (Million W-Sec)** |
|---|---|---|---|---|---|
| India | 714.4202 | 782.4789 | 861.5529 | 926.8579 | 977.2135 |
| China | 822.9994 | 843.299 | 869.421 | 822.2126 | 789.1668 |
| USA | 248.6308 | 265.9405 | 284.0371 | 321.017 | 358.7837 |
| World | 4720.838 | 5407.72 | 6023.789 | 6708.311 | 7255.928 |

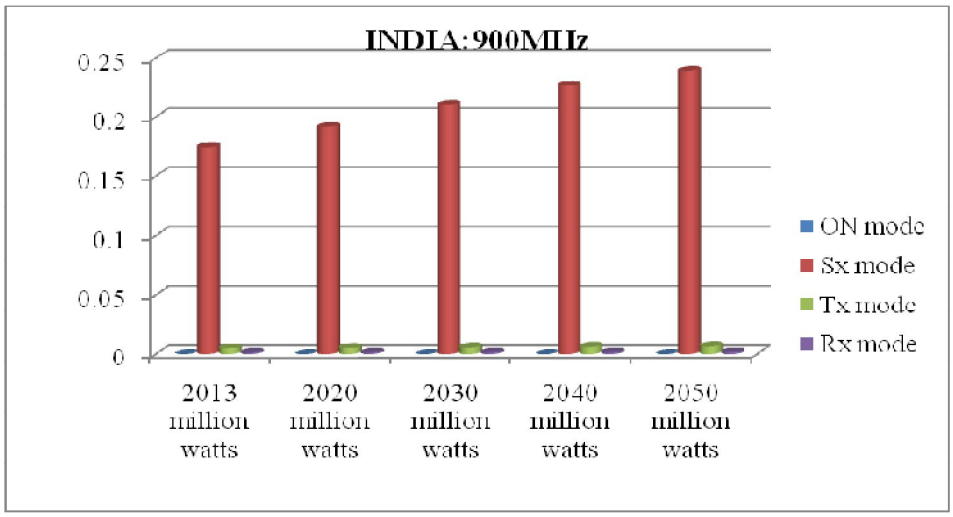


**Fig. 6**: EMF Radiation By Mobiles in India at 900MHz.

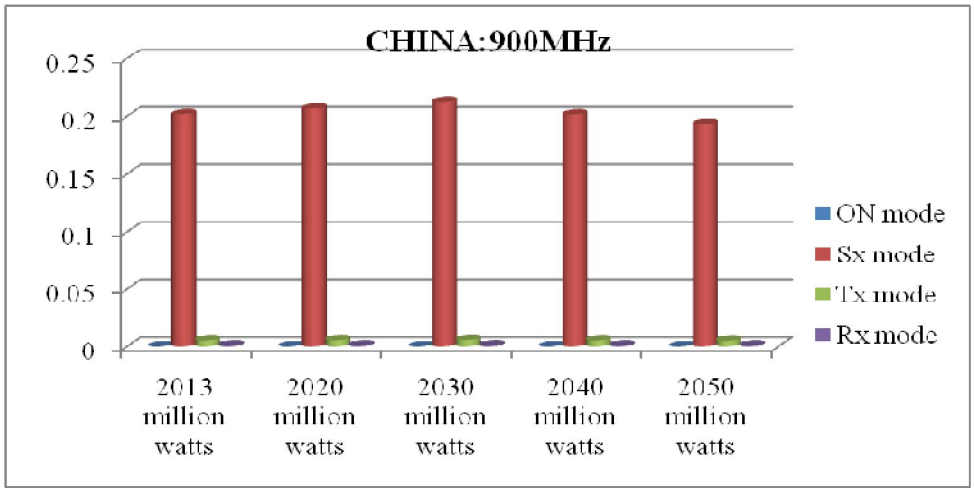


**Fig. 7**: EMF Radiation By Mobiles in China at 900MHz.

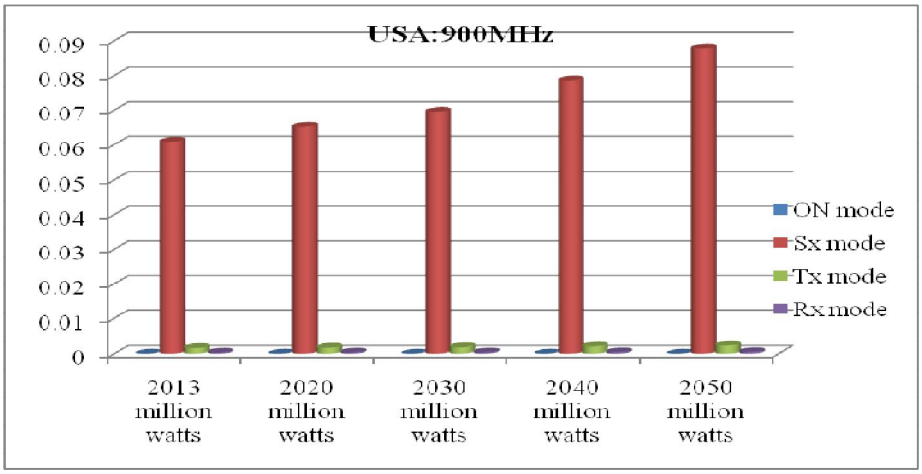


**Fig. 8**: EMF Radiation By Mobiles in USA at 900MHz.

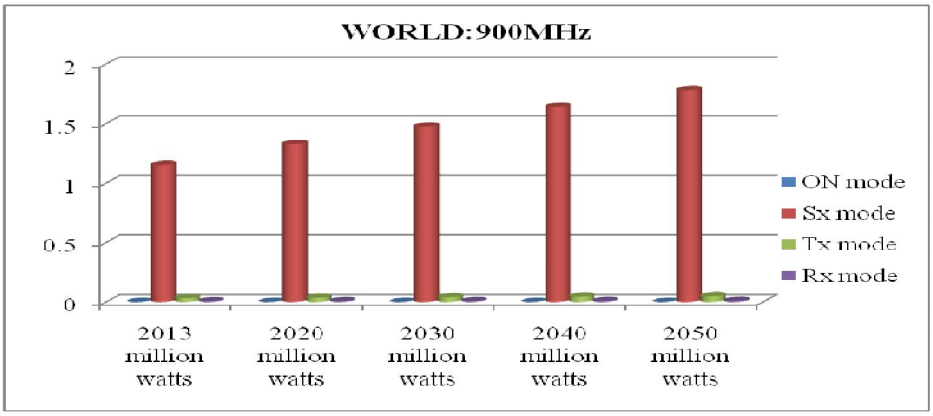


**Fig. 9**: EMF Radiation By Mobiles in the World at 900MHz.

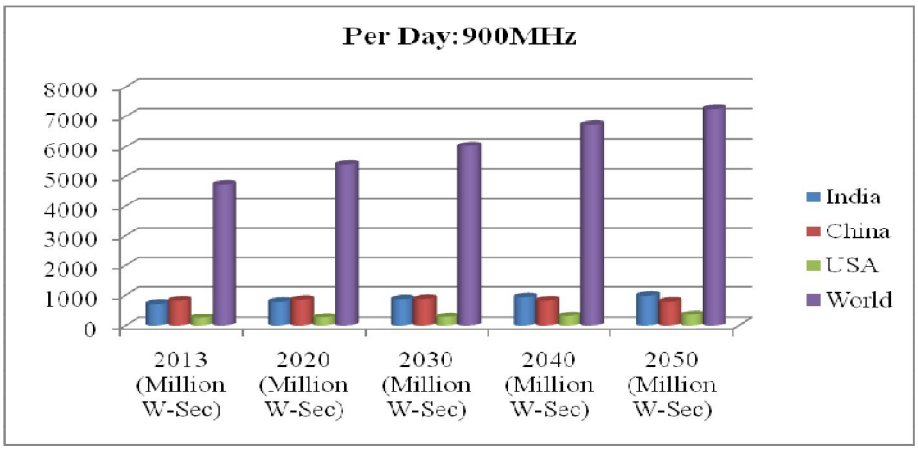


**Fig. 10**: EMF Energy Radiation By Mobiles Per Day at 900MHz.

### 4.1 EMF Radiation projections for India

The analysis results using tables 3 and 7 and figures 6 and 10 show the following EMF values for India.

- When India is in sleep mode it will radiate 4.795E-06 million watts of EMF power during on Mode in 2013 and will increase to 6.559E-06 million watts by 2050.
- In 2013 India will radiate 0.1749877 million watts of EMF power in search mode and will increase to 0.2393554 million watts by 2050.
- In 2013 India will radiate 714.4202 million watts-sec of EMF energy in a day and will enhance to 977.2135 million watts-sec by 2050.

### 4.2 EMF Radiation projections for China

The analysis results using tables 4 and 7 and figures 7 and 10 show the following EMF values for China.

- When China is in sleep mode it will radiate 5.524E-06 million watts of EMF power during on Mode in 2013 and will increase to 5.297E-06 million watts by 2050.
- In 2013 China will radiate 0.2015827 million watts of EMF power in search mode and will increase to 0.1932959 million watts by 2050.
- In 2013 China will radiate 822.9994 million watts-sec of EMF energy in a day and will enhance to 789.1668 million watts-sec by 2050.

### 4.3 EMF Radiation projections for USA

The analysis results using tables 5 and 7 and figures 8 and 10 show the following EMF values for USA.

- When USA is in sleep mode it will radiate 1.669E-06 million watts of EMF power during on Mode in 2013 and will increase to 2.408E-06 million watts by 2050.
- In 2013 USA will radiate 0.0608988 million watts of EMF power in search mode and will increase to 0.0878793 million watts by 2050.
- In 2013 USA will radiate 248.6308 million watts-sec of EMF energy in a day and will enhance to 358.7837 million watts-sec by 2050.

### 4.4 EMF Radiation projections for Entire world

The analysis results using tables 6 and 7 and figures 9 and 10 show the following EMF values for Entire world.

- When Entire world is in sleep/ON mode it will radiate 3.169E-05 million watts of EMF power during on Mode in 2013 and will increase to 4.87E-05 million watts by 2050.

- In 2013 Entire world will radiate 1.1563063 million watts of EMF power in search mode and will increase to 1.7772427 million watts by 2050.
- In 2013 Entire world will radiate 4720.838 million watts-sec of EMF energy in a day and will enhance to 7255.928 million watts-sec by 2050.

It was observed that a mobile EMF radiation density in search mode is very dangerous the average values of power density obtained was 1.5334w/$m^2$ in search mode. Inference is that this value is 100,000 to 1,000,000 Times more than the safety limits specified. It can be stated that less than 10 µw/$m^2$ is still a lower safety limit, 10-100 µw/$m^2$ is medium safety limit and anything above 100 µw/$m^2$ is higher exposure limit. The EMF power required for a mobile operation is -80 to -100 dbm. Thus power level a 50m is 50 db to 60dbm (100,000 to 1,000,000)times more than the requirement by a mobile phone. Bio –initiative report 2007 of USA also specifies power density up to 50µw/$m^2$ with higher limit as 100 µw/$m^2$ . The IEEE c95.1-2005 and ICNIRP 1998 (reaffirmed in 2009) also specifies that the exposure limit at 900 MHz is 4.5 w/$m^2$ and at 1800 MHz is 9 w/$m^2$ . This clearly brings out that EMF levels required for mobile operation require reconsideration. The accuracies of the values obtained through experiments in this research work are estimated at 1% of measured values.

## 5. Conclusions

The cell phones connectivity in modern society have altered the land scape of human beings in countless beneficial ways, however created the environmental exposures to Electromagnetic fields. As technology progresses and data demands have increased on mobile network, towns, cities and even rural villages have seen sharp increase in the cell phone numbers as projected in table 2 for India, China, USA and the entire world. Further as the costs of mobile technology and the cell phones have fallen, their uses have multiplied dramatically and the overall levels of exposure of the population and environment as a whole have increased drastically. The RF sources emit EMF radiation continuously. The level of EMF from sources has risen exponentially, by soaring popularity of wireless technology.

As of now there are no long term data available on environmental impacts of EMF radiation, in spite of the recent studies indicating possible harmful effects on several species. Moreover, electronic pollution from EMF radiation being a relatively new environmental issue. There is a lack of established standard procedures and protocols to study and monitor the EMF effects especially among wildlife/ environment, which often make the comparative evaluation between studies difficult. In addition the uncoordinated research in this field, the necessary regulatory policies and their poor implementation mechanism also have not kept pace with growth of mobile technologies.

There had already been some warning bells sounded in the case of bees and birds, which probably heralds the seriousness of this issue and indicates the vulnerability of other species as well[22]. The EMF radiations are being associated with the observed decline in the population of sparrow in London and several other European cities [23].

It is seen that when the entire world even in sleep mode it will radiate alarming values of EMF power in to environment. The world will radiate EMF energy of 4720.838 million watt-sec in 2013 and enhances to 7255.928 by 2050. These alarming trends will be unmanageable if EMF energy is measured and added for all electronic devices especially for all cell phone operators at all frequencies. Different countries have adopted different EMF values in spite of IEEE and ICNIRP(24) guidelines for EMF exposure safety.

There is a strong case in point to have a uniform EMF radiation policy across the world. This is more so because of the reason that cell phones can work in Austria with exposure limit of $0.001w/m^2$ and in USA, Canada and Japan with the exposure limit of $12W/m^2$ . There is a strong message from this research paper to advocate a single uniform exposure policy for entire world for sustainability. The EMF projections due to cell phones alone along with other EMF sources must be used as the precautionary principle and should prevail to better the standards of EMF radiation limits to match the best in the world to sustain the environmental safety and human health.

## 6. Future Scope

Future scope exists for further research to determine total EMF power and energy radiated in to environment by all operators together at all frequencies. This is to revise the EMF exposure limits and formulate a single uniform safety limits for entire world.

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