Cellular Mobiles CO\textsubscript{2} Emission Trends and Analysis for 2050

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Abstract - In this article experiments are conducted to determine the possible CO\textsubscript{2} emissions by cellular mobiles. The aim is to find out CO\textsubscript{2} emissions by cellular mobiles in to environment at present and estimate projections for 2020, 2030, 2040 and 2050 for India, China, USA and the Entire world respectively.

In this paper an attempt is made to find out quantity of CO\textsubscript{2} emissions contributed by cellular mobiles over the land surface of India, China, USA and the Entire world. These CO\textsubscript{2} emissions results are discussed and analysed with future scope of actions.

Keywords – Green Electronics Council, Carbon dioxide (CO\textsubscript{2}), greenhouses gases(GHG), United Nations Framework Convention on Climate Change (UNFCCC), Intergovernmental Panel on Climate Change(IPCC), K-30 CO\textsubscript{2} sensor

I. INTRODUCTION

Development and usage of electronics devices is one of the major technological evolution which has made a tremendous impact over the last few decades in the socioeconomically transformation all over the world. Several electronic devices and their derivates are in constant use in almost every sector of society such as research, education, health, industry, households, trade, business, governance and a host of public services and utilities.

A significant shift in the technological paradigm has also been witnessed which has led to the emergence of highly sophisticated but very handy mobile gadgets along with a gamut of mobile connectivity in providing such services across the globe. This has generated a phenomenal growth in the cell phones numbers and their use with deeper penetration in to towns and remote areas. Considering cell phones ever growing demands, research is being carried out in the electronics and its associated subjects to emerge out with environmentally friendly strategies to reduce their ill effects for a better human life and environmental safety.

2. HISTORICAL BACKGROUND AND NECESSITY

Carbon dioxide is a greenhouse gas. Carbon dioxide in Earth’s atmosphere is considered a trace gas currently occurring at an average concentration of about 400 parts per million by volume [1] (or 591 parts per million by mass). In urban areas CO\textsubscript{2} concentrations are generally higher and especially indoors they can reach 10 times higher than background levels.

It is well known that in the Earth’s atmosphere carbon dioxide concentration is approximately 390 ppm by volume [2-4]. Atmospheric concentrations of carbon dioxide fluctuate slightly with the change of the seasons. Over the years the concentration of CO\textsubscript{2} grew by about 2 ppm in 2009 [5] basically due to manmade activities such as industrialization and growth of electronic gadgets. The annual yearly increase of atmospheric CO\textsubscript{2} through 1960s was 37% of the 2000-2007 average [6-11].

Major CO\textsubscript{2} producing nations are China, USA, India, Russia and Japan stand in the order of merit as top 5 in the world. New research inputs from the latest Climate Change Journal on greenhouse gas emissions has listed 90 companies, most belonging to rich countries as the major sources who emitted nearly two-thirds of the carbon dioxide and methane emissions in the world since 1751-2010 [12-13]. The research shows that these 90 companies from across the globe had emitted 67% of total industrial emissions (CO\textsubscript{2} and Methane) during 1751-2010.

In the literature the contribution of CO\textsubscript{2} emission by all electronics devices and mobile communications is not available especially long term data. This clearly indicates that there is a strong necessity to know what is the contribution of CO\textsubscript{2} emission from electronics devices. The necessity further becomes stronger with increasing population, rapid urbanization, industrialization and exponentially ever expanding mobile communications in to towns including villages.

Population projections for India[14], China[15], USA[16] and the entire world[17-20] are as shown in the table.4.1 below till 2050.
<table>
<thead>
<tr>
<th>Year</th>
<th>India Population (Billions)</th>
<th>China Population (Billions)</th>
<th>USA Population (Billions)</th>
<th>World Population (Billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>1.240</td>
<td>1.339</td>
<td>0.304</td>
<td>7.060</td>
</tr>
<tr>
<td>2020</td>
<td>1.326</td>
<td>1.423</td>
<td>0.325</td>
<td>7.900</td>
</tr>
<tr>
<td>2030</td>
<td>1.460</td>
<td>1.454</td>
<td>0.351</td>
<td>8.800</td>
</tr>
<tr>
<td>2040</td>
<td>1.571</td>
<td>1.376</td>
<td>0.392</td>
<td>9.800</td>
</tr>
<tr>
<td>2050</td>
<td>1.657</td>
<td>1.320</td>
<td>0.438</td>
<td>10.60</td>
</tr>
</tbody>
</table>

Table 1. Population projections for 2050.

The growth of cell phone numbers and their estimated projections for India, China, USA and the entire world [21] for 2050 are as shown in the table below. In this research work for calculating cell phones projections for India, China, USA and the world for 2050, it is assumed that 74.71%, 75.32, 103.9% and 87% of respective countries population will be owning the cell phone connectivity.

<table>
<thead>
<tr>
<th>Year</th>
<th>India Mobiles (Millions)</th>
<th>China Mobiles (Millions)</th>
<th>USA Mobiles (Millions)</th>
<th>World Mobiles (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>908</td>
<td>1046</td>
<td>316</td>
<td>6000</td>
</tr>
<tr>
<td>2020</td>
<td>994.5</td>
<td>1071.8</td>
<td>338</td>
<td>6873</td>
</tr>
<tr>
<td>2030</td>
<td>1095</td>
<td>1105</td>
<td>361</td>
<td>7656</td>
</tr>
<tr>
<td>2040</td>
<td>1178</td>
<td>1045</td>
<td>408</td>
<td>8526</td>
</tr>
<tr>
<td>2050</td>
<td>1242</td>
<td>1003</td>
<td>456</td>
<td>9222</td>
</tr>
</tbody>
</table>

Table 2. Mobile projections for 2050.

In this research work CO₂ emissions from cellular mobiles are experimentally determined and projections for India, China, USA and the entire world carried out for 2014, 2020, 2030, 2040 and 2050.

### 3. EXPERIMENTAL METHODOLOGY

Critical and extensive survey was carried out for finding a suitable CO₂ measurement test equipment. Mars Technologies Pvt Ltd, Bangalore which designer and manufacturer of Multi-gas Analyser for automobiles was consulted and could not find a solution. Finally K-30 CO₂ Sensor Module was identified for this research work.

#### A. K-30 CO₂ Sensor Module

K-30 CO₂ Sensor Module is a very compact ready to use maintenance free CO₂ measurement device for CO₂ content in the air. This device was selected through critical literature survey for this research work. Salient features of this device are as listed below.

- K-30 CO₂ Sensor Module was found to be suitable for measurements of CO₂ content in the air emitted by any device.
- It adopts non-dispersive infrared (NDIR) methodology for CO₂ measurements.
- It is a low cost gas sensing solution.
- It is pre-calibrated, ready to use product and easy to install and interface with computer.
- It uses highly flexible advanced digital technology.
- It is a very small device whose dimensions are 51x57X14mm.
- It also conforms to various standards such as EN 6100-6-3 : 2001.
- It is very accurate with 1% of error of measured value.

#### B. EXPERIMENTAL PROCEDURE

This K-30 CO₂ sensor system contains completely self diagnostic procedures[22]. A full self test is executed automatically every time the power is switched on. For measurements on cellular mobiles separate suitable glass container was fabricated. The brief steps involved in the experimental procedure are as stated below.

- Identify a air locked room/laboratory away from vehicular traffic/polluted area.
- Place the sensor device inside the container as shown in figure and connect to the computer.
- Switch on the device and wait for self calibration.
- Install the inbuilt gas lab software into computer.
- Measure the background CO₂ & obtain the graph with respect to time/store it.
- Introduce the mobile gently in on mode and measure the CO₂ level after 60 seconds & obtain the graph and store it.
- Remove the mobile and wait for background settlement.
- Introduce the mobile in transmit mode, measure the CO₂ level, obtain the graph and store it after 60 seconds.
- Remove the mobile and wait for background settlement.
- Introduce the mobile in receive/ringing mode, measure the CO₂ level, obtain the graph and store it.
- Repeat the above steps take the graphical readings for 30 samples & store them.
Figure 1 shows the photo of K-30 sensor module and figure 2 shows the photo of experimental set up for mobile CO₂ measurement. The figure 3 shows the background CO₂ measurement in a container and figure 4 indicates the CO₂ measurement during ON(sleep) mode of mobile. Figure 5 shows the CO₂ measurement during transmit mode and figure 6 shows the CO₂ measurement during receiving mode of operation. By using the above procedure 30 mobile samples were utilised to experimentally determine the average CO₂ emission by a mobile. The average values were found to be 89ppm, 392ppm and 202ppm in ON(sleep), transmit and receive modes respectively for a duration of 60 seconds.

4. RESULTS, ANALYSIS AND DISCUSSIONS

From this researched work it was found that cellular mobiles emit dangerous level of CO₂. To understand and appreciate in a scientific way these CO₂ levels were determined experimentally have to be converted into kilogram and tons. For this the container used for this research has a spherical shape with 12cms radius which works on to have a volume of 7500cc. From this, CO₂ level in various modes were worked out as follows since 1ppm=1mg/litre:

- CO₂ emission by a mobile ion (Sleep) world is 89PPm = 89/100cc×7500cc = 667.5mg
- CO₂ Emission by mobile in tons Tx mode 392ppm = 392×7500cc/1000cc = 2940mg
- CO₂ Emission as a mobile in G tons Tx mode 202PPm = 202×7500cc/1000cc = 1515mg

From Table 2 the CO₂ emission levels by India, China, USA and World for 2013, 2020, 2030, 2040, & 2050 are calculated and projected which are illustrated in table 3-6 and in bar charts 7-10.
Table 3. CO\textsubscript{2} emissions by India due to mobiles

<table>
<thead>
<tr>
<th></th>
<th>On Mode</th>
<th>Tx mode</th>
<th>Rx Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Tons</td>
<td>606.09</td>
<td>1334.76</td>
<td>687.81</td>
</tr>
<tr>
<td>2020 Tons</td>
<td>663.83</td>
<td>1461.92</td>
<td>755.33</td>
</tr>
<tr>
<td>2030 Tons</td>
<td>730.91</td>
<td>1609.65</td>
<td>829.46</td>
</tr>
<tr>
<td>2040 Tons</td>
<td>786.32</td>
<td>1731.66</td>
<td>892.34</td>
</tr>
<tr>
<td>2050 Tons</td>
<td>829.04</td>
<td>1825.74</td>
<td>940.82</td>
</tr>
</tbody>
</table>

Table 4. CO\textsubscript{2} emissions by China due to mobiles

<table>
<thead>
<tr>
<th></th>
<th>On Mode</th>
<th>Tx mode</th>
<th>Rx Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Tons</td>
<td>698.21</td>
<td>1537.62</td>
<td>792.35</td>
</tr>
<tr>
<td>2020 Tons</td>
<td>715.43</td>
<td>1575.55</td>
<td>811.89</td>
</tr>
<tr>
<td>2030 Tons</td>
<td>737.59</td>
<td>1624.35</td>
<td>837.04</td>
</tr>
<tr>
<td>2040 Tons</td>
<td>697.54</td>
<td>1536.15</td>
<td>791.59</td>
</tr>
<tr>
<td>2050 Tons</td>
<td>669.5</td>
<td>1474.41</td>
<td>759.77</td>
</tr>
</tbody>
</table>

Table 5. CO\textsubscript{2} emissions by USA due to mobiles

<table>
<thead>
<tr>
<th></th>
<th>On Mode</th>
<th>Tx mode</th>
<th>Rx Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Tons</td>
<td>210.93</td>
<td>464.52</td>
<td>239.37</td>
</tr>
<tr>
<td>2020 Tons</td>
<td>225.62</td>
<td>496.86</td>
<td>256.04</td>
</tr>
<tr>
<td>2030 Tons</td>
<td>240.97</td>
<td>530.67</td>
<td>273.46</td>
</tr>
<tr>
<td>2040 Tons</td>
<td>272.34</td>
<td>599.76</td>
<td>309.06</td>
</tr>
<tr>
<td>2050 Tons</td>
<td>304.38</td>
<td>670.32</td>
<td>345.42</td>
</tr>
</tbody>
</table>

Table 6. CO\textsubscript{2} emissions by World due to mobiles

<table>
<thead>
<tr>
<th></th>
<th>On Mode</th>
<th>Tx mode</th>
<th>Rx Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Tons</td>
<td>4005</td>
<td>8820</td>
<td>4545</td>
</tr>
<tr>
<td>2020 Tons</td>
<td>4588</td>
<td>10103</td>
<td>5206</td>
</tr>
<tr>
<td>2030 Tons</td>
<td>5110</td>
<td>11254</td>
<td>5799</td>
</tr>
<tr>
<td>2040 Tons</td>
<td>5691</td>
<td>12533</td>
<td>6459</td>
</tr>
<tr>
<td>2050 Tons</td>
<td>6155</td>
<td>13556</td>
<td>6986</td>
</tr>
</tbody>
</table>

For further scientific analysis and to estimate CO\textsubscript{2} levels emitted by India, China, USA and World in a day and in a year into atmosphere in 2013, 2020, 2030, 2040 and 2050 the following conditions were assumed.

- A mobile is in On/Sleep mode of operation for a duration of 20hrs in a day.
- A mobile is in Tx & Rx modes of operation for duration of 2 hrs each in a day.
- 50% mobiles are in Tx mode and 50% are in Rx modes of operation.

With these critical conditions the CO\textsubscript{2} emission emitted in a day and in a year by India, China, USA and World are as shown in tables 7, 8 and bar charts 11 and 12 respectively.
India | China | USA | World
--- | --- | --- | ---
2013 Ktons | 1213 | 1397 | 422.1 | 8014
2020 Ktons | 1328 | 1432 | 451.4 | 9180
2030 Ktons | 1463 | 1476 | 482.2 | 10225
2040 Ktons | 1573 | 1396 | 544.9 | 11387
2050 Ktons | 1659 | 1340 | 609.1 | 12317

Table 7. CO₂ emissions in a day due to mobiles

<table>
<thead>
<tr>
<th>India</th>
<th>China</th>
<th>USA</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 GTons</td>
<td>0.44264</td>
<td>0.509919</td>
<td>0.154048</td>
</tr>
<tr>
<td>2020 GTons</td>
<td>0.48481</td>
<td>0.522496</td>
<td>0.164773</td>
</tr>
<tr>
<td>2030 GTons</td>
<td>0.53381</td>
<td>0.538681</td>
<td>0.175985</td>
</tr>
<tr>
<td>2040 GTons</td>
<td>0.57427</td>
<td>0.509431</td>
<td>0.198898</td>
</tr>
<tr>
<td>2050 GTons</td>
<td>0.60547</td>
<td>0.488957</td>
<td>0.222973</td>
</tr>
</tbody>
</table>

Table 8. CO₂ emissions in a year due to mobiles

A. Cellular Mobiles CO₂ emissions by India.

All cellular mobiles in India together will emit 606.09, 663.83, 730.91, 786.32 and 829.04 Tons of CO₂ in 2013, 2020, 2030, 2040 and 2050 in ON(sleep) mode respectively. The amount of CO₂ emitted by India will be 1213 Kilo Tons in a day in 2013 and will increase to 6155 Kilo Tons by 2050. The amount of CO₂ emitted in a year by India will be 0.44264 Giga Tons in 2013 and enhances to 0.6054675 Giga Tons by 2050.

B. Cellular Mobiles CO₂ emissions by China.

All cellular mobiles in China together will emit 698.21, 715.43, 737.59, 697.54 and 669.50 Tons of CO₂ in 2013, 2020, 2030, 2040 and 2050 in ON(sleep) mode respectively. The amount of CO₂ emitted by China will be 1397 Kilo Tons in a day in 2013 and will increase to 1340 Kilo Tons by 2050. The amount of CO₂ emitted by China will be 0.5099187 Giga Tons in 2013 and enhances to 0.4889565 Giga Tons by 2050.

C. Cellular Mobiles CO₂ emissions by USA.

All cellular mobiles in USA together will emit 210.93, 225.62, 240.97, 272.34 and 304.38 Tons of CO₂ in 2013, 2020, 2030, 2040 and 2050 in ON(sleep) mode respectively. The amount of CO₂ emitted by USA will be 422.1 Kilo Tons in a day in 2013 and will increase to 609.1 Kilo Tons by 2050. The amount of CO₂ emitted by USA will be 0.1540481 Giga Tons in 2013 and enhances to 0.2222973 Giga Tons by 2050.

D. Cellular Mobiles CO₂ emissions by World.

All cellular mobiles in the world together will emit 4005, 4588, 5110, 5691 and 6155 Kilo Tons of CO₂ in 2013, 2020, 2030, 2040 and 2050 in ON(sleep) mode respectively. The amount of CO₂ emitted by world will be 8014 Kilo Tons in a day in 2013 and will increase to 12317 Kilo Tons by 2050. The amount of CO₂ emitted by world will be 2.924964 Giga Tons in 2013 and enhances to 4.4956697 Giga Tons by 2050.

It is greatly observed that China is the only country which is reducing the CO₂ emissions after 2030 due to declining population.

As per United Nations Framework on climate change the total CO₂ emitted by India, China, USA and world are 1602.12, 7710.50, 5424.53 and 30,398.42 millions of tons in 2009, this does not include CO₂ emission due to slipping, aviation, and electronics devise including mobile communications.

The average CO₂ concentration in the fresh air between sea level and 30 km altitude varies between 0.036% (360ppm) and 0.039% (390ppm) depending upon the location [23]. The CO₂ gas is not classified as to rice or harmful in accordance with globally harmonised system of classification and labelling of chemical standards of United Nation Economic Commission for Europe by using OECD guide lines for the testing of chemical. Otherwise the CO₂ concentration up to 1% (10,000 ppm) it will make some people drowsy [24] and concentration of 7% to 10% may cause supotocalion, manifesting as dizziness, headache, visual and hearing dysfunction and within few minutes to an hour it will cause unconsciousness [25]. This situation will become dangerous, if CO₂ emissions from all electronics, communications, computer and Information technologies are determined and added together. Green electronics industry has to come up with environmental friendly solutions at the earliest to sustain environmental safety and human health.
5. CONCLUSIONS

In this research work using K.30 C02 sensor and gas lab software C02 emissions by cellular mobiles successively obtained through experiments. A successful attempt was made to determine, calculate and project CO2 emissions due to cellular mobiles by India, China, USA and whole world for 2013, 2020, 2030, 2040 and 2050. The results were analysed and discussed. It was found that a single mobile emits 89ppm(667.5mg), 392ppm(2940mg) and 202ppm(1515mg) during On(sleep), Tx and Rx modes of operation respectively for a duration of 60 seconds. It was found that a single mobile emits 1.3356 kgs of CO2 in a day and 487.494 kgs of CO2 in a year respectively.

It was observed that India, China, USA and world emit 606.09, 698.21, 210.93 Tons and 4005 Kilo Tons of CO2 in 2013 and will greatly increase by 2050. It is clear from this research work that CO2 levels are approaching dangerously high by 2020-2050 due to mobiles alone. These values will be unimaginable if all CO2 emissions are added due to all electronic devices. Urgent steps are required by Green Electronics Council, United nations, WHO and communications and ICT industries to make electronics devices more green for sustainable environmental safety and human health.

From this research work it is opined that immediate measures are required to determine better standards for greener electronics products and Green electronics manufacturers have to sacrifice some profits for the sustainability between growth of electronics and planet safety. The visible extraordinary research and productization in mobiles/iPods and other mobile services has to incorporate environmental friendly measures to control and reduce negative effects/harmful effects. Very extraordinary research is required to productize the wireless communication world by creating the green electronic products/mobiles.

6. FUTURE SCOPE

This research work stimulates for further research for newer materials for manufacture of future greener electronics devices. Further research is proposed to determine the total CO2 contribution by all electronics and ICT devices. Further research is also proposed to lay specific standards and regulations for this latest invisible electronic pollution as a single criteria.

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[17] List of countries by population-Wikipedia, the free encyclopedia.
[23] graphical map of CO2, World CO2 emission data by country.
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EICT Based Diagnostic Tool and Monitoring System for EMF Radiation to Sustain Environmental Safety

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Abstract—the adverse effects of electromagnetic radiation from mobile phones and communication towers on health issues are being well documented today. However, exact correlation between radiation of communication towers and their radiation levels, are not monitored.

Aim of this paper is to study, analyze, apply networking and data mining technologies to develop an EICT based Diagnostic tool and Monitoring system for electromagnetic radiation levels into environment. This system is to network all mobile towers of each service provider as a single entity and then connect all service providers to a central monitoring agency online for continuous monitoring. Since very large numbers of mobile towers exist in India, each state can have its own regional network which is further networked with national central network. This can be enlarged to entire world for monitoring the EMF radiation levels near every mobile tower. For these regional national and international networks the connectivity is to be instituted by the respective service provider.

In this paper an attempt is made to logically apply Data Mining and networking technologies to develop a central EICT based diagnostic tool and monitoring system for EMF radiation from each transmission tower. With this system regional, national and international agencies/authorities can monitor the EMF radiation at each and every transmission tower area continuously and verify them with exposure standards. It is proposed to display this information using Integrated Display System in front of monitoring authority at appropriate levels.

Keywords—EICT Based Diagnostic tool; Electromagnetic Fields(EMF) Radiation; Mobile Telephony; Data Mining; Data Warehousing; Electronics; Information and Communication Technologies(EICT); International Commission on Non-Ionizing Radiation Protection(ICNIRP); Compressed Natural Gas(CNG)

I. INTRODUCTION

Exponential growth and developments in various fields of science and technology in the last few decades have intensified the human interface into the natural environment and associated physical, biological and ecological systems resulting in various unintended and undesirable impacts on environment, human health and society.

Electronics, Information and Communication Technologies (EICT) is ushering in a revolution in every field of daily life and the technological advantages brought to society are unimaginable. EICT is helping mankind in many ways and at the same time giving away many negative effects on environment, wildlife, human health and society at large. In addition, with the growth of mobile subscribers and their transmission towers, India is also witnessing a rapid population growth which is going to overtake China. For growing population the agricultural productivity and the problems influencing them should be of concern. The population of many species such as honey bees, which is one of the most important pollinator and useful factor for agricultural productivity, has seen a drastic population drop. In literature there is no much data about the effects of electromagnetic radiation available for most of our free living floral and faunal species in India.

Mobile communication industry is one of the fastest growing industries in the world. In recent years, there has been an exponential increase in the usage of mobile telecommunication devices, which has become an easy means for communication. The use of mobiles have become more conspicuous, during the last decade and this has led to construction of transmission towers in large numbers, built in urban, as well as in rural areas including other sparsely populated areas. Transmission towers are based on the electromagnetic waves, which over prolonged usage have adverse impacts on humans as well as on other fauna. The adverse effects of electromagnetic radiation from mobile phones and communication towers on health of human beings are being well documented today. Recently the electromagnetic fields from mobiles and other sources have been classified as “possibly carcinogenic to human “by the WHO,s International Agency for Research on Cancer (IARC). However, exact correlation between radiation of communication towers and wildlife, are not yet very well established.

II. HISTORICAL BACKGROUND AND NECESSITY

The existing literature survey shows that the Electro Magnetic Radiations (EMRs) are interfering with biological systems in many ways. There had already been many warning bells sounded in the case of bees and birds, which probably heralds the seriousness of this problem, indicating vulnerability of other living beings as well. The electromagnetic radiations are being associated with the observed decline in the sparrow population in London and several other European cities (Balmori, 2002, Balmori, 2009, Balmori & Hallberg, 2007) [1-3]. A vast majority of scientific literature published across the world serious effects of EMFs in various other species too.
The pollution from EMRs being a relatively new environmental issue, there is a lack of established standard procedures and protocols to study and monitor the EMF impacts on humans especially among wildlife, which often make the comparative evaluations between studies difficult. In addition to the gap areas in research, the necessary regulatory policies and their implementation mechanism also have not kept pace with the growth of mobile communications industry. The present guidelines on exposure limits to EMF need to be refined since the ICNIRP Standard [4] currently followed in India is coined based on thermal effects of Radio Frequency radiation. One side Government agencies also due to lack of proof. and Government of India disapproves majority of these cases environmental effects of electromagnetic fields, reports the of the existing scientific literature on the negative hav

However, since the inception of mobile communication technologies, there have been concerns about the ill-effects of the mobile towers and mobile phones. Despite being a relatively newly acknowledged form of pollution, EMRs and their negative impacts on environment and biological systems have already been reported by several studies. However, most of the existing scientific literature on the negative environmental effects of electromagnetic fields, reports the results of experimental and epidemiological studies examining the serious impact on various aspects of human health. WHO and Government of India disapproves majority of these cases due to lack of proof. There is a conflict and difference of opinion exists among many agencies concerned about EMF radiation. One side Government agencies along with World Health Organization, another side cellular mobile operators along with manufacturers and third party is the society concerned with health issues. To resolve this issue initially monitoring of EMF radiation levels is the basic necessity so that mitigation activities can be initiated.

Therefore there is a strong case for design and development of EICT based diagnostic tool and on line monitoring system for EMF radiation in and around every transmission tower across the world. EICT can be effectively applied for design and development of diagnostic tool and monitoring system for continuous monitoring of EMF radiation from every transmission tower for ensuring environmental safety.

The large amount of varied EMF radiation data available across the country/world is to be surveyed, captured, meaningfully processed, sequenced, classified, structured, identified and hierarchically stored in various tiers based on policies decided. Data mining technology will be a solution involving high end advanced systems storage and state of the art software tools need to be included in the EICT Based Diagnostic tool and Monitoring system for continuous monitoring and analysis of EMF radiation levels from all the transmission towers. This information can be displayed in front of designated authorities through DLP for real time decisions to mitigate the irregularities in the EMF radiation patterns of any of the mobile service providers to confirm to safety standards. This requirement is that of the hardware, software and solution technologies.

III. METHODOLOGY

The data inputs considered for application to develop EICT based Diagnostic tool and Monitoring System for continuous monitoring of EMF radiation levels from each transmission tower is the radiated power density at specific distances.

The proposed methodology for networking of various EMF radiation values as inputs for EICT based Diagnostic tool and Monitoring system for on line monitoring EMF radiation levels around each transmission tower is an shown in figure. 1, 2 and 3.

![Image](https://example.com/image.png)

**Fig. 1.** Networking of EMF Radiation levels from each transmission tower service provider
Fig. 2. Networking of EMF Radiation levels from each service provider in a region

Fig. 3. Networking of EMF Radiation levels from each region to central monitoring authority

At every transmission tower wideband area monitor or smart monitor is envisaged at around 100m distance. Frequency switching to monitor EMF radiation to be inbuilt into this system which can be selected from either locally, regionally or nationally through respective network management software. The local monitoring set up at each transmission tower can be termed as local monitoring node which is as shown in figure 1.

From each monitoring node the measured EMF radiation data will be made to ride through respective service provider network. The EMF radiation data inputs from each node will pass through standard communication network such as multiplexer, sampling server, switch to database servers based at regional centre. The database servers are connected to NMS application server which is then connected through router to regional gateway server as shown in figure 1.

Similarly all the cellular mobile service providers will provide respective EMF radiation inputs to regional gateway server of the regional monitoring authority. The monitored EMF radiation levels as inputs from each regional gateway server are linked to the central NMS application server. These data inputs then stored sequenced and displayed through a high end data wall display system.

These data inputs are required to be mapped in respect of each transmission tower, networked, processed, stored, and fused which are required to be displayed in front of monitoring authority. To integrate all these inputs for maximum situational awareness a multi-input, multi-window display processor is proposed in this paper. A variety of incoming EMF radiation levels will need to be displayed in a compact arrangement in front of monitoring authority for viewing for taking right decisions for mitigation of imbalance when compared to standard radiation limits accepted by the Government.

For this a display system that could combine multiple incoming inputs and display them using Digital Signal Processing, sound processing system, integrated controller, switcher, and Digital Light Processor based projectors, projecting the comparative EMF radiation levels and accepted standard limits on a glass beaded screen requirements are proposed in this research paper which are structured in figure 4.

A. Salient Features of Customized Web NMS For This Application.

The customized web Network Management Software (NMS) of this proposed EICT base Diagnostic tool and monitoring system for EMF radiations is to have the following salient features.

- Comprehensive monitoring capabilities to monitor EMF radiation levels, health of infrastructure, components, network protocols, system metrics with a single tool.
- Centralized view of entire status of EMF radiation levels selectively.
- Fast detector of alarming increase in the EMF radiation levels and their alerts to designated authorities.
- Alert acknowledgements provide communication to particular cellular mobile service provider on alarming EMF radiation levels and problem response.
- In case of regional NMS management facility to reduce / switch of EMF radiation power levels.
- Generation of historical reports and EMF radiation levels compared with standard radiation levels.
- Multiuser access to customized Web NMS interface to health department authorities, environmental specialists and department of commutation to view the EMF radiation levels.
- Extendable architecture for integration with in house and global applications.
• Scales to monitor many regions and thousands of nodes.
• To have fail over capabilities to ensure nonstop monitoring.

B. Data Mining Concepts Application.

A high end advanced data capturing and analysis set up is proposed for this solution. The solution will involve high end advanced systems and storage and state of the art software tools for data analysis. The set of requirements proposed for this Diagnostic tool and monitoring system, EICT infrastructure needs are given below:-

• The EICT infrastructure should be capable of handling large data volumes of generally un-structured data available in various formats including but not limited to textual, video, audio and structured encrypted information.
• The total data volume will be in Gega Bites or in Tera Bites.
• The server infrastructure should be suitable for online analysis and processing and should be capable of handling large data volume providing near real time processing of large number of complex queries over the data volumes, generating required meaningful information. The input data flow will be from large numbers of transmission towers across the region and country from different mobile service providers.
• There should be provision for hierarchical storage, archiving, content management and data backup.
• The EICT infrastructure should be secure enough to the standards of security.
• The EICT infrastructure should provide support for data conversion from the available media to digital format and there should be appropriate mechanism for digital asset tracking.
• Switch. A network device used to interconnect various subsystems for intra-system communications and passage of various EMF data.
• Audio Amplifier. The amplifier is used to amplify the audio signal received by data input server and forward this Multi Graphic Controller as well as over the network through switch.
• Multi Graphic Controller. This controller processes the multiple EMF graphic/video signals and multiplexes them with the amplified audio signal for further display over data wall.
• Data Mining. Analytical tool for analyzing data from different perspective and summarizing it into useful information after comparison with standard accepted levels. In addition data mining is also the process of finding correlations or pattern among dozens of fields in large relational database.
• Security Overlay. Architecture to ensure secure communications between the sub-systems/nodes and regions. It includes encryption, media secrecy as well as confidentiality.
• Integrated Controller. It provides enterprise protection for servers and enhances the server performance. It provides support for all RAID levels to ensure safety of critical EMF levels which have exceeded standard levels.
• Data Wall. Data wall is a big multi-screen LCD display system for graphics output as well as for audio-visual display. The data wall provides easy projection of critical information (EMF levels) for further assimilation and analysis.

C. Data Fusion

The data fusion solution will be comprising of the following three technologies:-

• Data Warehousing (DW) for capturing and organizing the EMF radiation data for fast near real time processing and retrieval of meaningful information.
• Content Management (CM) for classifying and managing EMF radiation levels in a well defined logical layout.
• Hierarchical Storage Management (HSM) for identifying, structuring and management of EMF radiation data from various cellular mobile service providers from different regions and nodes into various storage tiers based on the policies decided.

IV. RESULTS & DISCUSSION

The IT infrastructure in figures 1, 2, 3 and 4 together forms the EICT based Diagnostic tool and Monitoring system for EMF radiation. The proposed system is to assist decision makers at regional and central (National) level to arrive at correct decision and have control over all cellular mobile providers at their disposal. This is an automated system for EMF radiation levels situation monitoring, to know status of

Fig. 4. Central Monitoring and Display System for EMF Radiation levels

• Data Inputs Server. This server receives and processes various EMF radiation inputs provided to the system and forward this information to various other sub-systems.
all data inputs in that particular node, region and to arrive at right decisions at right time to mitigate higher or dangerous levels of EMF radiation.

The proposed network of networks is geographically distributed system. Distribution of proposed network based EMF radiation monitoring is key to management of impacts of this radiation which will have geographically distributed networks. This also makes network management efficient and scalable, enabling the central monitoring authorities to focus on the analysis of exceeding levels of radiation data collected across the nodes and regions of different cellular mobile service providers.

Distributed Mediation Servers (DMS) are servers that can be deployed along with central NMS server in large scale or remotely distributed network such as the one proposed in this paper. Each DMS server performs network facing functions for a regional monitoring network of each cellular mobile server provider. The collected EMF data can then be correlated to transfer relevant EMF information to the central NMS server.

In distributed scenarios distribution is effective in providing scalability and remote management capabilities to NMS management applications since cellular mobile services are expanding in an exponential growth.

When deploying NMS management application to manage a very large EMF radiation data monitoring networks, the application needs to be highly scalable to manage the nodal, regional devices, ports and connectivity, both logical and physical of different service providers. This scalability need can be addressed by the customized web NMS distributing the network facing the functionality via the distributed mediation servers. The central EMF radiation monitoring NMS server can collate EMF radiation levels from different distributed mediation servers of different regions and provide a single console view of the entire network to the monitoring authority.

When NMS management applications are deployed by cellular mobile service providers, they do require management of their IT infrastructure health monitoring along with EMF radiation levels across multiple/remote locations. Here only EMF radiations are required to be transferred to regional or central monitoring location which can be addressed in NMS application server by deploying the distributed mediation servers at remote locations.

In a distributed set up like in the proposed EICT based diagnostic tool and monitoring system for EMF radiations the following components are very significant while deploying customized web NMS using DMS servers.

- Central Server
- Distributed Mediated Server and
- User interface

The central server here is a logical server and is made up of two servers, namely the back-end server and the front-end server. Front-end servers are servers to which the monitoring authorities and the DMS are connected. The numbers of front-end servers depend on the planned performance and scalability metrics. The back-end servers store all the networks EMF radiation data in a centralized database and processes requests from monitoring authorities through the front-end servers. Both these servers are located at the central monitoring site. The collated EMF radiation data stored in a local database and correlated by the DMS. This ensures that only summary and critical data are sent to the central customized web NMS server. User interface facilitates the monitoring authority to connect to the DMS server at the specified node of particular region of the selected cellular mobile service provider to view the EMF radiation data available in the DMS database.

Network Management software for this proposed system is required in an operational environment where large amounts of information and sources need to be managed. The built in automation features of the software will be required to allow operators in the control room to focus fully on the important tasks. It will allow operators in the control room to focus fully on the important tasks. It has to allow right integration with custom applications, so that operators do not have to learn new tools or user interfaces after installation.

V. Conclusion

The world’s entrance into the mobile telephony certainly had a profound impact on our society. It seems clear that the trend will continue to expand in many ways that will, no doubt, continue to surprise us. The expanding potential, however, is not an unmitigated blessing. It is very evident that there will be both positive and negative effects on society and environment.

The diagnostic tool and monitoring system proposed in this paper is an ideal solution for online monitoring of EMF radiations across all nodes, regions of different cellular mobile service providers to ensure environmental safety. This can give instant inputs of exceeding EMF radiation levels in any of the nodes of any region of any cellular mobile service provider. This can monitor in near real time and will be a great aid for knowing the EMF radiation levels across the nation.

However a diagnostic tool and monitoring system for respective controlling agencies such as Medical, Communication, Environment, Nongovernmental Organizations, Cellular mobile service providers and general public is felt appropriate for mitigating the higher EMF radiation levels.

A warehouse is more than an archive for data and more than a new way of accessing data. A warehouse is a subject oriented repository and provides tools to satisfy the information needs, not just for complex data queries, but as a general facility for getting quick, accurate, and often insightful information. It is to be designed in such a manner that users can recognize the information they want and access that information using this tool.

As per ICNIRP [11] guidelines EMF exposure limit in Canada is 3w/m², in India it is 9.2w/m² (now 0.92w/m²), 2w/m² in Australia, 0.09w/m² in Germany and 0.001w/m² in Austria and in New South Wales(Australia) it is 0.00001w/m². Also successful communication with GSM mobile established in Germany [12] with 0.001microwatts per square meter. A mobile phone requires -80 to -100 dbm power for its
operation. Thus it is seen that at a distance of 50m the power level is 50 to 60 dbm higher in reality, meaning 1, 00,000 to 10, 00,00 times more power is radiated for mobiles operation. This is gravely hazardous to environment, health and to society.

Until now, society has been absorbing the harmful, invisible EM radiations without even being aware of it. With exponential growth in mobile communications this EM radiation pollution has started showing ill effects on environment, health of human beings, birds, bees and animals. Hence there is an urgent requirement to take precautionary steps to safe guard the environment and society. In this first step it is to monitor for which the proposed EICT based diagnostic tool and monitoring system will be of great help. This system can give legal evidence and for regulatory authorities it will be a practical tool.

The growth of modern technologies in electronics, computers, and communications with availability of hardware for data mining and warehousing technologies, it is easy to realize the diagnostic tool and monitoring system proposed in this paper.

The EMF radiation from cellular mobiles and transmission towers is continuous and additive in nature. Stricter EMF radiation norms are required to be enforced. It is clear that we society has come up with alternate solutions for automobiles air pollution through unleaded petrol, CNG driven vehicles and hybrid vehicles. Similarly there is a need to come up with alternate solutions for EMF radiation problems and mandatory to monitor the EMF levels.

Cellular phone industries are multibillion dollar companies and products are linked to illness. Generally these Industries deny any health problem in spite of large number of health problems reported by many researchers from many countries. Mobile companies should not be in denial mode and have to accept that this is a real world problem.

Monitoring proposed in this research paper is the first step by regulatory authorities given the reason that in various countries the exposures limits vary from 12w/m² to 0.00001w/m². Entire world has to come up and should have a single exposure limit which is sufficient for cellular mobiles operation for sustainable environmental safety.

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AUTHOR’S INFORMATION

K Parandham Gowd obtained B.Tech in Electronics and Communication Engineering with distinction from S.V. University, Tirupati. In 1994 he has conducted RCS Reduction experiments on coated (by pasting of absorber sheets) and uncoated scaled models of aircraft during his ME (Microwaves and Radaras thesis work which is first time in India at IIT Roorkee. He has 48 research publications and 06 Technical reports to his credit most of them on RCS/RCS Reduction/Stealth Technology. He has one copyright to his credit on Dynamic RCS Range Validation Procedure from Govt of India. He is a Life Member of All India Management Association (AIMA), AesI and Fellow of IETE. He had authored a book on Stealth Aircraft Technology in Hindi and English.

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