ESTIMATING CELLPHONE SIGNAL INTENSITY & IDENTIFYING RADIATION HOTSPOT AREA FOR TIRUNELVELI TALUK USING RS AND GIS

Sangeetha M[1], B. M. Purushothaman[2], S. Suresh Babu[3]

[1]Scholar, [2]Assistant Professor, [3]Head of the Department, Department of Civil Engineering, Adhiyamaan College of Engineering, Hosur, Tamilnadu, India

Abstract

The increased uses of mobile phones have raised public interest in possible health issues associated with exposure to electromagnetic energy. For the speedy transmission and avoiding the construction of more towers, the single tower can be shared by multiple network operators. The simultaneous exposure to multiple frequency fields, the sum of all the radiation must be taken into consideration so the radiation intensity level exceeds by several times than the prescribed guideline. Hence, the public is being exposed to continuous, low intensity radiations from these towers. Present Survey has been designed to identify signal strength among the people dwelling near the base station. Signal Strength predicted by integration of NDVI methodology is taken into account for factors like trees, trunks, leaves, branches, their density and their heights relative to the antenna heights and also it has been calculated by both theoretical and practical. In this regard the present study, practical field investigations of existing towers have been done by using SCEPTOR (Mobile GIS/GPS receiver). These GPS data fed to GIS for creating a new layer along with DEM file and satellite image for creating virtual model.3D city model has been performed for the study area. Finally the radiation hotspot area has been identified by using viewshed analysis.

Keywords: *RF Coverage, Signal Strength, GIS, Remote Sensing, GPS, and Antenna*

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1. INTRODUCTION

In recent years there has been an unprecedented growth in the universal communication industry which has resulted in a dramatic increase in the number of wireless devices. Mobile services were launched in India at 1995 and it is one of the fastest growing mobile telephony industries in the world. According to the Telecom Regulatory Authority of India, the composition of telephone subscribers using wireless form of communication in urban area is 63.27% and rural area is 33.20%. By 2013, it is estimated that more than one billion people will be having cell phone connection in India. This has led to the mushrooming of supporting infrastructure in the form of cell towers which provide the link to base station from the mobile phone. With no guideline on the placement of cell towers, they are being placed randomly closer to schools, creches, public playgrounds, on commercial buildings, hospitals, college campuses, and terraces of densely populated urban residential areas. In Many cases for avoiding the tower pollution the tower commissioning people fixing more than one antenna on a single tower hence, the public is being exposed to continuous, low intensity radiations by double or triple times greater.

In India, we have adopted radiation norms given by ICNIRP guidelines of 1998 for safe power density of f/200, where frequency (f) is in MHz. Hence, for GSM900 transmitting band (935-960 MHz), power density is 4.7W/m2 and for GSM1800 transmitting band (1810-1880 MHz), it is 9.2W/m2. The ICNIRP guidelines clearly state that for simultaneous exposure to multiple frequency fields, the sum of all the radiation must be taken into consideration. However, in India, we have applied this limit to individual carrier, so the radiation level exceeds by several times than even prescribed by ICNIRP guidelines, depending upon the total number of transmitters in that area.

The biological effects of RF-EMF at molecular level induce thermal and non-thermal damage, which will be due to dielectric heating foremost to protein denaturation, polar molecular agitation, cellular response through molecular cascades and heat shock proteins, and changes in enzyme kinetics in cells. The three major physical parameters of RF-EMF radiation is frequency, intensity, and exposure duration. Although the non-ionizing radiations are measured less dangerous than ionizing radiation, over-exposure can cause health hazards.

The remote sensing integrated with GIS can play a major role in signal strength prediction by integration of NDVI methodology has been taken into account for considering factors such as trees, trunks, leaves, branches, their density and their heights relative to the antenna heights. This term "remote sensing" is broadly defined as the techniques for collecting images or other data about an object from measurements made at a distance from the object, these techniques have emerged as appropriate tools in providing with spatial information. Because of the systematic acquisition through satellites , affordability high level of precision & the possibility of obtaining time - series data , Satellite images are increased in the being utilized as data sources in conjunction with geographical information system (GIS) for mapping.

2. STUDY AREA

Tirunelveli town has been taken up for the detailed study. The district is located in the southern part of Tamil Nadu. It is surrounded by Virudhunagar District in the north, the Western Ghats in the west, Kanyakumari District in the south and Thoothukudi District in the east. The district covers an area of 6,823 km2. It lies between 8°05' and 9°30' north latitude and 77°05' and 78°25' east longitude. The district has diverse geographical and physical features. It has mountains (a stretch of the Western Ghats and low land plains. It has a perennial river (the Tamirabarani) and small seasonal rivers. study area lies in the south part of Tirunelveli district, in the North-east corner of Tirunelveli district and has spread over an area of 127 Km2 (8°05' to 9°30' N latitude and 77°05' to 78°25' E longitude).It lies at an altitude of 42 m above sea level and has a population of 1, 60,662 as per census of 2011.

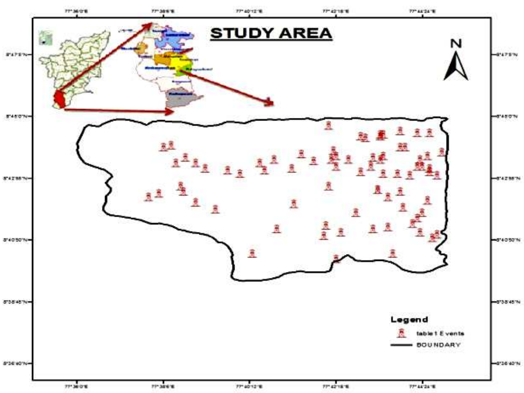

Fig -1: Study Area

3. MATERIALS AND METHODOLOGY

SOI topographic maps which surveyed on 1981-82 (updated for major details during 2005-06) are used for generation of base map. The topographical map no. 58H/10 is of the scale 1:50,000. The satellite data taken for this study is the multispectral Linear Imaging Self Scanning-III (LISS-III) sensor data of the RESOURCESAT acquired on 06th December 2012.This image variation shows the different characteristics like tone, texture, pattern color, etc. It is used to identify various land use and land cover classes. Software used is ERDAS Imagine 9.1, Arc GIS (Version 10.0) with Analysis Tool, Spatial Analyst and 3D Analyst.

Various thematic maps, NDVI, LULC map were prepared from satellite image. Settlement area was digitized from LULC map. Locations of existing tower GPS points were collected by SCEPTER. These obtained data were integrated into GIS environment. Finally the thematic map was created which shows the existing tower location. Viewshed analyses were accomplished for identifying the signal coverage and quantify hotspot area.

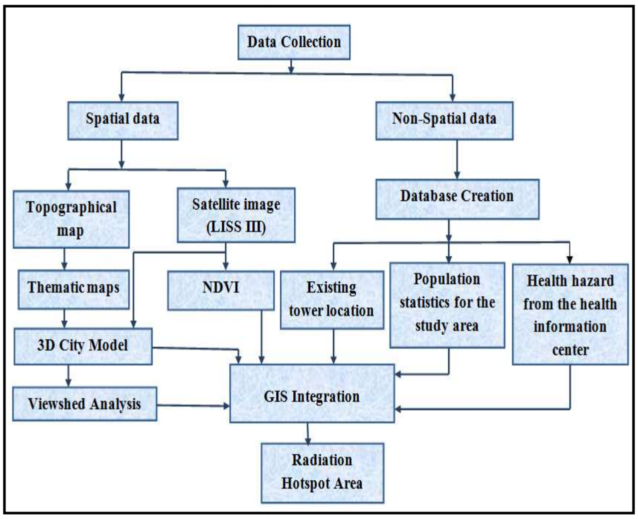

Fig -2: Methodology

3.1 Signal Strength Measurement

In general, the power levels at distance D can be calculated easily using equation below;

$$P_d = PG_i/4\Pi D^2 \; Watt/m^2$$

Whereas;

P_d is Power Density at a distance D;
P is Power;
G_i is absolute antenna gain,

For example

For p_t=20 W, G_t=17 db = 50, R=50 mP_d=0.0318 w/m^2

Conversion from Watts to dbm

$$P_{dbm} = 10 \log 1000 P (W) /1W) + 30$$

Table 1 shows the signal Strength which was calculated by both theoretical and practical.

Table-1: Comparison of Signal Strength

ID	No of Opera	Operators	Practical	Theoretical
1	4	BSNL, Vodafone, Airtel, Airce	15.05	13.8
2	3	BSNL, Idea, Vodafone	13.8	9.03
3	2	Airtell, Aircel	12.04	13.8
4	6	Airtel, Aircel, Reliance, BSNL,	16.81	12.04
5	2	Airtel, Aircel	12.04	13.8
6	4	BSNL, Airtel, Aircel, Idea	15.05	12.04
7	3	Idea, Docomo, Vodafone	13.8	13.8
8	2	Aircel, BSNL	12.04	13.8
9	5	BSNL, Airtel, Aircel, Docomo,	16.81	12.04
10	4	Reliance, MTS, Docomo, Idea	15.05	9.03
11	3	BSNL, Airtel, Aircel	13.8	9.03
12	1	BSNL	9.03	9.03
13	2	BSNL, Docomo	12.04	13.8
14	4	BSNL, Airtel, Aircel, MTS	15.05	9.03
15	5	Airtel, Aircel, Docomo, Idea,	16.81	9.03
16	6	Airtel, Aircel, Reliance, BSNL,	16.81	9.03
17	3	Aircel, Airtel, BSNL	13.8	13.8
18	2	MTS, BSNL	12.04	12.04
19	1	BSNL	9.03	15.05
20	1	Aircel	9.03	12.04
21	1	BSNL	9.03	12.04
22	3	BSNL, Airtel, Idea	13.8	12.04
23	2	Airtel, Aircel	12.04	16
24	4	Airtel, Aircel, Docomo, Idea	15.05	15.05
25	2	Reliance, MTS	12.04	13.8
26	2	BSNL, Airtel	12.04	9.03
27	2	Airtel, Aircel	12.04	12.04

4. RESULTS AND DISCUSSION

Wireless telecommunication is the transfer of information between two or more points that are physically not connected. In GSM network planners increasing system capacity by locating transmission antennas at heights lower then surround trees & buildings. The trees act as obstacles in the radio path causing both absorption and scatter of radio signal. A GSM antennas on cell tower transmit in the frequency range of 935-960MHz; 1805- 1830MHz. GSM-900 uses 890–915MHz to send information from the mobile station to the base station (uplink) and 935–960MHz for the other direction (downlink), providing 124 RF channels (channel numbers1 to 124) spaced at 200KHz..

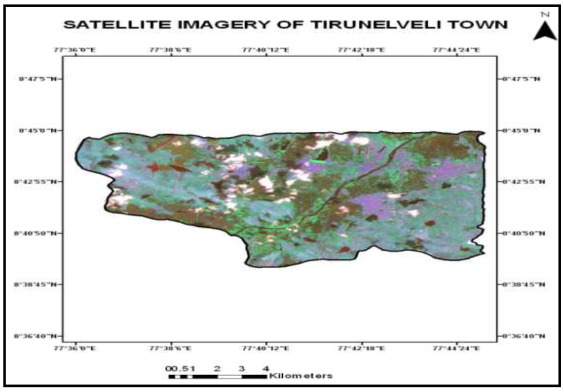

Fig -3: Satellite imagery of Study area

4.1 Existing Tower Location

Wireless communications requires efficient network planning of cellular mobile communication. The industry include network site identification and planning, signal strength measurements with coverage estimation for the expansion of system. In Tirunelveli city there are 76 fixed towers among them 34 BSNL, 23 Vodafone, 28 Airtel, 28 Aircel, 9 Reliance, 10 Tata Docomo and 12 idea towers. Their area of influence/coverage area, a peak hour of each tower has been discussed below.

4.1.1 BSNL

Thirty four numbers of towers having a Shared tower's coverage area of 8-9 kms with a height of 60-80ft. These towers are located in the north, central and western side of the city, but the southern and western part of some are properly take up the network connection.

4.1.2 Airtel

Twenty Eight numbers of towers having a Shared tower's coverage area of 9-10 kms with a height of 80 ft. Majority of the towers present in the centre of the city and they cover almost entire city.

4.1.2 Vodafone

Twenty Three numbers of towers having a shared tower's coverage area of 8-9 kms with a height of 70 ft. Located in centre, northern portion and another one is in north western part of the town, west and southern portions are not getting proper network connection.

4.1.3 Aircel

Twenty Three numbers of towers having a Shared tower's coverage area of 7-8 kms with a height of 50-60 ft. Two towers are located in north eastern and southwestern portion of the town.

4.1.4 Reliance

Nine numbers of towers having a Shared tower's coverage area of 14 kms with a height of 50-60 ft. Located in the south western and north eastern part.

4.1.5 Tata Docomo

Ten numbers of towers having a shared tower's coverage area of 5 kms with a height of 40-50 ft. Located in northern, western and south eastern part of the town.

4.1.6 Idea

Twelve numbers of Idea having a shared tower's coverage area of 9 kms with a height of 40-55 ft. located in southern part of the city.

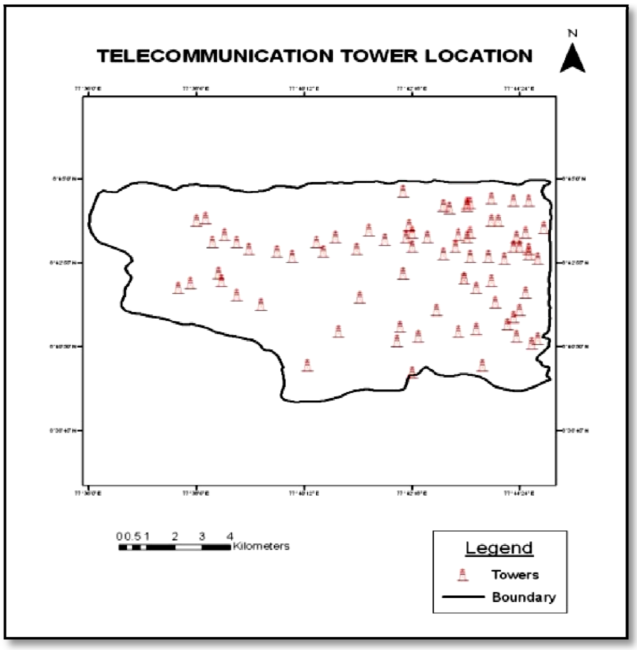

Fig -4: Existing Tower Location

Table -2: Attribute table for No. of Operators

tower point

FID	Shape	AREA	PERIMETER	TOWER#	TOWER-ID	NO.OPERATOR
1	Point	0	0	1	16	4
2	Point	0	0	2	17	3
3	Point	0	0	3	18	7
4	Point	0	0	4	19	4
5	Point	0	0	5	21	3
6	Point	0	0	6	22	4
7	Point	0	0	7	20	3
8	Point	0	0	8	23	5
9	Point	0	0	9	24	3
10	Point	0	0	10	25	2
11	Point	0	0	11	26	6
12	Point	0	0	12	27	4
13	Point	0	0	13	28	6
14	Point	0	0	14	29	3
15	Point	0	0	15	30	2
16	Point	0	0	16	31	2
17	Point	0	0	17	32	5
18	Point	0	0	18	33	3
19	Point	0	0	19	34	6
20	Point	0	0	20	35	1
21	Point	0	0	21	36	3
22	Point	0	0	22	37	5
23	Point	0	0	23	38	3
24	Point	0	0	24	39	6
25	Point	0	0	25	40	4
26	Point	0	0	26	41	2
27	Point	0	0	27	42	5
28	Point	0	0	28	43	1
29	Point	0	0	29	44	6
30	Point	0	0	30	45	3
31	Point	0	0	31	46	5
32	Point	0	0	32	47	7
33	Point	0	0	33	48	1
34	Point	0	0	34	49	4
35	Point	0	0	35	50	7
36	Point	0	0	36	51	4
37	Point	0	0	37	52	5

Table 2 shows the tower points which have five and more than five antennae.

4.2 NDVI Method

NDVI is an index of vegetation health and density. Clouds, water, and snow have larger reflectance's in the visible than in the near infrared while the difference is almost zero for rock and bare soil. Vegetation NDVI typically ranges from 0.1 up to 0.6, with higher values associated with greater density and greenness of the plant canopy. Surrounding soil and rock values are close to zero while the differential for water bodies such as rivers and dams have the opposite trend to vegetation and the index is negative. λNIR and λred are the reflectance in the near infrared and red bands respectively in the case of IRS-IC LISS III data. NDVI is calculated and applied for each pixel of sample areas of study area as per the equation

$$NDVI = (B3 - B2) / (B3 + B2).$$

The DN values of NIR band (B-3) in built up areas shows 50-100 ranges whereas in Red Band (B-2) in same built up areas shows range from 45-95. Hence NDVI for built-up areas becomes 0.1 to 0.35 .The DN values of NIR band (B-3 band) in water areas shows 25-35 ranges whereas in Red Band (B-2) in same built up areas shows 15-20 by which NDVI for built-up areas becomes negative values.

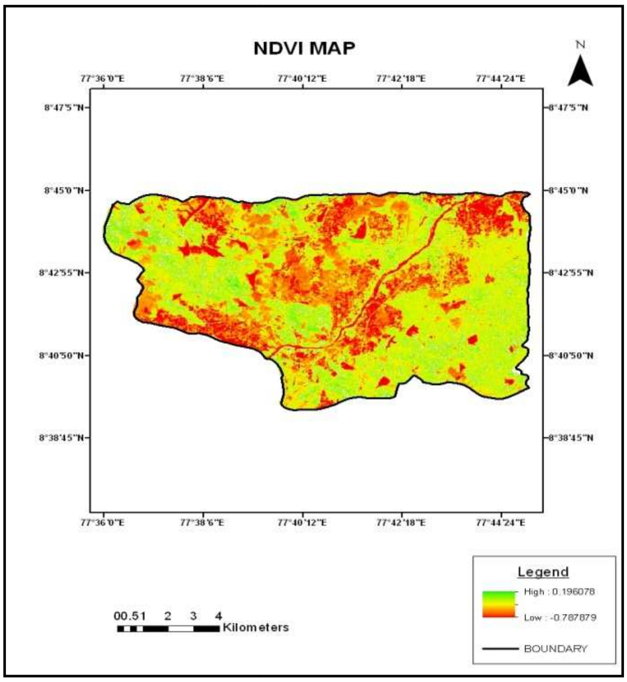

Fig -6: NDVI Map

Table -3: Signal strength measured by NDVI Analysis

NDVI

Site-No	X	Y	Z	signal Strength (db)
1	8.74	77.724	48	-78.2
2	8.728	77.742	49	-70.6
3	8.721	77.743	50	-79.3
4	8.722	77.738	51	-67.56
5	8.726	77.723	53	-97.7
6	8.74	77.723	52	-93.5
7	8.741	77.743	49	-85
8	8.73	77.748	49	-74.9
9	8.722	77.74	49	-73.2
10	8.729	77.691	48	-79.34
11	8.709	77.722	49	-72.65
12	8.719	77.715	51	-87.33
13	8.711	77.702	52	-75.8
14	8.726	77.703	52	-83.5
15	8.722	77.719	48	-86.90
16	8.739	77.723	52	-81.34
17	8.742	77.731	55	-89.34
18	8.738	77.717	53	-82.54
19	8.741	77.738	52	-74.3
20	8.728	77.724	50	-72.32
21	8.728	77.705	48	-79.68
22	8.722	77.705	47	-74.34
23	8.731	77.704	49	-71.30
24	8.734	77.638	50	-73.78
25	8.733	77.635	53	-94.3
26	8.724	77.64	54	-92.5
27	8.724	77.648	56	-84.3
28	8.721	77.652	53	-79.23
29	8.72	77.661	55	-74.34
30	8.72	77.676	48	-87.65
31	8.718	77.666	49	-83.57
32	8.727	77.644	50	-78.32

4.3 3D City Model

The methodology followed for the development and analysis of 3D model for the study area is shown in Figure 7. Initially, the satellite images downloaded from Bhuvan are collected and are geo-referenced using ground control points. Later, the geographical database of feature layers of existing features has been prepared for the study area in the ERDAS IMAGINE 9.1 environment. Then, attribute data is added to the created feature layers. The same feature layers are opened in Erdas Imagine Virtual GIS environment. The feature layers are first converted in to 3D features and then are extruded to a height of the value given in the respective attribute table to see a 3D model. Approximate height value is obtained from field data. The buildings and roads of Tirunelveli town were digitized in Erdas Imagine in the form of shape files. The buildings were created as polygon features. The boundary and the road layer have been created as a line features.

Fig -7: 3D City Model

4.4 Viewshed Analysis

In Geographic Information System environment, viewshed analysis is the result of a function that determines, given a terrain model, which areas on a map can be seen from a given point(s), line or area. In the communications industry, this function has been used to model radio wave coverage and to site transceiver towers for cellular phones. For wireless telecommunications providers, a GIS viewshed analysis has great potential to help plan network extensions by sitting transmitter towers.

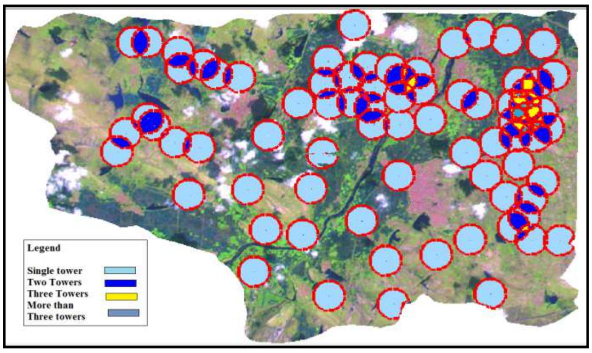

Fig -8: Viewshed Analysis

Wireless telecoms provide telecommunications access by using portions of the radio spectrum to transmit data.

Table -4: Attribute table for Viewshed Analysis

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Layer Number: 1

Row	Class Names	Color	Red	Green	Blue	Opacity	Histogram
0			1	1	1	0	37063
1	Perimeter		1	0	0	1	7065
2	Hidden Region		1	1	1	0	0
3	Visible by 1		0.64	0.85	1	1	11148
4	Visible by 2		0	0	1	1	1891
5	Visible by 3		1	1	0	1	352
6	Visible by 4		0.18	0.67	0.8	1	105

If the wavelength used is a Line-Of-Sight frequency, then a viewshed should show the regions that can receive a signal from a potential tower site. So, given the LOS properties of the wavelength, a viewshed would show the zones able to receive data, called a communications viewshed or 'commshed'. From that information, further viewshed analyses would aid in creating a chain of towers to cover a desired region. Next, building height data was recorded for the whole study area and about 1200 building sites are extracted from satellite data.

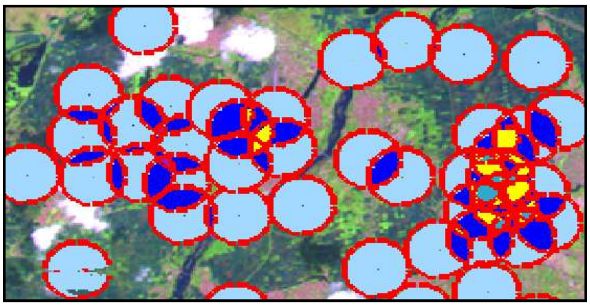

Fig -9: HotSpot zone for radiation

Above figure differentiate the region covered by single observer, two and more than two observer.

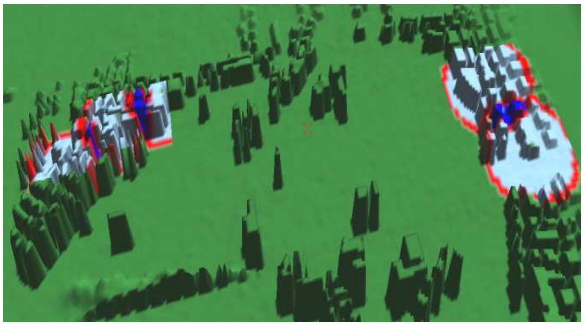

Fig -10: Viewshed Analysis with 3D Model

The radiation Hotspot zone for the study area has been shown in the figure 10 and 11.

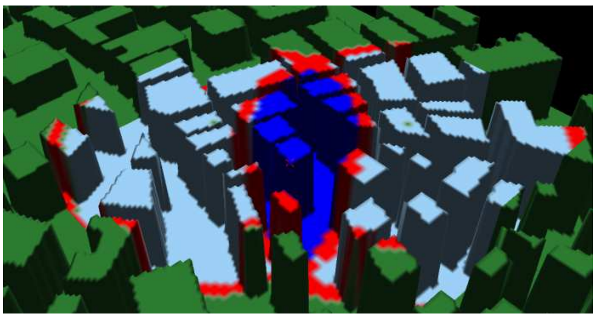

Fig -11: Hotspot Zone for Radiation

5. CONCLUSIONS

Remote Sensing and GIS oriented signal strength prediction can considerably improve prediction quality compared to the theoretical free space model which does not take into account any local terrain feature effects. Mobile towers are constructed without much considering the impacts of radiation intensity. This paper examines the frequency intensity & radiation hotspot area has been quantified. From this research we can conclude the radiation intensity level for K.T.C. Nager, Vannarpet, Thachanallur and Town has been significantly high so the network operators must aware about the radiation intensity.

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