

Study of Adverse Health Effects Due to Mobile Tower Radiation situated in Densely Populated Residential Areas

Amar Renke: shivaji University
Department of Electronics Engineering,
KIT's college of engineering,
Kolhapur, India
amarrenke@hotmail.com

Dr. Mahesh Chavan: shivaji University
Department of Electronics Engineering,
KIT's college of engineering,
Kolhapur, India
maheshpiya@hotmail.com

Abstract— Use of mobiles is increased tremendously in recent years; therefore to cover these mobile subscribers it is essential to increase the number of base stations. Nowadays these base stations are located in intensely populated areas. People around these base stations will get exposed to electromagnetic field (EMF) exposure which is radiated from base stations. This EMF exposure is called as non-ionizing radiation. Non-ionizing radiation has some adverse health effects. People are not aware of it in India. Power density is measured in nearby areas of mobile tower base stations which are located in densely populated areas. The places selected are Pachgaon, Kandalgaon, Kasba bawada, Tarabai Park, Mahalaxmi Nagar, RK Nagar, and Jarag Nagar in Kolhapur. The EMF exposure is measured in terms of power densities and electric field which were well below the international standard ICNIRP and national standard DoT. A questionnaire was prepared to find the different adverse health effects faced by the people living around the base stations. Different health symptoms of electromagnetic field exposure faced by the people within 20m, 50m and 150m are analyzed. Symptoms such as a headache and sleep disorder, daytime sleepiness, depression and memory changes were found in the study.

Keywords- Questionnaire, symptoms, power density, electromagnetic field (EMF), Non-ionizing radiation, base stations and adverse health effects etc.

I. INTRODUCTION

Today each and every person using a cell phone. Almost 70 to 80 % population is using mobile phones. To operate mobile phones supportive mobile network is required. To make this network operative base stations are required and these base stations are installed in densely populated areas today. People get exposed to EMF exposure. This exposure is also called as Non-ionizing radiation. It does not make ionization with body molecules but still, there are some effects due to non-ionizing radiation on the human body which is unknown to us. In recent years there is more concern about health effects caused by EMF exposure from base stations [1][2][3][4][5]. Mobile tower base stations radiate the electromagnetic energy this electromagnetic energy acting as an electromagnetic field exposure and the community living around these base stations will come into contact with EMF exposure. Today there is need to find out the impact of this EMF exposure on human health or how much is the health risk due to this EMF exposure from base stations [6][7][8]. Different studies claimed the impact of base station radiations on the human body such as a headache, sleep disorder, irritability, depression, dizziness etc [11][12]. There are two types of exposures: short term and long term exposure. In short-term exposure, people are getting exposed to EMF radiation for a short duration may be 10, 15, 30 minutes or 1 hour. In long-term, this exposure duration increases up to 5 to 6 hours or even more than that. The residential exposure was measured in different dwellings closer to the base stations, the distances selected were 20m, 50m and 100m.[9][10].

In May 2011, International Agency for Research on Cancer (IARC) has classified RF field as possibly carcinogenic to human (group 2B) based on increased risk for glioma, a malignant type of brain cancer associated with wireless phone use [2][15].

II. MATERIALS AND METHODS

A. Estimation of Power Density around Base Stations

Power density measurement was carried out on some selected different dwellings in densely populated areas around the base station. Initially, power density and electric field were measured at selected base stations which are located in the vicinity of densely populated areas. The purpose of power density is to establish a relationship between adverse health effects and intensity of power density and electric field. Power density and an electric field were measured with the help of instrument KM 195.

The power density is the rate of flow of electromagnetic energy per unit area used to measure the amount of radiation at a given point from a transmitting antenna. This quantity is expressed in units of watts per square meter (W/m²) or milliwatts per square cm (mW/cm²). The pointing theorem to express the average power is expressed as

$$P = |E \times H| \text{ -----(1)}$$

The power density of the equivalent plane wave is generally expressed as [14]:

$$\text{Power density} = \frac{1}{2} \text{Re} |E \times H| \text{ -----(2)}$$

$$\text{Power density} = |E_{\text{rms}}|^2 / Z_0 = Z_0 |H_{\text{rms}}|^2 \text{ -----(3)}$$

Where E and H are represented as electric and magnetic fields intensity of the transverse electromagnetic (TEM) waves.

The characteristic impedance is expressed as

$$Z = \sqrt{\mu_0 / \epsilon_0} \text{ -----(4)}$$

Where,

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m and}$$

$$\epsilon_0 = 10^{-9}/36\pi \text{ F/m}$$

Then after putting the values the impedance of free space is

$$Z = 377 \text{ ohm or } = 120.\pi \text{ ohm. -----(5)}$$

TEM wave is transverse and generally transmitted in free space so it is required to consider the intrinsic impedance of free space. the free space impedance of the medium is also given as

$$\eta = |E|/|H| \text{ ohms -----(6)}$$

The magnitude of the far-field radiated by the base station antenna system is determined by using the ray tracing algorithm based on the geometrical optics method. Thus, the total electric field can be expressed as a superposition of the incident and reflected field components [12, 13]:

$$E_{\text{total}} = E_{\text{incident}} + E_{\text{reflected}} \text{ -----(7)}$$

Where the corresponding incident and reflected electric field components are:

$$E_{\text{incident}} = E_0(\Phi, \theta)/R \cdot e^{-j\beta R} \text{ -----(8)}$$

and

$$E_{\text{reflected}} = [\rho(\Phi', \theta') E_0(\Phi, \theta)/R'] \cdot e^{-j\beta R'} \text{ -----(9)}$$

Where ρ is the appropriate reflection coefficient, and E_0 is the magnitude of the incident wave.

$$E(\Phi, \theta) = \sqrt{30N_{\text{radiated}}} \cdot G(\Phi, \theta)/R \text{ -----(10)}$$

Where N is the number of carriers,
Prad is the radiated power,
G(Φ,θ) is the radiation pattern for a particular antenna,
R is the distance from the base station,
(Φ,θ) are spherical coordinate angles, and
β is phase constant.

In addition, using a concept the perfect ground approximation it follows:

$$E_{\text{total}} = 2 \cdot \sqrt{30N_{\text{radiated}}} \cdot G(\Phi, \theta)/R \text{ -----(11)}$$

B. Specific Absorption Rate (SAR)

A suitable method to describe the absorption of RF fields in order to calculate specific absorption rate (SAR). It is expressed in W/kg. SAR is defined as the energy imparted from electric and magnetic fields to charged particles in an infinitesimal volume of an absorber per unit mass and time. SAR is energy stored in the electric and magnetic field. SAR is derived from Poynting vector and is expressed as

Power density = $\frac{1}{2} \text{Re} |E \times H|$ poynting vector

$$\text{SAR} = \sigma \cdot |E|^2/\rho \text{ -----(12)}$$

Where σ (S/m) is the electrical conductivity, E is the RMS value of the electrical field strength vector (V/m), and ρ is mass density of the medium (kg/m³).

C. Questionnaire

To study the adverse health effects and problems faced by the population living close to the base stations, the survey questionnaire was prepared from various research papers on various symptoms at the selected base stations in Kolhapur city [1]. The survey was conducted on 13 different symptoms and around 100 houses on 77 people. The scale used to study the adverse health effects is: 0 = never, 1 = sometimes, 2 = often, 3 = very often. Health effects faced by the population were analyzed and comparison has been made based on male, female and distance. Before giving the questionnaire the electric field and power density was measured at selected base stations.

III. DISCUSSION

People living near mobile towers having a distance less than 20, 50 meters facing more health complaints than 100 meters and above. Table I show that females having more complaints and more affected than men. Daytime sleepiness, depression, irritability, memory changes, morning fatigue, pain in joints, heaviness in the head, difficulty in concentration and sleep disorder these symptoms are more in the female, while daytime sleepiness, headache, sleep disorder, memory changes and morning fatigue are found in men. From table 1.0 on an average 21.58 % females and 16% males are get affected by mobile tower radiation living within 50-meter area.

TABLE I. COMPARISON OF COMPLAINTS BETWEEN MALE (28) AND FEMALE (18) LIVING NEAR THE BASE STATION WITHIN 50M (ALL THE FIGURES ARE IN PERCENTAGE).

Symptoms	0		1		2		3	
	M	F	M	F	M	F	M	F
Day time sleepiness			42.8	55.5	28.5	33.3	21.4	11.1
depression	14.2	22.2	42.8	33	14.2	33.3		
Difficulty in concentration	14.2	11.1	42.8	55.5	7.14	11.1	7.14	33
Dizziness	21.4	22.2	35.7	66.6	7.14			
Headache	7.14	11.1	50	88.8	14.2	11.1	21.4	
Heaviness in head	7.14		30	66.6	14.2	22.2	14.2	11.1
Irritability		11.1	60	44.4	14.2	55.5	14.2	11.1
Memory loss/ changes			20	22.2	21.4	33.3	21.4	
Morning Fatigue	7.14	11.1	35.7	55.5	33	22.2		11.1
Pain in joints	14.2	22.2	30	55.5	7.14	22.2	21.4	22.2
Palpitations of heart	14.2	22.2	42.8	77.7	7.14	11.1	7.14	
Sleep disorder	14.2	11.1	10	55.5	21.4	22.2	21.4	
Visual disturbance / Visual disorders	14.2	33.3	35.7	55.5	14.2	11.1	14.2	

Reference: 0 = never, 1 = sometimes, 2 = often, 3 = very often

Table 2.0 gives the health symptoms for the people living in 150-meter area from base station mobile tower. A headache, depression, daytime sleepiness, heaviness in the head, dizziness and visual disorders these symptoms are more in the female, while daytime sleepiness, difficulty in concentration,

heaviness in the head, morning fatigue and sleep disorder are found in men. From table 2.0 on an average 16.57 % females and 12.83 % males are get affected by mobile tower radiation living within 50-meter area.

TABLE II COMPARISON OF COMPLAINTS BETWEEN MALE (26) AND FEMALE (18) LIVING NEAR THE BASE STATION OUTSIDE 50M (FIGURES ARE IN PERCENTAGE).

Symptom	0		1		2		3	
	M	F	M	F	M	F	M	F
Day time sleepiness	36.1	18.1	47.2	59.0	11.1	22.7	5.5	
depression	33.3	9.09	47.2	45.4	13.9	36.3	5.5	9.0
Difficulty in concentration	30.5	40.9	41.6	45.4	27.8	13.6		
Dizziness	13.8	9.09	55.5	59.0	22.2	22.7	8.3	9.0
Headache	38.8	27.2	41.6	54.5	13.9	22.7	5.5	18.1
Heaviness in head	27.7	22.7	41.6	36.3	27.8	36.3	2.7	4.54
Irritability	41.6	45.4	41.6	40.9	16.7	13.6	0	0
Memory loss/ changes	55.5	50	41.6	50	2.78	0	0	0
Morning Fatigue	30.5	22.7	41.6	63.6	27.8	13.6	0	0
Pain in joints	44.4	45.4	27.7	31.8	22.2	18.1	5.5	4.54
Palpitations of heart	41.6	22.7	44.4	68.1	13.9	9.09	0	0
Sleep disorder	41.6	45.4	41.6	45.4	13.9	9.09	2.7	0
Visual disturbance / Visual disorders	36.1	31.8	44.4	50	13.9	18.1	5.5	0

Table III gives the comparison of percentage of symptoms between greater than 50 meter and less than 50 meter area around the mobile tower.

TABLE III – COMPARISON OF COMPLAINTS FROM ALL THE INDIVIDUALS (77) BASED ON DISTANCE (IN PERCENTAGE).

Symptom	0		1		2		3	
	<50 m	>50 m	<50 m	>50 m	<50 m	>50 m	<50 m	>50 m
Day time sleepiness	0	54.2	49.2	53.1	30.9	16.9	16.2	5.55
depression	36.5	42.4	37.9	92.6	23.8	25.1	0	7.32
Difficulty in concentration	25.3	71.4	49.2	87.1	9.12	20.7	20.0	
Dizziness	43.6	22.9	51.1	57.3	7.14	22.4	0	8.71
Headache	18.2	66.1	69.4	96.2	12.6	13.9	21.4	11.8
Heaviness in head	7.14	50.5	48.3	78.0	18.2	32.0	13.9	3.65
Irritability	11.1	87.1	52.2	82.5	34.9	15.1	13.9	
Memory loss/ changes		105.5	21.1	91.6	27.3	2.78	21.4	
Morning Fatigue	18.2	53.2	45.6	52.6	27.6	20.7	11.1	
Pain in joints	36.5	89.8	42.7	59.5	14.6	20.1	21.8	5.04
Palpitations of heart	36.5	64.3	56.2	56.3	9.12	11.4	7.14	
Sleep disorder	25.3	87.1	32.7	87.1	21.8	11.4	21.4	2.77
Visual disturbance / Visual disorders	47.6	67.2	45.6	94.4	12.6	16.0	14.2	5.55

From table III the people living less than 50-meter area are facing symptoms such as a headache, memory loss/changes, pain in joints, sleep disorder, daytime sleepiness, irritability, and morning fatigue. A headache, heaviness in the head, morning fatigue and pain joints these symptoms were found in people living around the base station and distance was approximately 100 meters. After studying tables 1.0, 2.0 and

3.0 the overall symptoms observed in people living around the close proximity of mobile tower base stations were listed as a headache, memory changes/ loss, sleep disorder, daytime sleepiness, pain in joints and irritability.

TABLE IV COMPARISON OF COMPLAINTS BETWEEN MALE (15) AND FEMALE (12) LIVING NEAR THE BASE STATION WITHIN 20M (FIGURES ARE IN PERCENTAGE).

Symptom	0		1		2		3	
	M	F	M	F	M	F	M	F
Day time sleepiness			20		40	25	60	25
Depression	20		40		60	50		
Difficulty in concentration	20		40	25	20	25	80	
Dizziness	60		40	50				
Headache		25	60	50	60		20	
Heaviness in head	20		20	25	40		40	25
Irritability			60		40	50	20	
Memory loss/ changes	20			50	60	25	40	
Morning Fatigue			40		60		40	25
Pain in joints	20		40	50	20		20	
Palpitations of heart	60		40	50				
Sleep disorder			40	50	40		40	
Visual disturbance / Visual disorders	20		60	25	20	25		

Table IV shows the comparison of complaints of people living very close to the base station tower that is 20 meters. Here the major symptoms found were day time sleepiness, difficulty in concentration, heaviness in head, morning fatigue and sleep disorder.

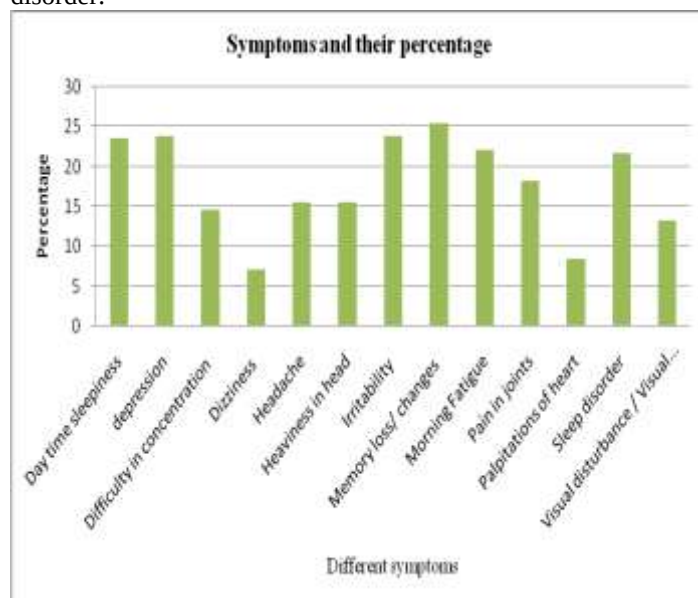


Figure. 1.0 Symptoms and their percentage for distance within 50m from base station.

Figure 1 shows the bar graph of different symptoms and their percentage. Memory changes is having highest percentage 25%, day time sleepiness and depression 23% , morning fatigue 22% and sleep disorder 22%.

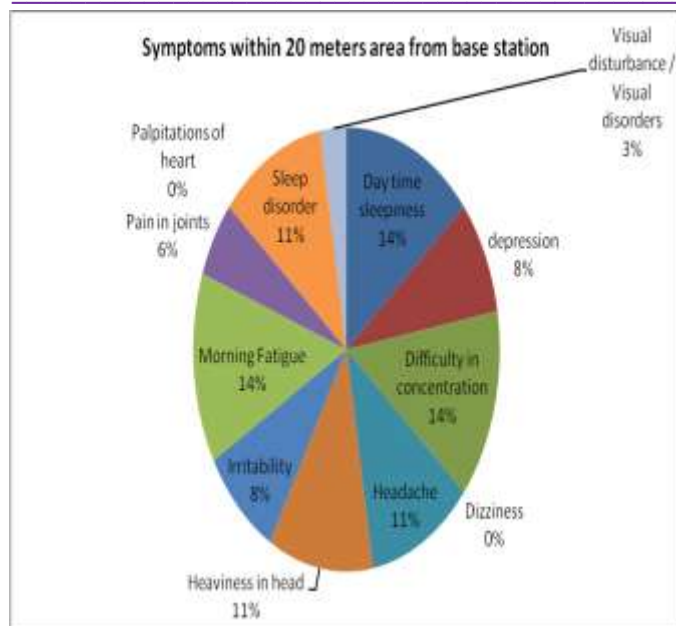


Figure 2.0 Symptoms and their percentage for distance within 20m from base station

Figure 2 represents the gravity of different symptoms in terms of pie chart within 20 meters.

IV. CONCLUSION

The results are presented here table I, II and III as well as from figures 1.0, 2.0. From the table I and figure 1.0 it is found that the people living within 50-meter area from the base station they are facing problems like daytime sleepiness, depression, irritability, memory changes/loss, morning fatigue and sleep disorder. The percentage of these symptoms ranges from 20 % to 26 %. Table II and figure 2.0 shows that people living within 100-meter area from the base station are facing problems such as morning fatigue, difficulty in concentration and heaviness in head. Their percentage was 12 %. In the third case i.e. within 20-meter area from the base station the symptoms found were morning fatigue, daytime sleepiness, difficulty in concentration, headache, heaviness in head and sleep disorder. Their percentage ranges from 11 % to 14 %.

The overall symptoms found in the people were morning fatigue, sleep disorder, difficulty in concentration and daytime sleepiness.

ACKNOWLEDGMENT

The authors would like to thanks the department of technology for using their labs for the experimentation and their cooperation.

REFERENCES

- [1] Lalrinthara Pachuau¹, Zaithanzaau Pachuau, "Study of Cell Tower Radiation and its Health Hazards on human body", IOSR Journal of Applied Physics (IOSR-JAP) e-ISSN: 2278-4861. Volume 6, Issue 1 Ver. I (Jan. 2014), PP 01-06
- [2] AM Martinez-Gonzalez, A Fernandez-Pascual, Practical Procedure for Verification of Compliance of Digital Mobile Radio Base Stations to Limitations of Exposure of the General Public to Electromagnetic Fields, IEEE Proceedings on

- Microwaves, Antennas and Propagation (USA) 149 (2002) 218-228.
- [3] A Ahlbom, A Green, *et al*, Epidemiology of Health Effects of Radiofrequency Exposure, *Environmental Health Perspectives* 112(17), (2004), 1741-1754.
- [4] U.S Food and Drug Administration (FDA), Radiation emitting Products: Reducing Exposure : Hands-Free Kits and Other Accessories, 2009.<http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductandprocedures/HomeBusinessandEntertainment/CellPhones/ucm116338.htm>
- [5] Nora D. Volkow, Dardo Tomasi, Gene-Jack Wang, Paul Vaska, Joanna S. Fowler, Frank Telang, Dave Alexoff, Jean Logan and Christopher Wong, Effects of Cell Phone Radiofrequency Signal Exposure on Brain Glucose Metabolism, *Journal of American Medical Association*, 305(8), 2011, 808-813.
- [6] World Health Organization (WHO) Media Centre, Electromagnetic Fields and Public Health : Mobile Phones, 2011. <http://www.who.int/mediacentre/factsheets/fs193/en/>
- [7] Chia SE, Chia H.P, Tan J.S, Prevalence of Headache Among Handheld Cellular Telephone Users in Singapore : A community Study, *Environmental Health Perspectives* 108(11), 2000, 1059-1062.
- [8] Oftedal G, Wilen G, Sandstrom M, Mild K.H, Symptoms experienced in Connection with Mobile Phone use, *Occupational Medicine*, 50(4), 2000, 237-245.
- [9] JF Viel, S Clerc, C Barrera, R Rymzhanova, M Moissonnier, M Hours, E Cardis, Residential exposure to Radiofrequency Fields from Mobile Phone Base stations, and Broadcast Transmitters: A population-Based Survey with Personal Meter, *Occup Environ Med* 66 (2009) 550-556.
- [10] Sabah Hawar Saeid Al-Bazzaz, "Theoretical Estimation of Power Density Levels around Mobile Telephone Base Stations", *Journal of Science & Technology* Vol. (13) No.(2) 2008 JST 3
- [12] H. Lai, "Biological Effects of Radiofrequency Radiation from Wireless Transmission Towers", A presentation at the Cell Tower forum: State of the Science/State of the Law, sponsored by the Berkshire-Litchfield Environmental Council, in Lakeville, CT, December 2000, pp. 339-347.
- [13] P. Bernardi, M. Cavagnaro, S. Pisa, E. Piuze, "Human Exposure in the Vicinity of Radio Base Station Antennas", 4th European Symposium on Electromagnetic Compatibility (EMCEurope 2000), Brugge, Belgium, September 11-15, 2000, pp. 187-192.
- [14] P. Bernardi, M. Cavagnaro, S. Pisa, E. Piuze, "Human Exposure to Radio Base Station Antennas in Urban Environment", *IEEE Transaction MTT*, Vol. 48, No. 11, November 2000, pp. 1996-2003.
- [15] K. Siwiak, "Radio Wave Propagation and Antennas for Personal Communications", 3rd Edition, Artech House, Boston, London, 2007.
- [16] A. Renke and M. Chavan, "An investigation on residential exposure to electromagnetic field from cellular mobile base station antennas," *Computing, Communication and Security (ICCCS), 2015 International Conference on*, Pamplemousses, 2015, pp. 1-4.
- [17] Amar Renke and Mahesh Chavan. Article: A Review on RF Field Exposure from Cellular Base Stations. *International Journal of Computer Applications* 104(12):9-16, October 2014.
- [18] Amar Renke and Mahesh Chavan. Article: An Estimation of Electromagnetic Field Exposure from Cellular Mobile Base Station Towers in Denselv Populated Residential Areas. *Communications on Applied Electronics* 4(3):5-9, January 2016. Published by Foundation of Computer Science (FCS), NY, USA.
- [19] A.L. Renke and Rohit A Patil " Keystroke dynamics for user authentication & identification by using typing rhythm " *International Journal of Computer Applications* (0975 – 8887) Volume 144 – No.9, June 2016.

-
- [20] A.L. Renke and Rohit A Patil “An innovative method for ordinary and fancy number plate recognition applied to intelligent transport system” National Conference on Emerging trends in engineering, technology & architecture NCETETA-2016 ,30 Jan. 2016.
 - [21] A.L. Renke and A R Karande “An innovative method to enhance resolution and contrast for satellite images using discrete wavelet transform” IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834.p- ISSN: 2278-8735.Volume 12, Issue 2, Ver. III (Mar.-Apr. 2017), PP 40-48
 - [22] A.L. Renke and A R Karande “A Review on Image Enhancement Methods” *International Journal of Computer Applications* (0975 – 8887) Volume 164 – No 6, April 2017.
 - [23] A.L. Renke and Deepa Raul “A modified image fusion approach using guided filter” *International conference on research methods in engineering and technology (ICRMET)*, July 3, 2016 at Tirupati, ISBN 978- 1535061506.
 - [24] A.L. Renke “Remote voice controlled system for physically challenged “National Conference on technology for social transformation and emerging trends in electronics & instrumentation UTKARSH – 2007. VES institute of technology chembur, Mumbai, January 12-13 2007.
 - [25] A.L. Renke, “ An efficient RTV scalant implementation through micro stepping of stepper motor” *National Conference on Recent trends in manufacturing NCRTM 2006*, 7-8 January 2006 at KIT, Kolhapur.
 - [26] A.L. Renke. “An efficient method to control home appliances from remote location through telephone using voice commands” National Conference on engineering trends in electronics, NCETE – 2006, 28-30 December 2006 at MAE Alandi, Pune.
 - [27] A.L. Renke. “Independent component analysis & applications”. *National Conference on advanced technology NIRMITI-2010*, NCOAT-NIRMITI, February 9-10, 2010 at PIET Nagpur.