MITIGATING THE RISKS OF ELECTROMAGNETIC RADIATION ON WORKERS IN AIR TRAFFIC CONTROL TOWER AT SUHAJ AIRPORT

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ABSTRACT:

One of the most important functions of the Airport Traffic Control Tower (ATCT) is to control and regulate the air traffic and prevent the air craft collisions on the ground and through controlled air field. These services are provided by air traffic controllers using different communication systems and navigation aids. Transmitting antenna of communication system emits electromagnetic waves which have adverse health effects on the workers of the tower. This work is dealing with the electromagnetic radiation effects on workers in Suhaj airport tower by using: simulation process for the antennas at frequencies dedicated for Suhaj airport, on-site measurements, comparing results with standards and a designed questionnaire. The main objective of this research is to mitigate the exposure of workers to hazard and risk from electromagnetic radiation and protect them from its side effects. This study concluded that most of the areas inside the ATCT meet the safe standards except the top roof area where, antenna exist. The questionnaire showed that most of the staff are concerned of EMR in the tower and thought that the EMR has adverse health effect.

Key words: *Airport Traffic Control Tower/ Transmitting Antenna/Electromagnetic Waves/Simulation/Questionnaire*

INTRODUCTION

Suhaj Airport Traffic Control Tower (ATCT) is located in Suhaj Governorate and consists of three basic components: control cab, tower shaft, and base building. The cab is situated at the desired elevation above ground level (AGL) about 30 meters height. The primary tower shaft function is to support the raised cab at the desired elevation.

The base building is normally used to house the equipment necessary to support the operational needs of the ATCT, including space for administrative and training functions and electrical and mechanical facilities. This tower is considered as a source of electromagnetic radiation, this represents a kind of risk on workers [1, 2].

This system is established to ensure safety, efficiency, and effectiveness to air traffic system. Its main goal is to keep separation between planes in the zone of the airport to protect planes from collision with

each other, but it also serves to regulate the aviation of air crafts [3].

The tower equipped with VHF communication systems used by controllers for voice communication with aircraft and with vehicles on the ground, these systems working on air-band frequencies which refers to VHF frequencies 118 to 137 MHz, used for navigation and voice communication with aircraft [4,5,6].

The tower's staff faced the communication engineers with the frequently asked question: "Are there adverse health effects on human bodies from operating VHF system in the tower?". This study will try to give answer to this question.

To answer the question, on-site practical measurements must be conducted to determine the electric and magnetic fields strength and the power density outdoor and indoor of the tower, there were different studies have been conducted around the world for RF radiation measurements from a variety of wireless communication sources, the study of Bill P. Curry and Gretchen V. Fleming showed the performing of RF radiation measurement program in Kokomo, Indiana , to determine the sources of Kokomo Hum[7], and the study of Tomasz Dlugosz, Hubert Trzaska presented a comparative analysis of EMF metrology in the near field and in the far field. Measurements in the near field are more difficult and burdened with a considerably larger error than measurements performed in the far field[8] and the study of Soichi Watanabe and Lira Hamada showed the feasibility of compliance evaluation by a

relatively simple measurement system such as a small probe for measuring tri-axial isotropic electric fields, and a combination of an antenna and a spectrum analyzer[9],and the study of A K M Fazlul Hoque et al showed that the measurements have been carried out on Bangladesh mobile operators (stations , centers), calculations were done for specific absorption rate (SAR) and consequent rise of temperature in human tissues[10].

Potential adverse health effects could be linked to excessive exposure to high-power densities of electromagnetic radiation. These health effects include: Cancer, Tumors, Headaches, Fatigue, Alzheimer's disease and Parkinson's disease[11,12,13]. The health effects of EMR are explained in many studies, the study of Adlina Suleiman et al showed that the comparison of symptoms frequencies and its significance (Chi-square test) between the exposed and not exposed residents from the TELCO tower showed statistical significance (p < 0.05) for headache, giddiness, insomnia, loss of memory, diarrhea, mental slowness, reduced reaction time and mood swing[14], and the study of Awn B. Rifai, Majed A. Hakami showed that, the accompanying electromagnetic fields (EMFs) are partially transformed into radiation that affects human health and the potential health hazards of radiation emanating from electric power lines[15], and the study of Kuldip Singh, Younis Muhammad showed that the radiations from Mobile base station towers, cell phones, computers, laptops, TV & FM towers and microwave ovens etc are very harmful for us and can have adverse effect on

human body depending on the intensity and frequency of the electromagnetic radiation[16].

Electromagnetic energy is absorbed by the body and deposits energy internally leading to thermal loads and temperature gradients. The measured rate at which energy is absorbed by the human body when exposed to a radio frequency (RF) electromagnetic (EM) field is specific absorption rate (SAR). SAR has been discussed in several studies, A K M Fazlul Hoque et al showed that the Calculations were done for specific absorption rate (SAR) and consequent rise of temperature in human tissues. Maximum power density value (for far field) observed is that for the Bangladesh Link operator (= 1.27×10^{-6} W/m2). SAR values and the corresponding temperature rise were calculated for the eye, brain and nerve tissues exposed to RF fields, for the general public and occupational workers of Bangladesh for each of the mobile operators [10], and study of M.Usha Rani et al showed the estimation of specific absorption rate of electromagnetic radiations inside human blood , muscle and bone as a function of frequency for different cellular frequency bands. Results are obtained for different conductivities , resistivity values , permeability at those frequency bands for blood, muscle and bone. These results are analyzed and are useful to compare the SAR values with recognized FCC standards[17] , and the study of C. S. Wang, G. X. Shen presented some comparisons and results about the relationships among SAR, different tissues and different resonant frequencies [18].

Safety Guidelines are proposed by several regulating organizations that have set exposure limits maximum permissible exposures (MPEs) and guidelines for RF radiation, such as The Institute of Electrical and Electronic Engineers (IEEE)[19], International Commission on Non-Ionizing Radiation Protection (ICNIRP)[20], The USA Federal Communications Commission (FCC)[21]. Some countries has its own regulations, such as Egyptian Protocol in Egypt[22].

These guidelines are designed to protect both occupational workers and the general public with a very large margin of safety. Most RF safety limits are described in terms of electric and magnetic field strengths as well as in terms of power density.

MATERIALS AND METHODS

To mitigate the risk, a simulation of electromagnetic sources has been conducted. In addition, measurements of electromagnetic fields and power density have been carried out. The measured values have been compared with the international values of global bodies like ICNIRP, IEEE, FCC and Egyptian protocol. A questionnaire has been designed to know the adverse effects of EMR emitted from the antennas of the ATCT on the workers. The methods had been used are:

1- Computer Simulation Technology (CST) Studio 2014 is the application used to simulate the four antennas of the tower [23].

2 - The measurements of power density, electric and magnetic fields were detected by using a handheld EXTECH RF EMF Strength Meter Model 480836 with three-channel (triaxial) measurement probe as shown in figure 1.

It measures all parameters in three directions X, Y and Z separately as in the features of instrument , the instrument does not measure total field readinngs[24].

3 – Microsoft Excel Program 2007 used to demonstrate the comparison processes [25].

4- Equations used for calculations are wavelength equation λ, specific absorption rate equation, power density equation P$_D$, field regions equations [26,27,28,29]

Fig.1 EXTECH EMF strength meter

Wavelength equation

$$\lambda = \frac{C}{f} \ (1)$$

Specific Absorption Rate

$$SAR = \frac{\sigma E^2}{\rho} \ (2)$$

Power Density Equation

$$Incident \ Power \ Density \ P_D \ = \frac{E^2}{Z_0} = \frac{E^2}{120\pi} = \frac{E^2}{377} \ (3)$$

Field Regions Equations

$$Reactive \ Near \ Field \ \leq 0.62 \times \sqrt{\frac{D^3}{\lambda}} \quad (4)$$

$$Radiating \ Near \ Field \ (\ Frensel \ Region) < \frac{2D^2}{\lambda} \ (5)$$

$$Far \ Field \ (Fraunhofer) \ \geq \frac{2D^2}{\lambda} \quad (6)$$

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WHERE

λ : Wavelength in meter m

C: Speed of light = 3×10^8 m/s

f: Frequency in hertz Hz

SAR: Specific Absorption Rate is in (W/kg)

σ (sigma): Tissue conductivity (S/m)

E:Electric field strength (V/m)

ρ (rho): The physical density (kg/m^3)

S (P_D)is in (W/m^2)

Z_0: The characteristic impedance of free space equals 377 ohms

R: The distance from the antenna surface

D:Maximum overall dimension of the antenna

5 - Tissue dielectric parameters (σ (sigma), ρ (rho))are computed according to the 4-Cole Model [30].

Methods include simulation of four antennas at dedicated frequency of each one, calculation of SAR and comparison with chosen standards, on-site measurements (outdoor and indoor), calculation of SAR and comparison with chosen standards and questionnaire.

A - SIMULATION

Computer Simulation Technology (CST) Studio 2014 is the application used to simulating four antennas existing in the tower and emitting radio frequency radiation (RFR) are

1 – Air / Ground frequency is 118.9 MHz dipole antenna.

2 – Emergency frequency is 121.5 MHz dipole antenna .

3 –Ground / ground frequency is 121.9 MHz dipole antenna .

4 – 2.4 GHz WiFi dipole antenna.

WHERE

the frequency 118.9 MHz is the operating frequency allocated for Suhaj airport tower only and the frequency 121.5 MHz is the emergency frequency which used in emergency state and the frequency 121.9 MHz is allocated for communication on the ground of the airport between the tower and all vehicles, workers and planes, while the 2.4 GHz frequency is the frequency of the WiFi router in the tower.

Simulation parameters are frequency f, wavelength λ, dipole length L, radius of dipole R, feedpoint of dipole separation g, S-Parameter $(S_{1,1})$, Directivity, Gain, Efficiency, Electric field E, Magnetic field H and Power Pattern.

Equation (1) used to determine the wave length where the dipole length related to wavelength λ and the radius of the dipole related to the dipole length.

The results of each simulated antenna as electric field, magnetic field, power density and antenna parameters were tabulated. Electric field, magnetic field and power density compared with standards of ICNIRP, IEEE, FCC and Egyptian protocol. After that, the specific absorption rate (SAR) and power density P_D will be calculated using equations (2, 3) respectively and field regions will be calculated by equations (4,5,6).

SAR is calculated for average brain, average skull, and average muscle at the four frequencies and will be compared with SAR standards of using the results and compared with standards bodies mentioned above.

B– On-Site Measurements divided into Outdoor and Indoor measurements where accomplished by using a handheld EXTECH RF EMF Strength Meter Model 480836.

The results of on-site measurement results will be tabulated and compared with the standards (ICNIRP, IEEE, FCC and Egyptian Protocol).

B-1 Outdoor Measurements performed in three directions X,Y and Z for ATC tower rooftop and out of tower at distances of 3m, 10m and 30m from the building, calculation of SAR and comparing the results with standards mentioned above to demonstrate that the areas mentioned above are safe or risky.

B-2 Indoor measurements performed in two directions X and Y for the tower CAB, equipment room, air nav. sys. engineering office, comm. administration office, the tower reception and the walkthrough in the tower building where the measurements were taken as: reactive near field of WiFi router at 0.02m from the beginning point of walkthrough, near field of WiFi router at 0.04m from the beginning point of walk -through, Far field of WiFi router at 1m from the beginning point of walkthrough, middle point (at10m from the beginning) of walkthrough and end point Figure 2 ATC tower facility component (at20m from the beginning) of walkthrough. Calculation of SAR and comparing the results with standards mentioned above to demonstrate that the areas mentioned above are safe or risky, figure 2 demonstrates the air control tower facility components: (tower where the CAB mounted and the rooftop, basebuilding where rooms, administrative offices and walkthrough) .

RESULTS AND DISCUSSIONS

The measurements showed that both risky and safe areas in the tower and outside it with related SAR calculations comparisons charts. This study shows two examples one for risky area and the other for safe area
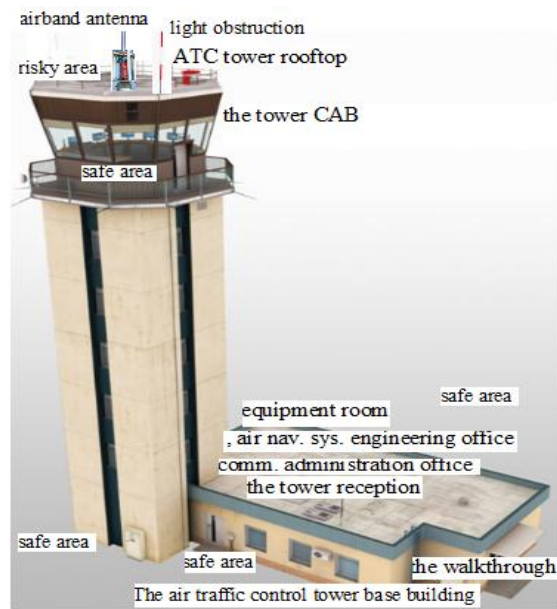
The air traffic control tower facility

(Fig.2 ATC tower facility)

where the measured parameters are:

E_{max} (**Maximum Electric field strength**) **V/m**

E_{ave} (**Average Electric field strength**) **V/m**

$E_{max\ ave}$ (**Maximum Average Electric field strength**) **V/m**

H_{max} (**Maximum Magnetic field strength**) **A/m**

H_{ave} (**Average Magnetic field strength**) **A/m**

$H_{max\ ave}$ (**Maximum Average Magnetic field strength**) **A/m**

P_{max} (**Maximum Power Density**) **(W/m^2)**

P_{ave} (**Average Power Density**) **(W/m^2)**

$P_{max\ ave}$ (**Maximum Average Power Density**) **(W/m^2).**

Example 1, Risky Area

Outdoor Measurement, SAR calculation and Comparisons tables for rooftop of the ATC tower in X,Y and Z directions in Near Field Region are tabulated as following :

1- Table 1, Near Field Region Measurements.

2- Table 2, Near Field Region SAR calculations.

3 -Table 3, Near Field Region E_{max} , H_{max} , P_{max} / Standards Comparison Chart.

4 -Table 4, Near Field Region SAR calculation comparison chart.

Note: The values in tables of comparisons 3,4,are expressed in terms of logarithms to enabling comparison process.

Table 1 Near field region measurements

	EMR Parameters			Limits of RMS Values of Electric and Magnetic Fields, Power Density (S) (W/m^2) in Controlled Environments			
				ICNIRP P	IEEE	FCC	Egy. code
Near Field Region Measurements In X – Direction	E_{max}	E_{ave}	$E_{max\,ave}$	(E) (V/m)			
	534.2 mV/m	11.7 mV/m	12.12 V/m	61	61.4	61.4	---
	Percentage Value of $E_{max} \Rightarrow$			0.8757	0.87	0.87	---
	H_{max}	H_{ave}	$H_{max\,ave}$	(H) (A/m)			
	230.2mA/m	22$\mu A/m$	33.4$\mu A/m$	0.16	0.163	0.163	---
	Percentage Value of $H_{max} \Rightarrow$			143.875	141.226	141.226	---
	P_{max}	P_{ave}	$P_{max\,ave}$	power density (S) (W/m^2)			
	22.67 W/m^2	0.2 $\mu W/m^2$	8.74 W/m^2	10	10	10	4
	Percentage Value of $P_{max} \Rightarrow$			226.7	226.7	226.7	566.75
Near Field Region Measurements In Y – Direction	E_{max}	E_{ave}	$E_{max\,ave}$	(E) (V/m)			
	131.1[a] V/m	11.7 mV/m	118.2 V/m	61	61.4	61.4	---
	Percentage Value of $E_{max} \Rightarrow$			214.918	213.518	213.518	---
	H_{max}	H_{ave}	$H_{max\,ave}$	(H) (A/m)			
	284.2mA/m	35.5 $\mu A/m$	132.5 mA/m	0.16	0.163	0.163	---
	Percentage Value of $H_{max} \Rightarrow$			177.825	174.356	174.356	---
	P_{max}	P_{ave}	$P_{max\,ave}$	power density (S) (W/m^2)			
	16.3 W/m^2	0.1 $\mu W/m^2$	8.296 W/m^2	10	10	10	4
	Percentage Value of $P_{max} \Rightarrow$			163	163	163	407.05
Near Field Region Measurements In Z – Direction	E_{max}	E_{ave}	$E_{max\,ave}$	(E) (V/m)			
	56.25 V/m	5.8 mV/m	6.7 V/m	61	61.4	61.4	---
	Percentage Value of $E_{max} \Rightarrow$			92.213	91.612	91.612	---
	H_{max}	H_{ave}	$H_{max\,ave}$	(H) (A/m)			
	274.6mA/m	24.4 $\mu A/m$	103.1 mA/m	0.16	0.163	0.163	---
	Percentage Value of $H_{max} \Rightarrow$			171.625	168.466	168.466	---
	P_{max}	P_{ave}	$P_{max\,ave}$	power density (S) (W/m^2)			
	16.79 W/m^2	0.1 $\mu W/m^2$	8.4 W/m^2	10	10	10	4
	Percentage Value of $P_{max} \Rightarrow$			167.9	167.9	167.9	419.75

Table 2 Near field region (SAR calculation and comparison)

tissue dielectrics		measured E_{max}	SAR calculated value	SAR Limits of INCIRP, IEEE=2 W/Kg & FCC=1.6 W/Kg	
				(pct) of SAR calculated	
conductivity σ	density ρ			2.0 W/kg averaged over 10g of tissue	1.6 W/kg averaged over 1g of tissue
Rooftop of ATC Tower : Near Field Region In X – Direction					
Brain		534.2 mV/m	0.00012733	0.00637 %	0.00796 %
0.459574	1030				
Skull			18.89 $\mu W/kg$	0.000944 %	0.00118 %
0.122461	1850				
Muscle			0.000203	0.0101 %	0.0126 %
0.739187	1040				
Rooftop of ATC Tower : Near Field Region In Y – Direction					
Brain		131.1 V/m	7.6887	383.4366 %	479.296 %
0.459574	1030				
Skull			1.1377	56.885 %	71.11 %
0.122461	1850				
Muscle			12.216	610.7962 %	763.495 %
0.739187	1040				
Rooftop of ATC Tower : Near Field Region In Z – Direction					
Brain		56.25 V/m	1.4118	70.59%	88.24%
0.459574	1030				
Skull			0.2094	10.47 %	13.09%
0.122461	1850				
Muscle			2.4889	112.444 %	140.555%
0.739187	1040				

According to tables 1, 2 of near field region (measurements and SAR calculations) as following:

a. In X – direction

It is obviously that the value of E_{max} is too small in comparing with standards limits and values of H_{max} and P_{max} are too large in comparing with standards limits, so it is a risky area

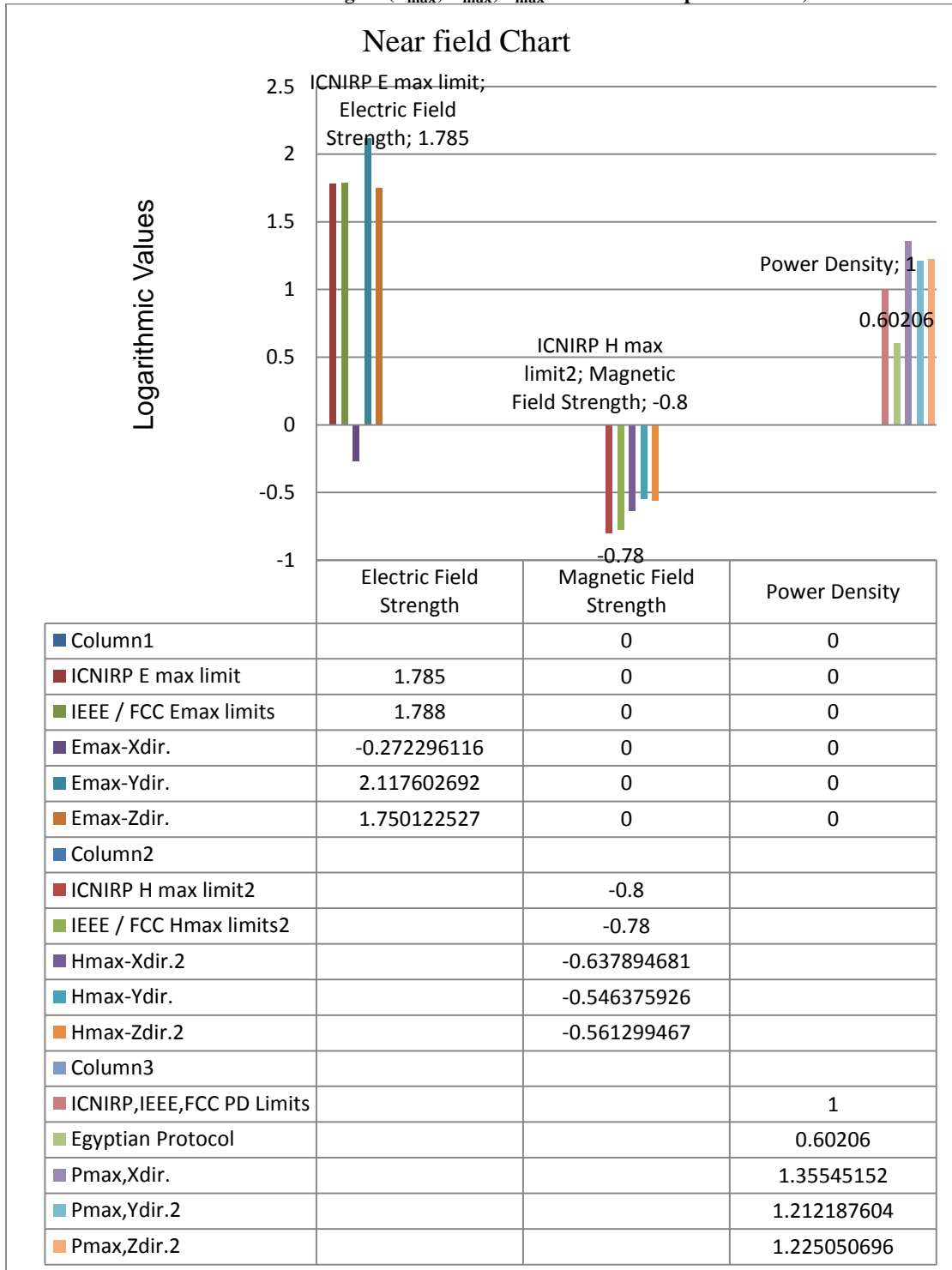It is obviously that the SAR values are too small in comparing with the standards limits.

b. In Y – direction

The values of E_{max} , H_{max} and P_{max} are too large than the limits of standards, so it is a risky area. SAR value for average brain and average muscle are too large than limits of all standards, so it is a risky area. SAR value for average skull is within the limits.

c. In Z – direction

It is obviously that the value of E_{max} within the standards limits, while H_{max} and P_{max} values are too large comparing with the standards limits.SAR values for average brain and average skull are within the limits, while SAR value for average muscle comparing with standards is very greater than the limits of these standards, so it is a risky area, since the rooftop area is risky, it is needed to control the exposure and protect the workers. The exposure is controlled by two types : engineering controls which include shielding and using interlocks as applicable; filtering, and waveguides below cutoff. RF protective clothing may be used in antenna zone, administrative controls which include RF safety training, increasing distance, controlling exposure time, restricting access, and using warning signs.

Table 3 Near field region (E_{max}, H_{max}, P_{max}/ standards comparison chart)

Near field Chart

	Electric Field Strength	Magnetic Field Strength	Power Density
■ Column1		0	0
■ ICNIRP E max limit	1.785	0	0
■ IEEE / FCC Emax limits	1.788	0	0
■ Emax-Xdir.	-0.272296116	0	0
■ Emax-Ydir.	2.117602692	0	0
■ Emax-Zdir.	1.750122527	0	0
■ Column2			
■ ICNIRP H max limit2		-0.8	
■ IEEE / FCC Hmax limits2		-0.78	
■ Hmax-Xdir.2		-0.637894681	
■ Hmax-Ydir.		-0.546375926	
■ Hmax-Zdir.2		-0.561299467	
■ Column3			
■ ICNIRP,IEEE,FCC PD Limits			1
■ Egyptian Protocol			0.60206
■ Pmax,Xdir.			1.35545152
■ Pmax,Ydir.2			1.212187604
■ Pmax,Zdir.2			1.225050696

As shown in the chart above, values ofE_{max} in Y- direction exceeds the limits, H_{max} in X, Y and Z directions exceed the limits also, while the P_{max} in all directions within the Egyptian limits but the other limits ICNIRP, IEEE, FCC exceeded. The rooftop is a risky area because the safety limits are exceeded, so, the access in this area is restricted and the individuals authorized to enter this area who are aware of the potential for exposure as a concomitant of employment and perform various maintenance works , they must follow the instructions in safety programs and using the personal protection equipments .

Table 4 Near field region (SAR calculation comparison chart)

Rooftop Near field SAR Comparison Chart

	ICNIRP, IEEE Limits for 10 gm =2W/kg	FCC Limit for 1 gm= 1.6 W/kg	Tissues- X direction	Tissues-Y direction	Tissues-Z direction
■ ICNIRP, IEEE Limits	0.30103		0	0	
■ FCC Limit	0	0.20412	0	0	
■ Brain-X	0	0	-3.895069261	0	
■ Skull-X			-4.723768042		
■ Muscle-Z			-3.692503962		
■ Column1					
■ Brain-Y				0.885852916	
■ Skull-Y				0.056027758	
■ Muscle-Y				1.086925469	
■ Column2					
■ Brain-Z					0.149773178
■ Skull-Z					-1.679023323
■ Muscle-Z2					0.396007448
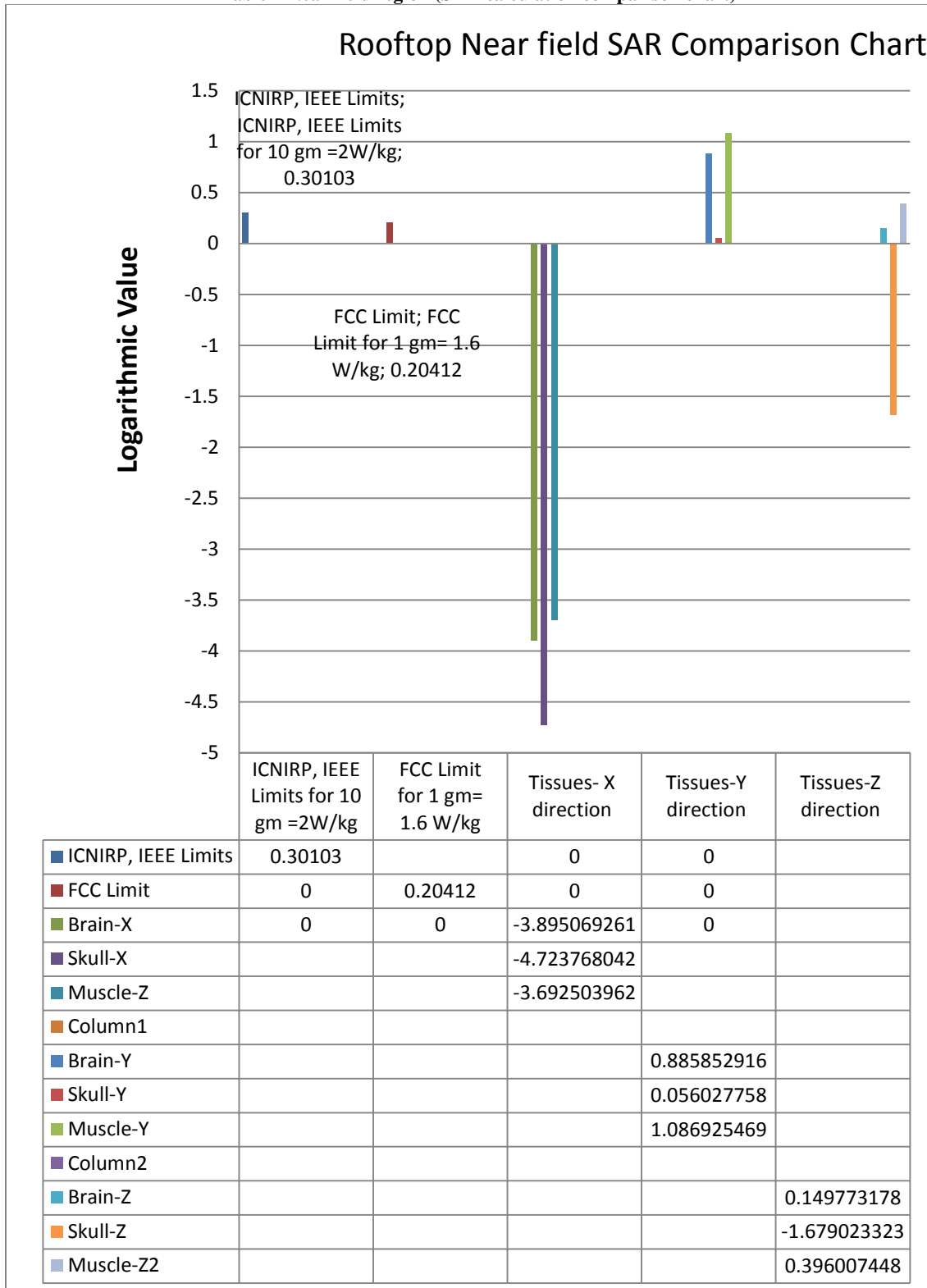
As shown in the chart above, values of brain and muscle in Y direction and muscle in Z-direction exceed the limits, on the other hand the values in all directions within the limits or less greater than the limits.

Example 2, Safe area

Indoor Measurement, SAR calculations and Comparisons tables for the Tower CAB are tabulated as following:

5- Table 5, the Tower CAB Measurements.

6- Table 6, the Tower CAB SAR calculations.

7- Table 7, the Tower CAB E_{max} , H_{max} , P_{max} / Standards Comparison Chart

8- Table 8, the Tower CAB SAR calculation comparison chart.

Table 5 Tower CAB measurements

	EMR Parameters			Standards and Regulations			
				ICNIRP	IEEE (W/m^2)	FCC	Egypt code
	E_{max}	E_{ave}	$E_{max\,ave}$	(E) (V/m)			
EMR Measurements In X – Direction	561.9 mV/m	10 mV/m	187.3 mV/m	61	61.4	61.4	---
	Percentage Value of $E_{max} \Rightarrow$			0.92 %	0.915 %	0.915 %	---
	H_{max}	H_{ave}	$H_{max\,ave}$	(H) (A/m)			
	1.9mA/m	15.3 $\mu A/m$	757.5 $\mu A/m$	0.16	0.163	0.163	---
	Percentage Value of $H_{max} \Rightarrow$			0.0031 %	0.003 %	0.003 %	---
	P_{max}	P_{ave}	$P_{max\,ave}$	power density (S) (W/m^2)			
	793 $\mu W/m^2$	0.1 $\mu W/m^2$	132.3 $\mu W/m^2$	10	10	10	4
	Percentage Value of $P_{max} \Rightarrow$			0.00793 %	0.00793 %	0.00793 %	0.019825 %
	E_{max}	E_{ave}	$E_{max\,ave}$	(E) (V/m)			
	401.5 mV/m	5.8 mV/m	6.7 mV/m	61	61.4	61.4	---
	Percentage Value of $E_{max} \Rightarrow$			0.6581 %	0.6539 %	0.6539 %	---
EMR Measurements In Y – Direction	H_{max}	H_{ave}	$H_{max\,ave}$	(H) (A/m)			
	1.249mA/m	17.7 $\mu A/m$	26.5$\mu A/m$	0.16	0.163	0.163	---
	Percentage Value of $H_{max} \Rightarrow$			0.780 %	0.766 %	0.766 %	---
	P_{max}	P_{ave}	$P_{max\,ave}$	power density (S) (W/m^2)			
	576.5 $\mu W/m^2$	0.1 $\mu W/m^2$	0.9 $\mu W/m^2$	10	10	10	4
	Percentage Value of $P_{max} \Rightarrow$			0.00567 %	0.00567 %	0.00567 %	0.01418%

Table 6 Tower CAB (SAR calculation and comparison)

tissue dielectrics		measured E_{max}	SAR calculated value W/Kg	SAR Limits of INCIRP, IEEE=2 W/Kg & FCC=1.6 W/Kg	
				(pct) of SAR calculated	
conductivity σ	density ρ			2.0 W/kg averaged over 10g of tissue	1.6 W/kg averaged over 1g of tissue
Tower CAB SAR Calculations In X – Direction					
Brain			0.0001409	0.007044 %	0.0088 %
0.459574	1030				
Skull		561.9 mV/m	20 $\mu W/kg$	0.001045 %	0.00125%
0.122461	1850				
Muscle			0.0002244	0.01122 %	0.014025%
0.739187	1040				
Tower CAB SAR Calculations In Y – Direction					
Brain			71.93 $\mu W/kg$	0.003596 %	0.0045 %
0.459574	1030				
Skull		401.5 mV/m	10.67 $\mu W/kg$	0.0005335 %	0.00067 %
0.122461	1850				
Muscle			0.0001145	0.005725 %	0.00716 %
0.739187	1040				

According to tables 5 and 6 of the Tower CAB measurements and SAR calculations as following:
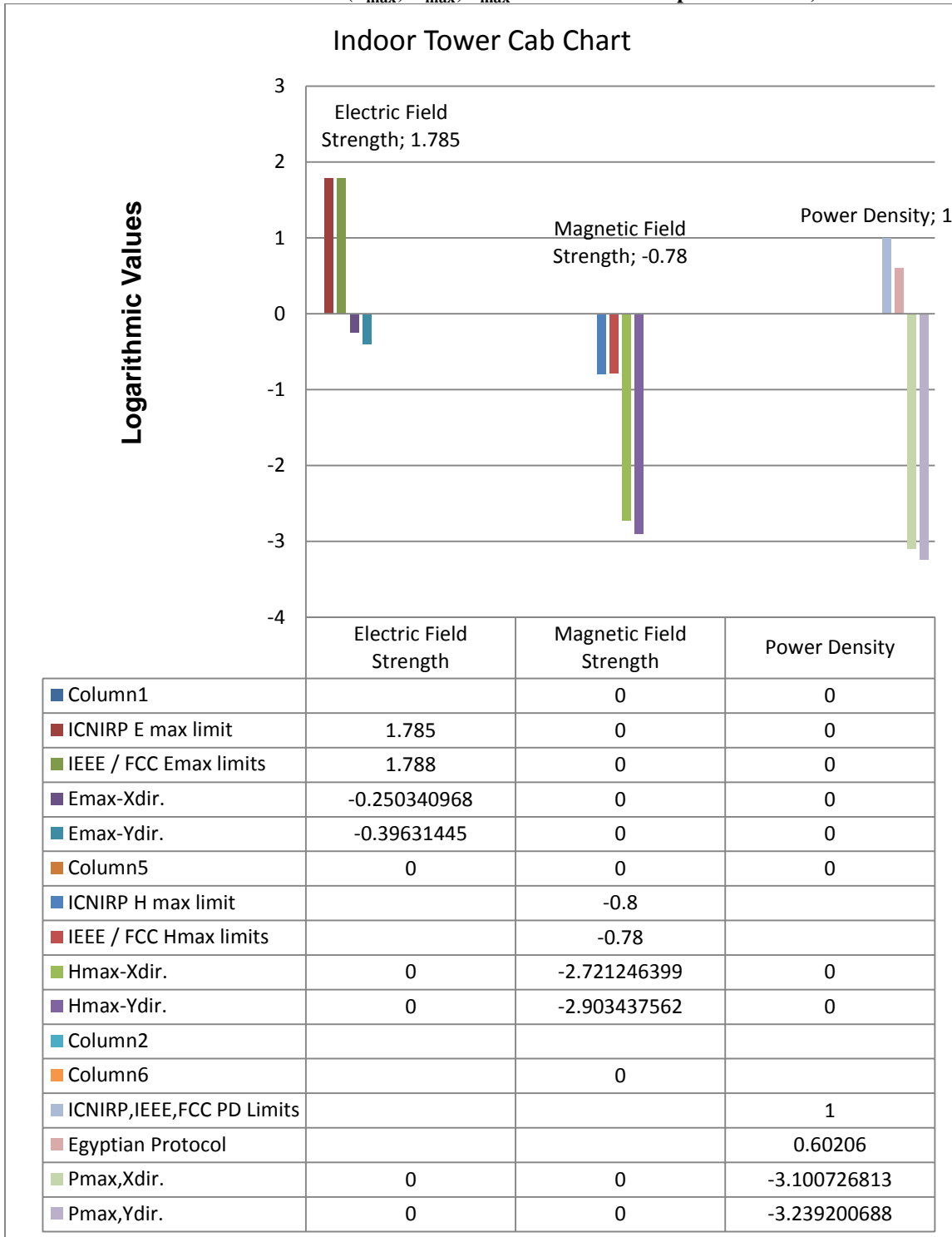
a. In X – direction

It is obviously that the values of E_{max}, H_{max} and P_{max} are too small in comparing with standards limits, so it is a safe area. It is obviously that the SAR values are too small in comparing with standards limits, so it is a safe area.
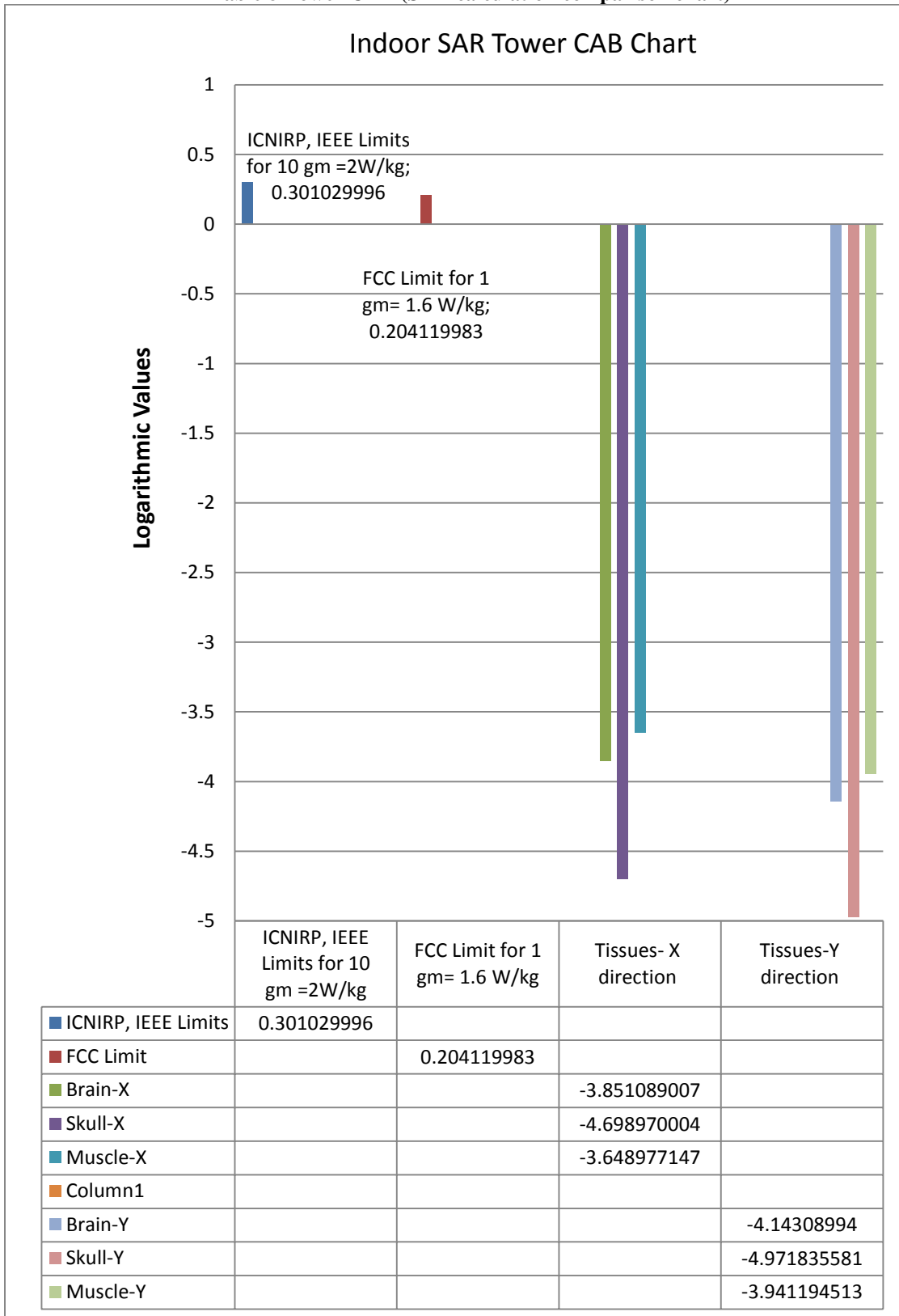
b. In Y – direction

The values of E_{max} , H_{max} , P_{max} are too small comparing with the limits of standards, so it is a safe area. It is obviously that all SAR values are too small comparing with the limits of all standards, so it is a safe area.

Table 7 Tower CAB (E$_{max}$, H$_{max}$, P$_{max}$ / Standards Comparison Chart)

Indoor Tower Cab Chart

Electric Field Strength; 1.785

Power Density; 1

Magnetic Field Strength; -0.78

Y-axis: **Logarithmic Values** (scale from -4 to 3)

	Electric Field Strength	Magnetic Field Strength	Power Density
Column1		0	0
ICNIRP E max limit	1.785	0	0
IEEE / FCC Emax limits	1.788	0	0
Emax-Xdir.	-0.250340968	0	0
Emax-Ydir.	-0.39631445	0	0
Column5	0	0	0
ICNIRP H max limit		-0.8	
IEEE / FCC Hmax limits		-0.78	
Hmax-Xdir.	0	-2.721246399	0
Hmax-Ydir.	0	-2.903437562	0
Column2			
Column6		0	
ICNIRP,IEEE,FCC PD Limits			1
Egyptian Protocol			0.60206
Pmax,Xdir.	0	0	-3.100726813
Pmax,Ydir.	0	0	-3.239200688

As shown in the chart above the values are less than the limits

Table 8 Tower CAB (SAR calculation comparison chart)

Indoor SAR Tower CAB Chart

	ICNIRP, IEEE Limits for 10 gm =2W/kg	FCC Limit for 1 gm= 1.6 W/kg	Tissues- X direction	Tissues-Y direction
▉ ICNIRP, IEEE Limits	0.301029996			
▉ FCC Limit		0.204119983		
▉ Brain-X			-3.851089007	
▉ Skull-X			-4.698970004	
▉ Muscle-X			-3.648977147	
▉ Column1				
▉ Brain-Y				-4.14308994
▉ Skull-Y				-4.971835581
▉ Muscle-Y				-3.941194513

As shown in the chart above the values are less great than the limits

C - QUESTIONNAIRE

In response to staff concerning, questionnaire survey was performed and based on form as following:

1- Dividing the staff of 60 persons in five specialized working groups WGs depending on the work nature as following

WG1: Air Traffic Controllers, WG2: Communication engineers, WG3: Maintenance engineers,

WG4: Air Operations Officers, WG5: Administrative Employees.

2- Asking all the staff of 60 persons four questions as following

Q1: Are you concerning from EMR in your workplace?

Q2: What are the symptoms you feel when you are in a tower?

Q3: Do you have awareness about International standards and guidelines controlling the EMR?

Q4: Do you have awareness about Egyptian protocol?

Note : the kinds of effects are thermal effects and nonthermal effects

Tables 9, 10 demonstrate the questionnaire and the comparisons.

Table 9 Questionnaire results

	Total Staff		Q1	Q2	Q3	Q4
Staff	60		---	---	---	---
WG1	12	20 %	12=100% of WG1	12=100% of WG1	6=50 % of WG1	0
WG2	10	16.667 %	10=100% of WG2	10=100% of WG2	8=80 % of WG2	2=20 % of WG2
WG3	12	20 %	12=100% of WG3	12=100% of WG3	0	0
WG4	12	20 %	12=100% of WG4	12=100% of WG4	0	0
WG5	14	23.333 %	6=42.86%ofWG5	3=21.43% of WG5	0	0
(pct) ratio		100 %	86.67%	81.67%	23.33%	3.33%

The results show that 86.666 % of staff are concerned of EMR in the tower, 81.666% of staff are thought that the EMR has adverse health effect, 23.333% of staff has awareness of Int. standards and 3.333% of staff has awareness of Egyptian protocol.

The study recommends modifying and upgrading Egyptian protocols and raising staff awareness about Int. standards and Egyptian protocols, also making a shielding mesh in the CAB roof, providing the communication engineers and workers with personal protection equipments (PPE) protecting them from the harm of EMR.

CONCLUSIONS

This research is the first of its kind to be carried out in one of the air traffic control towers, where practical measurements of the levels of electromagnetic radiation emitted from radio transmission sources were carried out inside and outside the tower. As a result, dangerous and safe places were located.

Therefore, procedures for the safety and protection of workers and to provide a safe workplace safe from the electromagnetic radiation (EMR) risks will be applied .

This study concluded that most of the areas inside the ATCT meet the safe standards

except the top roof area where, antenna exist.

The main effect of exposure to RF/MW fields is heating of body tissues as energy from the fields is absorbed by the body, prolonged exposure leads to heat stroke and damage organs, specific thermal effects as ocular effects and auditory effects, nonthermal effects as nervousness, irritability, headache, depression, sleeplessness, altered cell membrane permeability, behavioral effects, and others.

A questionnaire showed that most of the staff are concerned of EMR in the tower and thought that the EMR has adverse health effect.

This study recommends that the employer (NANSC) must have policy and program for EMR safety, there is no policy or program yet, establish a medical screening program for early detection of EMR health effects on workers. modifying and upgrading Egyptian protocols and raising staff awareness about International standards and Egyptian protocols. It recommends, also, making a shielding mesh in the CAB roof and providing the communication engineers and workers with personal protection equipment (PPE) to protect them from the EMR and provides the tower facility with EMR first aid.

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تخفيف المخاطر المصاحبة لإنبعاثات الإشعاع الكهرومغناطيسى على العاملتن فى برج المراقبة الجوية بمطار سوهاج الدولي

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الملخص العربي :

من اهم وظائف برج المراقبة الجوية فى المطارات مراقبة الحركة الجوية وتنظيمها ومنع حوادث التصادم بين الطائرات وبعضها البعض على أرض المهبط وبينها وبين المركبات كذلك وايضا بين الطائرات فى المجال الجوى.

جميع تلك الخدمات يتم تقديمها بواسطة ضباط المراقبة الجوية للطائرات من خلال أنظمة الإتصالات ببرج المراقبة الجوية والمساعدات الملاحية.

هوائى الإرسال الخاص بنظام الاتصالات والموجود أعلى مقصورة البرج يبث الموجات الكهرومغناطيسية فى جميع الإتجاهات وتلك الموجات لها تأثيرات صحية سلبية على العاملين ببرج المراقبة الجوية ويتعامل هذا البحث مع تأثيرات الإشعاع الكهرومغناطيسى على العاملين فى برج المراقبة الجوية بمطار سوهاج الدولى بإستخدام برنامج على الحاسب الآلى CST studio٢٠١٤ لإنجاز عملية المحاكاة للهوائيات عند الترددات المخصصة لمطار سوهاج الدولى وقياس المجالين الكهربى والمغناطيسى وكثافة القدرة بأماكن متنوعة بموقع البحث داخل وخارج البرج ومقارنة تلك النتائج مع المعايير العالمية والمحلية بعمل جداول و رسوم بيانية بإستخدام برنامج Microsoft Excell ٢٠٠٧ كذلك تم إجراء القياسات العملية داخل البرج وأعلى سطحه والمنطقة حوله بإستخدام جهاز قياس meter RF EMF strength من نوع EXTECH طراز ٤٨٠٨٣٦ وتم عمل نموذج استبيان للعاملين بالبرج.

الهدف الرئيسى لهذا البحث هو تخفيف تعرض العاملين للمخاطر من الإشعاع الكهرومغناطيسى وحمايتهم من تأثيراته السلبية عليهم. وخلصت هذه الدراسة إلى أن معظم الأماكن داخل مبنى برج المراقبة الجوية تتفق مع معايير السلامة ما عدا منطقة أعلى مقصورة البرج حيث يوجد هوائى الإرسال وأظهر الإستبيان أن طاقم العاملين بالبرج قلق بسبب الإشعاع الكهرومغناطيسى بالبرج ويعتقدون انه يسبب تأثيرات صحية سلبية عليهم وأنه حلا لمشكلة تأثير الإشعاع الكهرومغناطيسى على العاملين بالبرج نرى أنه يجب عمل برنامج للسلامة والحماية من مخاطر التأثيرات المصاحبة للإشعاع الكهرومغناطيسى ويقوم على تنفيذ هذا البرنامج وتطبيقه شخص مؤهل ومتخصص فى هذا المجال وتشتمل طريقة الحماية والتخفيف من مخاطر الإشعاع الكهرومغناطيسى على عدة عناصر من أجل التحكم فى تلك المخاطر وهى التحكم الهندسى الذى يشمل على تعديلات فى المبنى والأجهزة مصدر الإشعاع الكهرومغناطيسى و التحكم الإدارى الذى يشمل على تغييرات فى طرق آداء العمل وسياسات العمل واستخدام وسائل التوعية كالعلامات الإرشادية والتحذيرية والتدريب على البرنامج واستخدام أدوات الحماية الشخصية للإشعاع الكهرومغناطيسى على العاملين وكذلك يلزم عمل برنامج للفحص الطبى الدورى للعاملين للكشف المبكر عن التأثيرات الصحية للإشعاع الكهرومغناطيسى عليهم.