CHAPTER ONE

Introduction

There has been a dramatic increase in the use of mobile phone technology in the last decades. With wide spread benefits in many Professional and private activities. In the parallel with this, the concern regarding the possibility of adverse health effects due to absorption of electromagnetic field by human also increase [1, 2]. For several years, many research groups in deferent countries have been developing research projects on these subjects in the area of medicine biophysics, engineering, etc. also, the world health organization (WHO) has coordinated efforts including many countries to access the exiting scientific evidence of harmful health effects of non-ionizing radiation (NIR) emitted from different communication equipment, such as the base station.

Previous studies show no evidence of impacts of base stations to human health. New studies suggest emitted from base station might double the risk on human health. [3, 4, 5]. The main focus of this work is on the electromagnetic radiation emitted from telecommunication towers and its impact on human health.

(1. 1) Research problem:

Increasing of communication through mobile phone has compulsorily let the telecommunication companies built new networks and expanding it all over the country.

At the same time have many question arises about the health damage caused by electromagnetic radiation to this towers. [6, 7, 8] There are also a large number of citizens have significant questions on this subject and therefore there is an urgent need to provide adequate information on this topic by showing the impact of mobile networks and the rate of influence on electromagnetic radiation causes by these towers.

(1. 2) Literature review:

The increase in demand for cellular phones results in massive deployment of cellular towers that radiate signals travelling hundreds of meters to establish contact with individual cell phones. This deployment can be noticed in close proximity to even where people live. The radiation from these towers may be associated with health problems to humans.

Many attempts were made to study the biological hazards of mobile towers [6, 7]. In a study done by Chand ran et al., (2012) on the impact of radiation on human health showed that people living within 50m from the radiation source were likely to be affected by diabetes, heart diseases and hearing problems; and that those who live 100m away were likely to suffer respiratory problems, skin diseases, hair loss and anemia [8].

Lai et al., (2010) reveals results which show an increased symptoms and complaints from persons living closer to a RF transmission tower. At less than 10m, symptoms include; nausea, loss of appetite, visual disruptions,

And difficulty in moving. Significant differences are reported to occur within 100m for irritability, depressive tendencies, concentration difficultiesmemory loss, dizziness, and lower libido. Between 100 and 200m, symptoms included headaches, sleep disruption, feelings of discomfort, and skin problems. Beyond 200m, fatigue is significantly reported more often. Women are significantly reported to reveal symptoms more often thanmen, except for libido loss. There was no increase in premature menopause in women in relation to distance from towers [9]. Magras and Xenos (1997) reported that mice exposed to low-intensity RFR became less reproductive. Further, after five generations of exposure the mice were not able to produce offspring which shows that the effects of RFR can pass from one generation to another [10].

Persson et al. (1997) reported an increase in permeability of the blood-brain barrier in mice when the energy deposited in the body exceeded 1.5J/kg, a measurement of the total amount of energy deposited. This suggests that a short-term, high intensity exposure can produce the same effect as a long-term, low-intensity exposure, and is another indication that RFR effects can accumulate over time [11].

Other biological effects have also been reported after long termExposure to RF radiations. Effects are observed by Baranski (1972) and Takashima et al. (1979) after prolonged, repeated exposure but not after short-term exposure to RF radiations.Dumansky and Shandala (1974) and Lai et al.(1989) observed different effects after different exposure durations. Thus, the effects of long term exposure can be quite different from those of short term exposure to RF radiations [12, 13].

Radiations from wireless cellular towers are associated with greater increase in brain tumor due to the damage in the blood brain barrier and the cells in the brain which are concerned with learning, memory and movement [14]. A study by Carl Blackman shows that weakelectromagnetic radiations release calcium ions from cell membranes which leaks into the cytosol and acts as a metabolic stimulant, andaccelerates growth and healing, but it also promotes the growth of tumors. Despite the successes of most of the researches in relating towers radiation levels to the permissible doses, but they does not study the spatial dependence of the tower doses extensively [15].

(1. 3) Hypotheses:

1. Increasing in horizontal distance is associated with decrease in the level of radiation.
2. Increasing in the height of the tower is associated with increase in the level of radiation.
3. Electromagnetic radiation emitted by telecommunication towers may be effect human health.
4. The Sudanese telecommunication companies work within international permissible dose.

(1. 4) Area of study:

This study takes place in three Sudanese states:

1. Khartoum state.
2. River Nile state.
3. Red sea state.

(1. 5) Methodology:

In this study one followed the experimental method to determine the rate of radiation emitted by telecommunication towers.

Random samples will be taken for (360) towers for the three companies

(ZAIN, SUDANI, MTN) in Sudan, at three states (Khartoum, River Nile and Red sea).

All these samples will be subjected to the radioactive power examination using international standard radiometers as well as the well-established NARDA measurements and technology.

(1. 6) Objectives:

1. To Assess the Impact of this radiation on human health.
2. To compare between the radiation emitted by towers and international permissible dose.
3. To provide the recommendations of this study for state officials in health and communications sector to reduce (if any) the effects of this radiation on human health.
4. To introduce this study for the first time in the health and communications field

(1. 7) Arrangement of the study:

This work is organized as follows:

Chapter (1) presents the basics of the study, Chapter (2) contains the theoretical background, Chapter (3) reviews some of the literatures that are related to this study, Chapter (4) covers our approach where we discuss the methods used to conduct this study; Chapter (5) shows the results and concludes our work, following with recommendations and having direction for further works.

CHAPTER TOW

Theoretical background

(2. 1) Introduction:

The development of any country depends on extent of infrastructure development especially in the telecommunication sector. To accomplish the networks for Telecommunication for accommodating multiple uses of Mobile phone applications and broadcasting services requires massive deployment of transmission towers to support capacity and coverage requirements. The installation of transmission towers raises the public concern on the health effects from the exposure of radio frequency (RF) radiations. Prior to installation of any RF transmission towers, the Standard and the guidelines provided by International Commission on Non-Ionizing Radiation Protection (ICNIRP) require being adhered. However, in some developing countries like Sudan, despite of the adherence to the Standards and guidelines, different RF transmission towers for different services are installed in single sites thus creating difficulties in enforcing compliance to standards and guidelines when towers of different services are co-located around residential areas. The proliferation of installation of RF transmission towers also increases the level of electromagnetic radiation. Electromagnetic radiations are divided in two categories. Which are ionizing and non-ionizing. This work deals with non-ionizing radiations (NIR) which encompass the long wavelength, and the low photon energy, except for the narrow visible region, the NIR is not perceived by any of the human senses unless its intensity is so great to be felt as heat.

The ability of NIR to penetrate the human body depends on the distance from the source, time taken to stay in the direction of the source as well as shielding mechanism. Based on the standards and guidelines from the International Committee of Non-Ionizing Radiation Protection and Word Health Organization the public exposure limits from cellular towers are provided. As far as these exposure limits are concerned, the side effects can be discussed by considering the time that the object is exposed to radiation and its distance from the source.

(2. 2) Electromagnetic radiation:

electromagnetic radiation Is a form of energy emitted and absorbed by charged particles, which exhibits wave-like behavior as it travels through space, EMR has both electric and magnetic field components, which stand in a fixed ratio of intensity to each other, and which oscillate in phase perpendicular to each other and perpendicular to the direction of energy and wave propagation. In a vacuum, electromagnetic radiation propagates at a characteristic speed, the speed of light. Electromagnetic radiation is a particular form of the more general electromagnetic field, which is produced by moving charges. Electromagnetic radiation is associated with EM fields that are far enough away from the moving charges that produced them, that absorption of the EM radiation no longer affects the behavior of these moving charges. These two types or behaviors of EM field a reSometimes referred to as the near and far field. In this language, EMR is merely another name for the far-field. Charges and currents directly produce the near-field. However, charges and currents produce EMR only indirectly—rather, in EMR, both the magnetic and electric fields are produced by changes in the other type of field, not directly by charges and currents. This close relationship causes the electric and magnetic fields in EMR to stand in a fixed ratio of strengths to each other, and to be found in phase, with maxima and nodes in each found at the same places in space. EMR carries energy—sometimes called radiant energy—through space continuously away from the source (this is not true of the near-field part of the EM field). EMR also carries both momentum and angular momentum. These properties may all be imparted to matter with which it interacts. EMR is produced from other types of energy when created, and it is converted to other types of energy when it is destroyed. The photon is the quantum of the electromagnetic interaction, and is the basic "unit" or constituent of all forms of EMR. The quantum nature of light becomes more apparent at high frequencies (or high photon energy). Such photons behave more like particles than lower-frequency photons do. In classical physics, EMR is considered to be produced when charged particles are accelerated by forces acting on them. Electrons are responsible for emission of most EMR because they have low mass, and therefore are easily accelerated by a variety of mechanisms. Rapidly moving electrons are most sharply accelerated when they encounter a region of force, so theyare responsible for producing much of the highest frequency electromagnetic radiation observed in nature. Quantum processes can also produce EMR, such as when atomic nuclei undergo gamma decay, and processes such as neutral peon decay.

(2. 3) Properties of EM radiation:

1. Electromagnetic waves can be imagined as a self-propagating transverse oscillating wave of electric and magnetic fields. The 3D diagram shows a plane linearly polarized wave propagating from left to right. This 3D diagram shows a plane linearly polarized wave

propagating from left to right, the electric and magnetic fields in such a wave are in-phase with each other, reaching minima and maxima together

2. The physics of electromagnetic radiation is electrodynamics.Electromagnetism is the physical phenomenon associated with the theory of electrodynamics. Electric and magnetic fields obey the properties of superposition. Thus, a field due to any particular particle or time-varying electric or magnetic field contributes to the fields present in the same space due to other causes. Further, as they are vectorfields, all magnetic and electric field vectors add together according to vector addition. For example, in optics two or more coherent light waves may interact and by constructive or destructive interference yield a resultant irradiance deviating from the sum of the Component irradiances of the individual light waves.
3. In refraction, a wave crossing from one medium to another of different density alters its speed and direction upon entering the new medium. The ratio of the refractive indices of the media determines the degree of refraction, and is summarized by Snell's law**.** Light of composite wavelengths (natural sunlight) disperses into a visible spectrum passing through a prism, because of the wavelength dependent refractive index of the prism material (dispersion); that is, each component wave within the composite light is bent a different amount.
4. Electromagnetic radiation exhibits both wave properties andparticle properties atthe same time (see wave-particle duality). Both wave and particle characteristics have beenconfirmed in a large number of experiments. Wave characteristics are more apparent when EM radiation is measured over relatively large timescales and over large distances

while particle characteristics are more evident when measuring small timescales and distances. For example, when electromagnetic radiation is absorbed by matter, particle-like properties will be more obvious when the average number of photons in the cube of the relevant wavelength is much smaller than 1. It is not too difficult to experimentally observe non-uniform deposition of energy when light is absorbed; however this alone is not evidence of "particulate" behavior of light rather, it reflects the quantum nature of matter. Demonstrating that the light itself isquantized, not merely its interaction with matter is a more subtle problem.

(2. 4) Electromagnetic radiation spectrum:

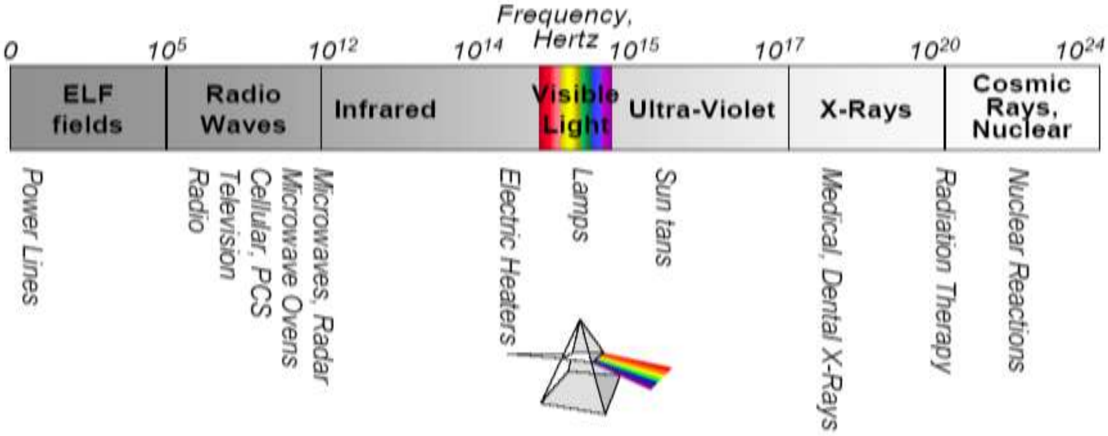


Figure (2. 4. 1): Shows the electromagnetic radiation spectrum

EMR is classified according to the frequency of its wave. The electromagnetic spectrum in order of increasing frequency and decreasing wave length consists of radio waves, microwaves, and infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays. The eyes of various organisms sense a small and somewhat variable but relatively small range of frequencies of EMR called the visible spectrum or Light. The effects of EMR upon biological systems (and also too many other chemical systems, under standard conditions) depends both upon the radiation's power and frequency. For lower frequencies of EMR up to those of visible light (i.e., radio, microwave, infrared), the damage done to cells and also too many ordinary materials under such conditions is determined mainly by heating effects, and thus by the radiation power. By contrast, for higher frequency radiations at ultraviolet frequenciesand above (i.e., X-rays and gamma rays) the damage to chemicalmaterials and living cells by EMR is far larger than that done by simple heating, due to the ability of single photons in such high frequency EMR to damage individual molecules.

(2. 5) Maxwell’s equations:

Maxwell’s equations relate electric field and magnetic field behavior. An electric field of intensity E and flux density D is related to the magnetic field of intensity H, and flux density B, through the relations:

$$\nabla . D = \rho \qquad (2-5-1)$$

$$\nabla . B = 0 \qquad (2-5-2)$$

$$\nabla \times E = \frac{\partial B}{\partial t} \qquad (2-5-3)$$

$$\nabla \times H = J + \frac{\partial D}{\partial t} \qquad (2-5-4)$$

Where (ρ) is the charge density and (J) is the electric current density.

The relation between flux density and field intensity, are related via the electric permittivity (E) and magnetic permeability (μ) According to the relations:

$$D = \varepsilon E \qquad (2 - 5 - 5)$$

$$B = \mu H \qquad (2 - 5 - 6)$$

The conductivity σ relates the current density J and electric intensity E according to the relation

$$J = \sigma E \qquad (2 - 5 - 7)$$

The continuity equation is given by:

$$\nabla . J + \frac{\partial p}{\partial t} = 0 \qquad (2 - 5 - 8)$$

Taking the curl of both sides of equations (2 – 5 – 3) with the aid of (2 – 5 – 4) and (2 – 5 – 7)

$$\nabla \times \nabla \times E = -\mu \frac{\partial \nabla \times H}{\partial t} = -\mu \frac{\sigma \partial E}{\partial t} \mu \frac{\varepsilon \partial^2 E}{\partial t2} = -\mu\sigma \frac{\partial E}{\partial t} - \mu\varepsilon \frac{\partial^2 E}{\partial t2}$$

(2 – 5 – 9)

But since $\nabla \times \nabla \times \mathrm{E} = \nabla(\nabla . \mathrm{E}) - \nabla^2 \mathrm{E}$ (2 – 5 - 10)

From (2 – 5 – 1) in no charged media

$$\varepsilon \nabla . E = 0$$

Thus: $\nabla . E = 0$ (2 – 5 – 11)

Sub (2 – 5 – 1) in (2 – 5 – 10) and (2 – 5 – 9) yields

$$-\nabla^2 E = \mu \sigma \partial E \backslash \partial t + \mu \varepsilon \partial^2 E \backslash \partial t^2$$

$$-\nabla^2 E + \mu\, \sigma\, \partial E\backslash \partial t \ + \mu\, \varepsilon \partial^2\, E\backslash\, \partial t^2 = 0 \qquad (2-5-12)$$

This is a usual electric Maxwell's equation in non charged media.

(2. 6) Propagation of electromagnetic waves in free space:

The wave equation for electric field intensity is given by:

$$E = E_0 e^{-\gamma z} e^{jwt} \qquad (2-6-1)$$

Substituting Equation $j = \sqrt{-1}$ in (2 – 6 - 1) gives:

$$\frac{\partial E}{\partial t} = jwE\, \frac{\partial^2 E}{\partial t2} \nabla^2 E = \frac{\partial^2 E}{\partial z2} = \gamma^2 . E \qquad (2-6-2)$$

Inserting equation (2- 6 - 1) in equation (2 – 6 – 2) gives:

$$(-\gamma^2 + jw\, \mu\, \sigma - \mu\, \varepsilon\, w^2)\, E = 0 \qquad (2-6-3)$$

One of the possible solutions $\gamma^2 = j\, w\, \mu\, \sigma - w^2\, \mu\, \varepsilon$

$$\gamma = \sqrt{j\, w\mu\sigma - w^2\mu\varepsilon} \qquad (2-6-4)$$

In free space $\sigma = 0$ (2 – 6 – 5)

Thus:

$$\sqrt{-1}\, w\sqrt{\mu\varepsilon} = j\, w\sqrt{\mu\varepsilon} = j\, \frac{w}{v} = jk \qquad (2-6-6)$$

Thus the form of E in free space can be given according to equation

(2 – 6 – 6) by

$$E = E_0 e^{j\,(wt - kx)} \qquad (2-6-7)$$

This represents a travelling electric wave vector in free space.

(2. 7) Radiation power and Intensity:

The radiation density can be obtained from the energy and work done (W) by electric charge of density p In a field of potential (V) where

$$W = \frac{1}{2} \int p \text{ v } d\tau \qquad (2-7-1)$$

But $$p = - \epsilon_0 \nabla^2 \text{ v} \qquad (2-7-2)$$

Thus inserting (2 – 4 – 2) in (2 – 4 – 1) yields

$$W = - \frac{\epsilon_0}{2} (\int (V \nabla V) ds - \int (\nabla V)^2 d\tau) \qquad (2-7-3)$$

But

$$E = -\nabla \text{v} \int_s V \nabla \text{v} ds = 0 \qquad (2-7-4)$$

Hence

$$W = \frac{\epsilon_0}{2} \int (E^2)\, d\tau \qquad (2-7-5)$$

Thus the energy density of electromagnetic field is given by

$$E_{de} = \frac{\epsilon_0}{2} E^2 \qquad (2-7-6)$$

Similarly the magnetic energy density equations

$$E_{dm} = \frac{\mu_0}{2} B^2 = E_{de} \qquad (2-7-7)$$

Thus the radiation intensity takes the form

$$I = (E_{de} + E_{dm}) C = \epsilon_0 E^2 C \qquad (2-7-8)$$

(2.8) Radiation from ahalf - wave antenna:

The wave have antenna illustrated in figure (1) is commonly used for radiating electromagnetic waves into space. When a current $I_0 \cos(\omega t)$

Is established at the center by means of a suitable electric circuit,

A standing wave is formed along conductor. The standing wave along antenna can be expressed in exponential form as follows

$$I = R_e \frac{I_0}{2}\ [\,exp(jwt - kz) + exp(jwt - kz)] \qquad (2 - 8 - 1)$$

In calculating the electric field intensity at any point away from antenna by the distance r (where r `` k). Then the electric field intensity dE from the element dz is given by the following equation:

$$E = 60\ \Theta\ \frac{(\,jwt)I_0 exp}{r}\ \text{x}\ \ \frac{\cos\left(\frac{\pi}{2}\cos\text{⍰}\right)}{\sin\text{⍰}}\ \text{⍰}_1 \qquad (2 – 8 – 2)$$

Similarly one can find magnetic field intensity as the following:

$$H = \frac{jI_0 exp(\,jwt)}{r}\text{x}\ \frac{\cos\left(\frac{\pi}{2}\cos\text{⍰}\right)}{\sin\text{⍰}}\ \psi_1 \qquad (2 – 8 – 3)$$

The average pointing vector S_{av}gives the average flux of radiated energy. By definition the pointing vector takes the following form:

$$S_{av} = \ \frac{1}{2} R_e(\text{E x H}\quad) \qquad (2 – 8 – 4)$$

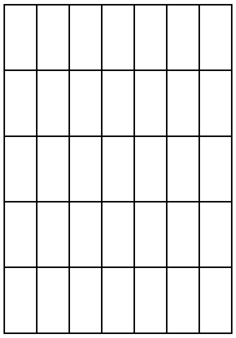


Fig (2. 8. 1): schematic representation of a half-wave Antenna

By substitutingequation (2) and (3) into equation (4)(8) S_{av} will be

$$S_{av} = 9.55\ \frac{\mathrm{I}^2{}_{rms}}{\mathrm{r}^2}\ \mathrm{x}\ \frac{\cos^2\left(\frac{\pi}{2}\cos\theta\right)}{\sin^2\theta}\,\mathrm{r}_1 watt/\mathrm{m}^2 \qquad (2-8-5)$$

The total radiated power Pt can be obtained by integrating of (5) to gets

$$P_t = 73.10\,\mathrm{I}^2{}_{rms}\ watt \qquad (2-8-6)$$

Where I rms represent root mean square of current, substituting equation (6) into equation (5) one gets

$$P_D = \frac{0.13XP_t}{\mathrm{r}^2}\mathrm{x}\frac{\cos^2\left(\frac{\pi}{2}\cos\theta\right)}{\sin^2\theta}\,watt/\mathrm{m}^2 \qquad (2-8-7)$$

Where Pd represents power density at any point a way from antenna by the distance r.

(2. 9) Mast or tower:

The terms "mast" and "tower" are often used interchangeably. However,in structural engineering terms, a tower is a self-supporting or cantilevered structure, while a mast is held up by stays or guys. Broadcast engineers in the UK use the same terminology. In US broadcast engineering, a tower is an antenna structure attached to the ground; whereas a mast is a vertical antenna support mounted on some other structure (which itself may be a tower, a building, or a vehicle). Masts (to use the civil engineering terminology) tend to be cheaper to build but require an extended area surrounding them to accommodate the guy wires. Towers are more commonly used in cities where land is in short supply. There are a few borderline designs that are partly free-standing and partly guyed, called additionally guyed towers.

Mobile Tower is a triangular / cone shaped metal structure which ismorethan nine meter in height on which 3 or more antennas are fixed, the structural height may depend on whether it is fixed on land or on a building. Height of the Ground based towers varies from 30-200 metershowever most of the towers are of 40 meters and roof-top towers vary from 9-30 meters. Mobile Tower Antennas are the source of radiation in a mobile tower. However, a telecom infrastructure consists of electronic (active) and non-electronic infrastructure.Electronic infrastructure includes base tower station, microwave radio equipment, switches, antennas,

Transceivers for signal processing and transmission. Non-electronic infrastructure includes tower, shelter, air-conditioning equipment, diesel electric generator, battery, electrical supply, technical premises.

For a good quality wireless communication, Mobile Tower Base Stations (MTBS) are an inevitable part of the telecom infrastructure system.

(2. 10) Working of a mobile tower:

Mobile phone operators divide a region in large number of cells, and each cell is divided into number of sectors. The base stations are normally configured to transmit different signals into each of these sectors. In general, there may be three sectors with equal angular coverage of 120 degrees in the horizontal direction as this is aConvenient way to divide a hexagonal cell. If number of users is distributed unevenly in the surrounding area, then the sectors may be uneven. These base stations are normally connected to directional antennas that are mounted on the roofs of buildings or on free-standing masts. The antennas may have electrical or mechanical down-tilt, so that the signals are directed towards ground level. Mobile Tower Antennas are the source of radiation in a mobile tower.

(2. 11) Materials:

A large Steel lattice tower: The steel lattice is the most widespread form of construction. It provides great strength, low weight and wind resistance, and economy in the use of materials. Lattices of triangular cross-section are most common, and square lattices are also widely used. When built as a tower, the structure may be parallel-sided or taper over part or all of its height. When constructed of several sections which taper exponentially with height, in the manner of the Eiffel Tower, the tower is said to be an Eiffel zed one. The Crystal Palace tower in London is an example.

Tubular steel: Guyed masts are sometimes also constructed out of steel tubes.This construction type has the advantage that cables and other components can be protected from weather inside the tube and consequently the structure may look cleaner. These masts are mainly used for FM-/TV-Broadcasting, but sometimes also as mast radiator. The big mast of Mühlacker transmitting station is a good example of this. A disadvantage of this mast type is that it is much more affected by winds than masts with open bodies. Several tubular guyed masts have collapsed. In the UK, the Emley Moor and Waltham TV stations masts collapsed in the1960s. In Germany the Biel stein transmitter collapsed in 1985. Tubular masts were not built in all countries. In Germany, France, UK, Czech, Slovakia, Japan and the former Soviet Union, many tubular guyed masts were built, while there are nearly none in Poland or North America.

In several cities in Russia and Ukraine several tubular guyed masts withCrossbars running from the mast structure to the guys were built in the 1960s. All these masts, which are designed as 30107 KM, are exclusively used for FM and TV transmission and, except for the mast in Vinnitsa, are between 150 and 200 meters tall. The crossbars of these masts are

Equipped with a gangway that holds smaller antennas, though their main purpose is oscillation damping. TV Tower in Stuttgart (Germany): the first reinforced-concrete TV tower.

Reinforced concrete: Reinforced concrete towers are relatively expensive to build but provide a high degree of mechanical rigidity in strong winds. This can be important when antennas with narrow beam widths are used, such as those used for microwave point-to-point links, and when the structure is to

be occupied by people. In the 1950s, AT&T built numerous concrete towers, more resembling Silos than towers, for its first transcontinental microwave route. Many are still in use today. In Germany and the Netherlands most towers constructed for point-to-point microwave links are built of reinforced concrete, while in the UK most are lattice towers. Concrete towers can form prestigious landmarks, such as the CN Tower in Toronto. In addition to accommodating technical staff, these buildings may have public areas such as observation decks or restaurants. The Stuttgart TV tower was the first tower in the world to be built in reinforced concrete. It was designed in 1956 by the local civil engineer Fritz Leonhardt.

Wood: There are fewer wooden towers now than in the past. Many were built in the UK during World War II because of a shortage of steel. In Germany before World War II wooden towers were used at nearly all medium-wave transmission sites, but all of these towers have since been demolished, except for the Gliwice Radio Tower. Ferryside television relay station is an example of a TV relay transmitter using a wooden pole. Other types of antenna supports and structures:

Poles: Shorter masts may consist of a self-supporting or guyed wooden pole, similar to a telegraph pole. Sometimes self-supporting tubular galvanized steel poles are used: these may be termed monopoles.

Buildings: In some cases, it is possible to install transmitting antennas on the roofs of tall buildings. In North America, for instance, there are transmitting antennas on the Empire State Building, the Willis Tower, and formerly on the World Trade Center towers. When the buildings collapsed, several local TV and radio stations were knocked off the air until backup transmitters could be put into service.[2] Such facilities also exist in Europe, particularly For portable radio services and low-power FM radio stations. In London, the

BBC erected in 1936 a mast for broadcasting early television on one of the towers of a Victorian building, the Alexandra Palace. It is still in use.

Disguised cell-sites: Completed in December 2009 at Epiphany Lutheran Church in Lake Worth, Florida, this 100' tall cross conceals equipment for T-Mobile. Many people view bare cellphone towers as ugly and an intrusion into their neighborhoods. Even though people increasingly depend upon cellular communications, they are opposed to the bare towers spoiling otherwise scenic views. Many companies offer to 'hide' cellphone towers in, or as, trees, church towers, flag poles, water tanks and other features.[3] There are many providers that offer these services as part of the normal tower installation and maintenance service. These are generally called "stealth towers" or "stealth installations", or simply concealed cell sites. The level of detail and realism achieved by disguised cell phone towers is remarkably high; for example, such towers disguised as trees are nearly indistinguishable from the real thing, even for local wildlife (who additionally benefit from the artificial flora).[4] Such towers can be placed unobtrusively in national parks and other such protected places, such as towers disguised as cacti in Coronado National Forest.[5], Even when disguised, however, such towers can create controversy; a tower doubling as a flagpole attracted controversy in 2004 in relation to the U.S. Presidential campaign of that year, and highlighted the sentiment thatSuch disguises serve more to allow the installation of such towers in subterfuge away from public scrutiny rather than to serve towards the beautification of the landscape.[original research.Disguised cell sites sometimes can be

Introduced into environments that require a low-impact visual outcome, by being made to look like trees, chimneys or other common structures.

Mast radiator: A mast radiator is a radio tower or mast in which the whole structure works as an antenna. It is used frequently as a transmitting antenna for long or medium wave broadcasting. Structurally, the only difference is that a mast radiator may be supported on an insulator at its base. In the case of a tower, there will be one insulator supporting each leg.Telescopic, pump-up and tilt over towers.

Cell on wheels: A special form of the radio tower is the telescopic mast. These can beErected very quickly. Telescopic masts are used predominantly in setting up temporary radio links for reporting on major news events, and fortemporary communications in emergencies. They are also used in tactical military networks. They can save money by needing to withstand high winds only when raised, and as such are widely used in amateur radio.Telescopic masts consist of two or more concentric sections and come in two principal types: Pump-up masts are often used on vehicles, and are raised to their full height pneumatically or hydraulically. They are usually only strong enough to support fairly small antennas.Telescopic lattice masts are raised by means of a winch, which may be powered by hand Oran electric motor. These tend to cater for greater heights and loads than the pump-up type. When retracted, the whole assembly can sometimes be lowered to a horizontal position by means of a second tilt over winch. This enables antennas to be fitted and adjusted at ground level before winching the mast up.

Design features: Economic and aesthetic considerations communications tower, camouflaged as a slim tree The cost of a mast or tower is roughly proportional to the square of its height.[citation needed]. A guyed mast is cheaper to build than a self-supporting tower of equal height.A guyed mast needs additional land to accommodate the guys, and is thus best suited to rural locations where land is relatively cheap. An unguyed tower will fit into a much smaller plot. A steel lattice tower is cheaper to build than a concrete tower of equal height. Two small towers may be less intrusive, visually, than one big one, especially if they look identical.

Towers look less ugly if they and the antennas mounted on them appear symmetrical. Concrete towers can be built with aesthetic design - and they are, especially in Continental Europe. They are sometimes built in prominent places and include observation decks or restaurants.

Limiting tower height to below 200 feet and therefore not requiring aircraft illumination under U.S. Federal Communications Commission (FCC) rules. The limit is more commonly set to 190 or 180 feet to allow for masts extending above the tower.

(2. 12) Antenna properties and ratings:

An antenna gives the wireless system three fundamental properties - gain, direction, and polarization. Gainis a measure of increase in power.Directionis the shape of the transmission pattern. A good analogy for an antenna is the reflector in a flashlight. The reflector concentrates and intensifies the light beam in a particular direction similar to what aparabolic dish antenna would do to a RF source in a radio system. Antenna gain is measured in decibels, which is a ratio between two values. The gain of a specific antenna is compared to the gain of an isotropic antenna. An isotropic antenna is a theoretical antenna with auniform three-dimensional radiation pattern (similar to a light bulb with no reflector). dBi is used to compare the power level of a given antenna to the theoretical isotropic antenna. The U.S. FCC uses dBi in its calculations. An isotropic antenna is said to have a power rating of 0 dB, meaning that it has zero gain/loss when compared to itself.Unlike isotropic antennas, dipole antennas are real antennas. Dipole antennas have a different radiation pattern compared to isotropic antennas. The dipole radiation pattern is 360 degrees in the horizontal plane and 75 degrees in the vertical plane (assuming the dipole antenna is standing vertically) and resembles a donut in shape.

Because the beam is “slightly” concentrated, dipole antennas have a gain over isotropic antennas of 2.14 dB in the horizontal plane. Dipole antennas are said to have a gain of 2.14 dBi (in comparison to an isotropic antenna).

Some antennas are rated in comparison to dipole antennas. This is denoted by the suffix dBd. Hence, dipole antennas have a gain of 0 dBd (= 2.14 dBi).

Note that the majority of documentation refers to dipole antennas as having a gain of 2.2 dBi.

(2. 13) Types of antennas used for cellular networks:

The following typical types of antenna are commonly found at base station or antenna sites. In each case, a photo is given of the antenna(s).While the locations described refer to areas directly in line with the antenna, the exclusion zone / compliance boundary in other locations (e.g. above, below, behind) may, though Small (in the range of several centimeters), exist.

Omni-directional coverage: These antennas radiate RF energy equally in all directions in the horizontal plane. The antenna input power is typically 10 – 80 watts, and the compliance boundary for a worker typically extends 0.1 – 1.5 meters from the antenna. Sector coverage: These antennas restrict most of their radiated RF energy to a narrow angular sector in their forward direction (typically 60 to 120 degrees in the horizontal plane, typically 8 to 14 degrees in the vertical plane). The photograph shows2 sector antennas, one mounted above the (29) other. The antenna input power is typically 10 – 80 watts, and thecompliance boundary for a worker extends typically 0.2 – 3 meters from the front face of the antenna.

Antenna farms (or clusters): Antennas are often grouped together on masts. The combination illustrated here is that of an Omni-directional antenna mounted above a cluster of 3 sector antennas. In the case that multiple antennas are present on a site, whenever an additional antenna is installed, the compliance boundary of each antenna should be evaluated again, taking into account the additional exposure of the newly installed antenna.

Radio relay (also known as fixed point-to-point link):

These antennas concentrate their RF energy into a narrow beam in the

or ward direction e.g., parabolic dish antennas. Since the power levels are typically low, less than 1 watt, the safety distances in this forward direction (L) are often small (in centimeters) and in many cases there is no need of any safety distance for occupational exposure. Areas above, below and to the sides of the antenna, as well as the area behind the antenna, are normally safe at even shorter distances. Thus, the compliance boundary has the shape of the antenna with the diameter D and the length L in the forward direction. However, workers should never step in front of these antennas because it will interrupt radio link.

(2. 14) Determination of the radiation intensity at any distance from the mast:

Our first task in this section is to create the relation between$\propto$, h, x and Θ as shown in figure (2) (10) . From figure (2) one gets

$$\Theta = 180 - \propto - \beta \qquad (17)$$

$$x0 = 0.5 * z \sin\alpha \qquad (18)$$

$$y0 = 0.5 * z \cos\alpha \qquad (19)$$

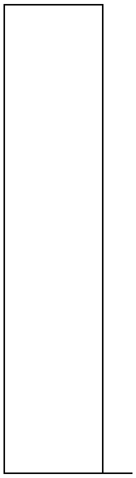


Figure (2. 14. 1): schematic representation of Antennas main beam

$$\sin\beta = \frac{x - \propto \emptyset}{r} \qquad (20)$$

$$\cos\beta = \frac{y0 + h}{r} \qquad (21)$$

$$r = \sqrt{((x - x_0)^2 + (y_0 + h)^2)} \tag{22}$$

From equation (17) one gets

$$\cos\emptyset = \sin\propto\sin\beta - \cos\alpha\cos\beta \tag{23}$$

$$\sin\emptyset = \sin\propto\cos\beta + \cos\alpha\sin\beta \tag{24}$$

Substituting equations (18), (19) and (22) in equations (20) and (21) to gets

$$\sin\beta = \frac{x-0.5*z\cos\alpha}{\sqrt{((x-0.5*z\sin\propto)^2+(h+0.5*\cos\propto)^2)}} \tag{25}$$

$$\cos\beta = \frac{h+0.5*z\cos\alpha}{\sqrt{((x-0.5*z\sin\propto)^2+(h+0.5*\cos\propto)^2)}} \tag{26}$$

Substituting equations(25) and (26) into equations (23) and (24) gets

$$\cos\square = \frac{0.5*z+h\cos\propto-x\sin\propto}{\sqrt{((x-0.5*z\sin\propto)^2+(h+0.5*\cos\propto)^2)}} \tag{27}$$

$$\sin\square = \frac{h\sin\propto+x\cos\alpha}{\sqrt{((x-0.5*z\sin\propto)^2+(h+0.5*\cos\propto)^2)}} \tag{28}$$

$$\sin^2\square = \frac{(h\sin\propto+\mathrm{x}\cos\propto)^2}{(x-0.5*z\sin\propto)^2+(h+0.5*z\cos\propto)^2} \tag{29}$$

$$P_D = \frac{0.13*P_t\cos^2(\frac{\pi}{2}(\frac{0.5*z+h\cos\propto-x\sin\propto}{\sqrt{((x-0.5*z\sin\propto)^2+(h+0.5*\cos\propto)^2)}}))}{(h\sin\propto+\mathrm{x}\cos\propto)^2} \tag{30}$$

$$P_{Dt} = \frac{0.13*P_s\left(\ln\left(\sqrt{(\omega\mu\sigma)*d}/\sqrt{2}\right)\right)\cos^2(\frac{\pi}{2}(\frac{0.5*z+h\cos\propto-x\sin\propto}{\sqrt{((x-0.5*z\sin\propto)^2+(h+0.5*\cos\propto)^2)}}}{(h\sin\propto+\mathrm{x}\cos\propto)^2} \tag{31}$$

$$P = \frac{1}{\mathrm{x}^2} \tag{32}$$

(2. 15) General effects of electromagnetic radiation:

The effects of electromagnetic radiation upon living cells, including those in humans, depend upon the power and the frequency of the radiation. For low-frequency radiation (radio waves to visible light) the best-understood.

Effects are those due to radiation power alone, acting through the effect of simple heating when the radiation is absorbed by the cell. For thesethermal effects, the frequency of the radiation is important only as itaffects radiation penetration into the organism (for example microwaves penetrate better than infrared). Initially, it was believed that low frequency fields that were too weak to causesignificant heating could not possibly have any biological effect.

Despite this opinion among researchers, evidence has accumulated that supports the existence of complex biological effects of weaker non-thermal electromagnetic fields, (including weak ELF magnetic fields, although the latter does not strictly qualify as EM radiation and modulated RF and microwave fields. Fundamental mechanisms of the interaction between biological material and electromagnetic fields at non-thermal levels are not fully understood. Bio electromagneticsis the study of these interactions and effects.The World Health Organization has classified radiofrequencyelectromagnetic radiation as a possible group 2b carcinogen.This group contains possible carcinogens with weaker evidence, at the same level as coffee and automobile exhaust. For example, there have been a number of epidemiological studies of looking for a relationship between cell phone use and brain cancer development, which have been largely inconclusive,Save to demonstrate that the effect, if it exists, cannot be a large one. See the main article referenced above.At higher frequencies (visible and beyond), the effects of individual photons of the radiation begin to become important, as these now have enough energy individually directly or indirectly to damage biological molecules. All frequencies of UV radiation have been classed as Group 1 carcinogens by the World Health Organization. Ultraviolet radiation from sun exposure is the primary cause of skin cancer.Thus, at UV frequencies and higher (and probably somewhat also in the visible range), electromagnetic radiation does far more damage tobiological systems than simple heating predicts. This is most obvious in the "far" (or "extreme") ultraviolet, and also X-ray and gamma radiation, are referred to as ionizing radiationdue to the ability of photons of this radiation to produce ions and free radicalsin materials (including living tissue). Since such radiation can produce severe damage to life at powers that produce very little heating, it is considered far more dangerous (in terms of damage-produced per unit of energy, or power) than the rest of the electromagnetic spectrum.

(2.16) Thermal effects:

One well-understood effect of microwave radiation is dielectric heating, in which any dielectric material (such as living tissue) is heated by rotations of polar molecules induced by the electromagnetic field. In the case of aperson using a cell phone, most of the heating effect will occur at the

Surface of the head, causing its temperature to increase by a fraction of a degree. In this case, the level of temperature increase is an order of magnitude less than that obtained during the exposure of the head to direct sunlight. The brain's blood circulation is capable of disposing of excess heat by increasing local blood flow. However, the cornea of the eye does not have this temperature regulation mechanism and exposure of 2–3 hours duration has been reported to produce cataracts in rabbits' eyes at SAR values from 100–140 W/kg, which produced temperatures of 41 °C. There were no cataracts detected in the eyes of monkeys exposed under similar conditions.[10] Premature cataracts have not been linked with cell phone use, possibly because of the lower power output of mobile phones.

(2.17) Non-thermal effects:

The communications protocols used by mobile phones often result in low-frequency pulsing of the carrier signal. While the existence of effects due to the field is undisputable, whether these modulationsarecausingtheseeffects or these are still of thermal nature is subject to debate.Some researchers have argued that so-called "non-thermal effects" could be reinterpreted as a normal cellular responsetoanincreaseintemperature.

The German biophysicist Roland Glaser, for example,[12] has argued that there are several thermo receptor molecules in cells, and that they activate a cascade of second and third messenger systems, gene expression mechanisms and production of heat shock proteins in order to Defend the cell against metabolic cell stress caused by heat. The increases in temperature that cause these changes are too small to be detected by studies such as REFLEX, which base their whole argument on the apparent stability of thermal equilibrium in their cell cultures.

Other researchers believe the stress proteins are unrelated to thermal effects, since they occur for both extremely low frequencies (ELF) and radio frequencies (RF), which have very different energy levels.[13] Another preliminary study published in 2011 by The Journal of the American Medical Association conducted using fluoro deoxyglucose injections and positron emission tomography concluded that exposure to radiofrequency signal waves within parts of the brain closest to the cell phone antenna resulted in increased levels of glucose metabolism, but the clinical significance of this finding is unknown.

CHAPTER THREE

Literature review

(3. 1) Introduction:

Different attempts were made to determine the electromagnetic power emitted by phone or transmission lines for different countries. This chapter exhibits some of them.

(3. 2) Interaction of Mobile Telephone Radiation with Biological Systems in Veterinary and Medicine:

During recent years there has been increasing public concern on potential health risks from extremely low frequency electromagnetic fields and radiofrequency beside microwave radiation.

It is well known that at sufficiently high power levels, radiofrequency and microwave energy can produce deleterious biological effects. Some investigations suggested that these fields may have genotoxic effects and may increase the risk of several cancers and neurological disorders such as Alzheimer's disease.

This research shows that these fields can influence several biological functions of cells and tissues. [13]

(3. 3) Conference paper a review on the impact of the electromagnetic radiation on the human's health:

A dense deployment of public mobile base stations, additional electromagnetic (EM) radiation in human environment increase the exposure to EM radiation emitted by such sources. In order to determine the level of radio frequency radiation generated by base stations, extensive EM field strength measurements were carried out for 664 base station locations, from which 276 locations refer to the case of base stations with antenna system installed on buildings.

Having in mind the large percentage (42 %) of locations with installations on buildings, as well as the inevitable presence of people in their vicinity, a detailed analysis of this location category was performed. Measurement results showed that the maximum recorded value of total electric field strength has exceeded International Commission on Non-Ionizing Radiation Protection general public exposure reference levels at 2.5 % of locations and Serbian national reference levels at 15.6 % of locations.

The values exceeding the reference levels were observed only outdoor, while in indoor total electric field strength in no case exceeded the defined reference levels. [14]

(3. 4) Critical Review Mobile Radiations Effects: Problems & Remediation:

Majority of cell towers are mounted near the residential and office buildings providing good coverage to the users. These transmit radiation 24x7 exposing residents in proximity to 104 to 107 time's stronger signal.

The human body, because of high fluid content, absorbs electromagnetic Radiation and is heated causing damage to organs including. Human height is much greater than wavelength of cell tower transmitting frequencies causing multiple resonances in the body triggering heating inside the body

Resulting in boils, drying up of the fluids around eyes, brain, joints, heart, abdomen, etc. High exposure can also instigate Alzheimer’s disease, Morgellon's disease, Tinnitus, bone weakening, sleep disorders, Neurodegenerative Diseases and even high cancer risk. In addition to the continuous radiation from cell towers, there is radiation from cell phones, wireless phones, computers, laptops, TV towers, FM towers, AM towers, microwave ovens, etc.

We are exposed to all these radiations which are additive in nature. Hence, it is imperative that stricter radiation norms must be enforced by the policy makers. [15]

(3. 5) Awareness and self-reported hHealth hazards of EM Waves from mobile phone towers in Dhaka, Bangladesh:

Over the last few years there have been concerns regarding the health effects of electromagnetic waves (EMW) produced by mobile phone base transmitter stations (BTS). Data on possible health effects of EMW in developing countries are rare.

This study was conducted to determine the awareness and self-reported health hazards of EMW from the mobile phone BTS in Dhaka city. A cross-sectional study was conducted among 220 respondents living around BTS in Dhaka city.

Data was collected on sociodemographic characteristics, mobile phone use, BTS and EMW awareness, and self - reported health problems. The majority of respondents (92.7%) reported to have seen a BTS but only 29.5% knows how it works and 74.5% had no knowledge about the EMW. 49% respondents experienced sleeping disturbances while recent episodes of headache or dizziness were reported by 47% and mood change or anxiety or depression by 41%. About 22% complained about other physical or mental symptoms. [16]

(3. 6) Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem:

The effect of radio-frequency electromagnetic field (RF-EMF) from cell towers and wireless devices on the biosphere, based on current available literature, it shows that RF-EMF radiation exposure can change neurotransmitter functions, blood-brain barrier, morphology, rophysiology, cellular metabolism, calcium efflux, and gene and protein expression in certain types of cells even at lower intensities.

The biological consequences of such changes remain unclear. Short-term studies on the impacts f RF-EMF on frogs, honey bees, house sparrows, bats, and even humans are scarce and long-term studies are non-existent in India. Identification of the frequency, intensity, and duration of non-ionizing electromagnetic fields causing damage to the bio system and ecosystem would evolve strategies for mitigation and would enable the proper use of wireless technologies to enjoy its immense benefits, while suring one’s health and that of the environment. [17]

(3. 7) Summary and critique:

Alot of work was done for studying the biological hazards of mobile phone towers [6 Ref]. Some of these were made a broad, while some were made in Sudan [6 Ref]. The studies made in general concentrates mainly on the relation between the radiation dose and biological hazards [4 Ref]. These studies do not relate the number of towers or corporation towers style (model) with the concentration of radiation.

The studies also have nothing to do with the tower geometry or its spatial distribution.

CHAPTER FOUR

Materials and methods

(4. 1) Introduction:

Due to the public concern on the installation of Communication transmission towers on the health effects from the exposure of radio frequency radiations (RFR), the Assessment was conducted through literature works and one have proved the presence of health effects due to radiation from cellular towers.

Different bodies worldwide and Countrywide usually regulate the deployment of towers and their associated radiation. Regulatory authorities in Sudan is the national telecommunication corporation (NTC), it should come up with regulation guidelines on issues related to communication

In this practical study for the radiation in Khartoum state, river Nile state and red sea state, there are several techniques were used for the determination of the impact of electromagnetic radiation on the environment and human health. Each of these techniques will be discussed in this chapter.

(4. 2) Materials:

In this work the following devices and materials were used:

(4. 2.1) Radiations Measurements (EMF-Meter):

1. Distance Meter: The distance meter reads to the maximum range and the minimum reading is 0.00), with sensitivity 0.001mCamera: this camera is made in Japan; it's made by Sony company With serial number 749291
2. GPS Receiver: With device, Cable and mounting hardware, Interface and mountable receiver for positioning data documentation.
3. Computer programmers for data: is made in Japan, its made by DELL company, with serial number 30203 – 2013.

(4 .3) Electromagnetic measurements:

The Narda Broadband Field Meter BM-550 is part of the NBM-500 device family. It makes extremely accurate measurements of non-ionizing radiation, this device is made in United States of America (USA), and it's made by

Narda Safety Test Solutions Company with serial number. No. US D570, 235 S. It measures the electromagnetic radiation intensity in the frequency range 100KHZ – 60 GHZ, and the sensitivity of the mw\m2 device is 1 mw\m2.

(4. 3.1) Properties of EMF-Meter:

1. Available with Isotropic probes to cover 100 kHz to 60 GHz.
2. Large graphical Display.
3. Intelligent Probe Interface with Automatic probe parameter detection.
4. Fully automatic zeroing.
5. Extensive memory for logging of up to 5000 results.
6. GPS Interface and mountable receiver for positioning data documentation (optional).
7. Voice recorder for adding comments (optional).

(4. 3. 2) Description: The NBM – 500 series is the most accurate non-ionizing radiation survey system available. It provides the broadest frequency coverage of electric and magnetic fields. Beth flat response probes and probes shaped to international standards are available. All NBM probe can be used with any NBM-500 series meter and still maintain total calibration.

Figure (4. 3. 1): GPS receiver connected to the NBM-550.

The Narda Broadband Field Meter BM-550 is part of the NBM-500 device family. It makes extremely accurate measurements of non-ionizing radiation, this device is made in United States of America (USA), and it’s made by Narda Safety Test Solutions Company

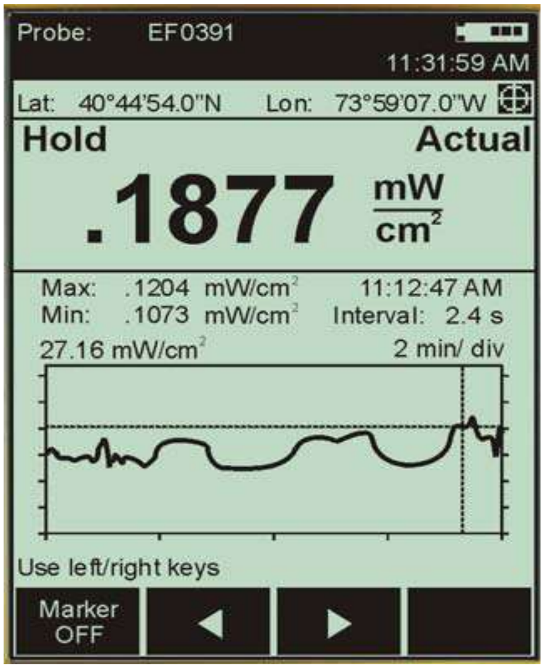

Probe: EF0391
11:31:59 AM
Lat: 40°44'54.0"N Lon: 73°59'07.0"W
Hold Actual
.1877 $\frac{mW}{cm^2}$
Max: .1204 mW/cm^2 11:12:47 AM
Min: .1073 mW/cm^2 Interval: 2.4 s
27.16 mW/cm^2 2 min/ div
Use left/right keys

Figure (4. 3. 2)

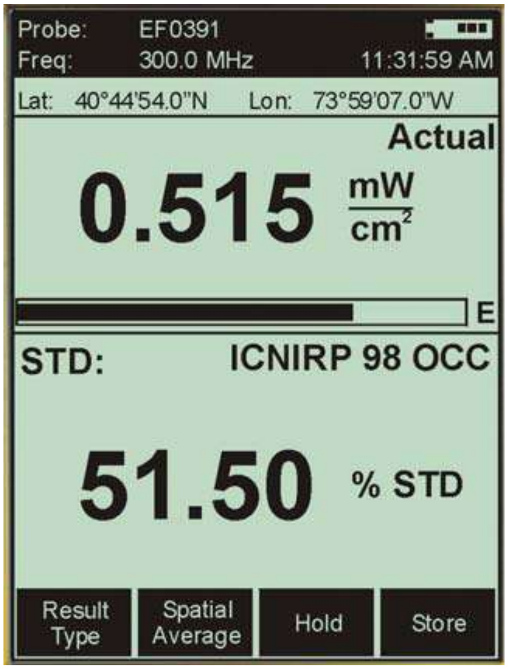

Probe: EF0391
Freq: 300.0 MHz 11:31:59 AM
Lat: 40°44'54.0"N Lon: 73°59'07.0"W
Actual
0.515 $\frac{mW}{cm^2}$
STD: ICNIRP 98 OCC
51.50 % STD

Figure (4. 3. 3)

Figure (4. 3. 2) show the Screen of the device shows the variation of field strength versus time as a graph.

Figure (4. 3. 3) show Apply Standard: display the field strength as a percentage of the limit value of a standard even when using flat probes. Simply select the standard on the NBM-550 (ICNIRP in the example shown) and set the frequency. The evaluation is useful if the main component of the field strength is due to a single source of known frequency.

(4. 3. 3) Applications:

Precision measurement of electric or magnetic field strength for personal safety at work where high radiation levels are present, such as:

1. General RF safety program measurements.

2. Service work on transmitting and radar equipment.
3. Service work on mobile antennas, broadcasting and satellite communication systems.
4. Working with heating and packaging machines in the food industry.
5. Operating diathermy equipment and other medical instrument producing short-wave radiation.
6. Drying equipment in the tanning and timber industries.

(4. 3. 4) Feature, Display and Operation:

1. Backlit Monochrome LCD; readable even in bright daylight.
2. Graphical user interface (GUI) with selectable languages.
3. Simple – to – use 9 button keypad.
4. Hold button soft key for" freezing" measurement display during
5. Readings.
6. User defined setups can be saved for repetitive survey needs.
7. Keypad can be locked guard against inadvertent inputs.
8. User selectable "auto-off" feature to save battery life.

(4. 3. 5) Reading displayed:

1. 5 Types of results can be displayed – actual, minimum, maximum, average and maximum average.
2. History mode – history memory operates continuously in the background, allowing you to display past readings at any time, up to 8 hours.
3. Selectable units – V/m, W/m2, and "% of Standard" when using shaped frequency response probes.

4. Stored standards and guidance's in the NBM's memory allow you to simultaneously display readings as a "% of standard" if frequency is known.
5. Data memory for up to 5000 measurements.

(4. 3. 6) Averaging functions:

1. Time Averaging – 4 seconds to 30 minutes, in 2 – second intervals.
2. Spatial averaging – discrete or continuous.

(4. 3. 7) Audible alarm:

1. Variable alarm threshold setting.
2. Audible indication of increasing or decreasing field strength.

(4. 3. 8) Probe interface:

1. Automatic detecting of probe type and calibration information.
2. Fully automatic and variable zero adjustment interval times.
3. Additional optical for separating probe from meter.

(4. 3. 9) Remote control:

1. PC connection via USB or Optical interface.
2. Trigger input for externally initiating readings to be taken.
3. NBM – TS software enables remote controlled measurements.
4. Screenshots can be downloaded to PC.

(4. 3. 10) NBM option set:

Consider the option set for the NBM – 550 and how it can simplify your survey reports – a major advantage. This option set adds a GPS receiver and conditional logging. It also allows you to add voice storage to stored readings via our built-in microphone. By adding the power and versatility of audible comments to stored readings, you will not remember the particulars of when and where readings were taken imagine that!

(4. 3. 11) The NBM – 550 option set includes:

1. GPS receiver, cable and mounting hardware.
2. Audio recorder for adding voice comments to store readings.
3. Conditional logging – data can be logged when threshold is
4. exceeded (upper or lower), outside of user – defend level "window" or only store first and last time readings that cross conditional boundaries.
5. The option set is field (or factory) installable, so it can be added any time you choose, without having to return it to the factory.

(4. 3. 12) NBM – TS SOFTWARE (supplied with NBM – 550):

The supplies NBM – TS software provides for convenient data management, documentation of result and future evaluation. It also provides you the capability to remotely control the NBM and perform firmware upgrades. This innovative software package also allows you to link the optional GPS data with actual pictures from mapping programs like Google Earth TM, making field survey data take on more relevance with the reader. And, to ensure it will be viable for years to come, this software was designed with Microsoft Vista TM operating system in mind.

(4. 4) Methods:

(4. 4.1) The experimental methodology is based on:

1. Selection of states: To study the effect environments on the towers emitted power, three states having different environments were selected
2. Selection of companies: The three biggest companies of telecommunication in Sudan (ZAIN, SUDANI, and MTN) were selected
3. Selection of towers: The towers were selected from different companies to throw light on the effect towers electronic structure on radiation power of 120 towers from ZAIN Company, 120 towers from Sudani Company and 120 towers from MTN Company.

(4. 4. 2) States which were selected for study:

Khartoum state: Is characterized by heavy population and huge number of towers. 120 towers were selected.

River Nile state: Is characterized by intensive plantation and forestation and it’s near the River Nile. 120 towers were selected.

Red sea state: Is characterized by mountains, high humidity and it’s near the red sea, 120 towers were selected. The measurement of radiationintensity I, each tower is done by locating the intensity meter (NBM- broad band meter) at 6 different horizontal locations from the towers, these horizontal distances are: 5m, 10m, 15m, 20m, 25m and 30m. The highest of the towers is also measured to see how the radiation intensity varies with highest.

(4. 5) Standardization metrology for the mobile phone station:

Table (4. 5. 1) Standardization metrology for the mobile phone station recommended by National Telecommunication Council:

Standard	Metrology
60 m – 15	The height of the antenna for the ground towers
10	The most highest level of the tower on the roof
6	Distance between antennas & human, towards the main ray.
12	Distance between antennas &nearest building horizontally towards the dissemination on the highest is not less than
12	Distance between two towers on the same building
6	Preventive wire wall around the tower, and far from its center about
20	Distance between the antenna and the nearest school
100	The most high emission energy
0.5mw/cm2	The allowable density of electromagnetic power
2	The lower level of SAR
60dB-distance8m	Level of noise of the motor

(4 . 6): Standardization metrology recommended according to:

1. Recommendations of the meeting of the Arab committee for Communications and information's (20 – 21 Nov 2004).

2. Instructions of the executive committee of Arab communications ministers (25 – 26 Nov 2004).

3. Standards of WHO and the ICNIRP.
4. International telecommunication union and European standards committee.

CHAPTER FIVE

Results, discussion and conclusion

(5. 1) Introduction

The radiation intensity emitted from mobile phone towers were measured in this work as a function of a horizontal distances from the tower. Three states characterized by different environment were selected here. These states are Khartoum, River Nile and Red sea. Since these samples are very large and each 40 towers give similar results, only (10) towers from (40) were selected to represent a certain company in a certain state.

All these samples were subjected to the radioactive power examination using international standard radiometers as well as the well-established NARDA measurements and technology. This is in an attempt to determine the radiation intensity emitted from these towers as a function of horizontal distance as well as towers heights.

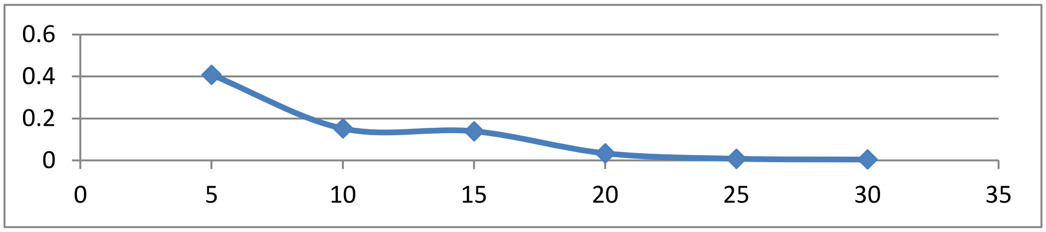
The towers numbers examined or tested in each state is (120) towers, the number of tower related to ZAIN company in each state are (40) , the same numbers are chosen for Sudani and MTN company. Curves relating between radiation intensity, horizontal distance and tower highest, were drawn. In each curve the average readings of towers relate to a certain company in a certain specific state are represented graphically.

(5. 2) Results:

Table (5. 2. 1): Relation between distance (X) and intensity (I) for ZAIN tower (1) at Khartoum state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.408	0.152	0.139	0.034	0.008	0.004

I (mw\m^2)



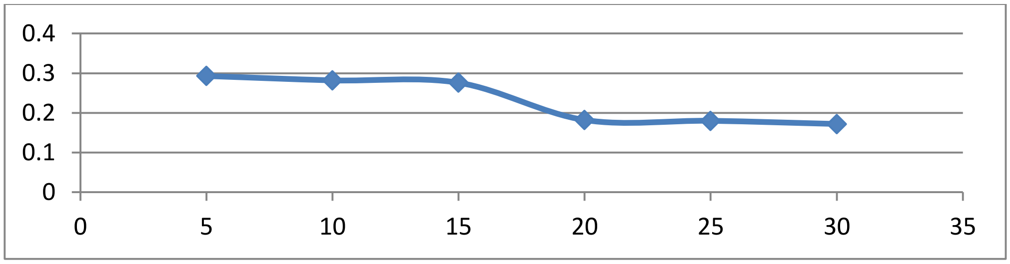
X

Figure (5. 2. 1): Relation between (X) and (I) of ZAIN tower (1) at Khartoum state

Table (5. 2. 2): Relation between (X) and (I) for ZAIN tower (2) at Khartoum

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.293	0.282	0.276	0.182	0.180	0.172

I (mw\m^2)



X

Figure (5.2. 2): Relation between (X) and (I) of ZAIN tower (2) at Khartoum state

Table (5. 2. 3): Relation between (X) and (I) for ZAIN tower (3) at Khartoum

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.482	0.402	0.392	0.323	0.128	0.072

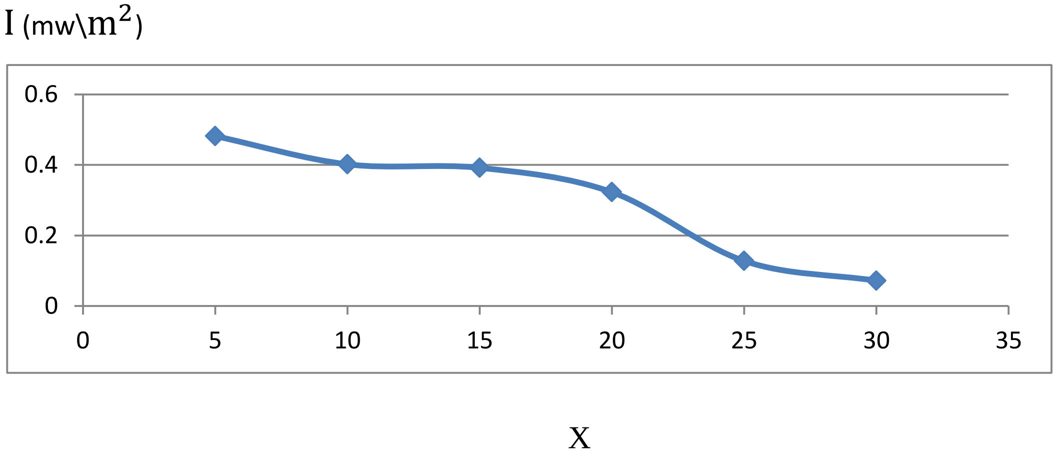


Figure (5.2. 3): Relation between (X) and (I) of ZAIN tower (3) at Khartoum state

Table (5. 2. 4): Relation between (X) and (I) for ZAIN tower (4) at Khartoum

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.366	0.246	0.176	0.167	0.108	0.103

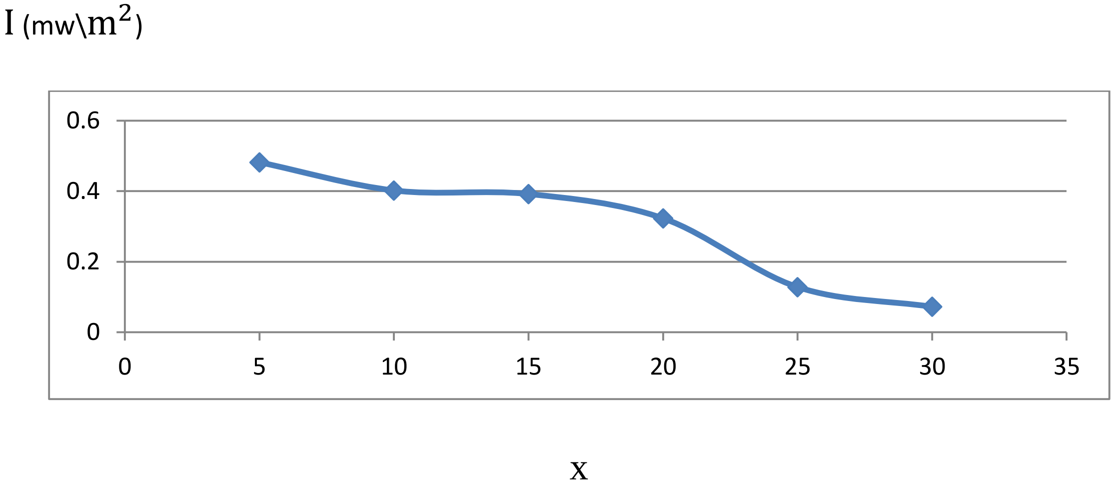


Figure (5.2. 4): Relation between (X) and (I) of ZAIN tower (4) at Khartoum state

Table (5. 2. 5): Relation between (X) and (I) for ZAIN tower (5) at Khartoum

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.512	0.480	0.427	0.395	0.322	0.280

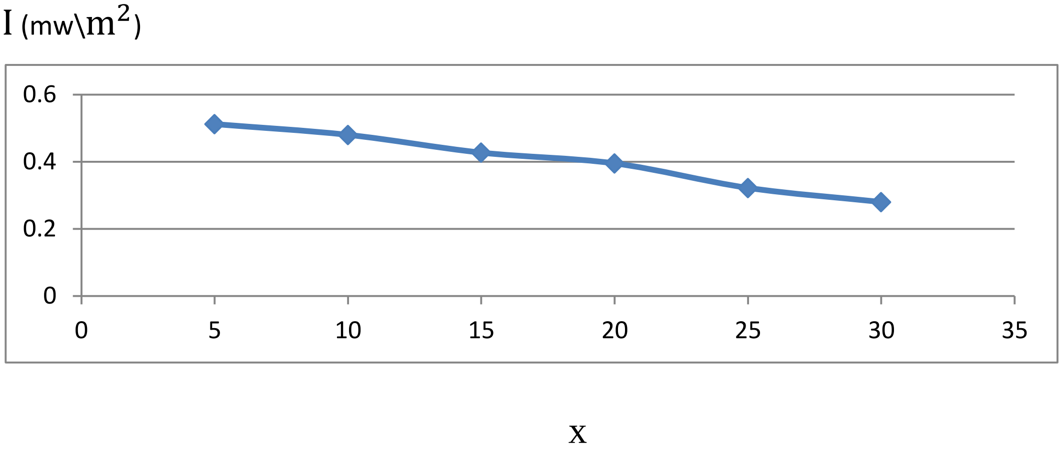


Figure (5.2. 5): relation between (X) and (I) of ZAIN tower (5) at Khartoum state

Table (5. 2. 6): Relation between (X) and (I) for ZAIN tower (6) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.500	0.212	0.188	0.165	0.122	0.046

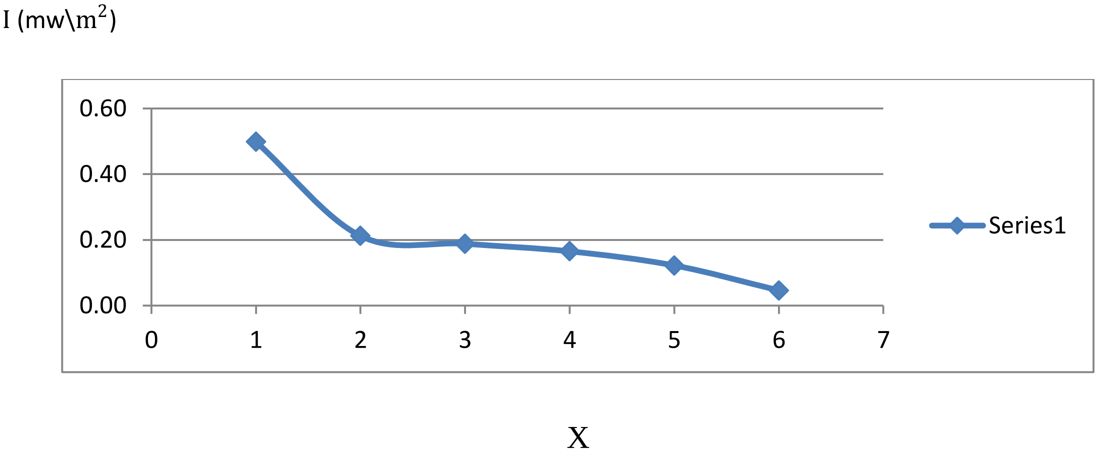


Figure (5.2. 6): relation between (X) and (I) of ZAIN tower (6) at Khartoum state

Table (5. 2. 7): Relation between (X) and (I) for ZAIN tower (7) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.223	0.197	0.185	0.170	0.151	0.131

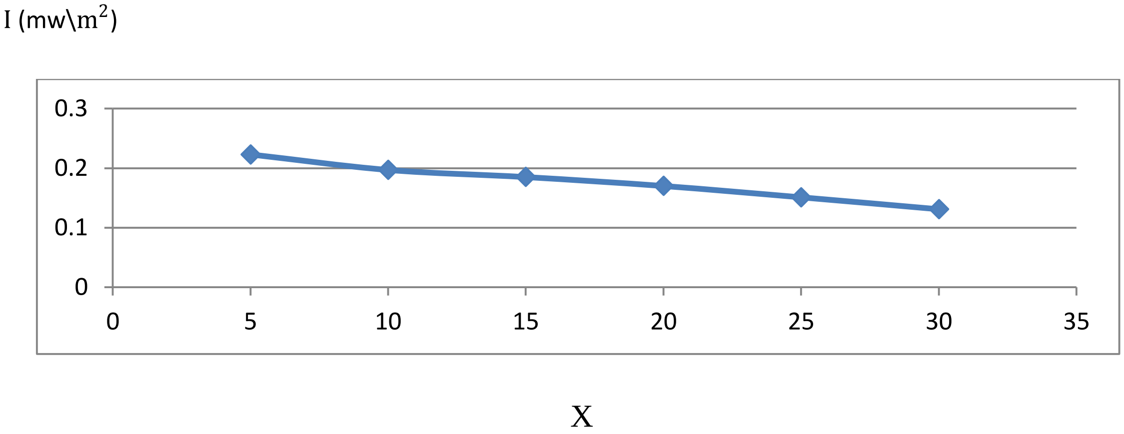


Figure (5.2. 7): relation between X and I of ZAIN tower (7) at Khartoum state

Table (5. 2. 8): Relation between (X) and (I) for ZAIN tower (8) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.483	0.416	0.310	0.208	0.115	0.075

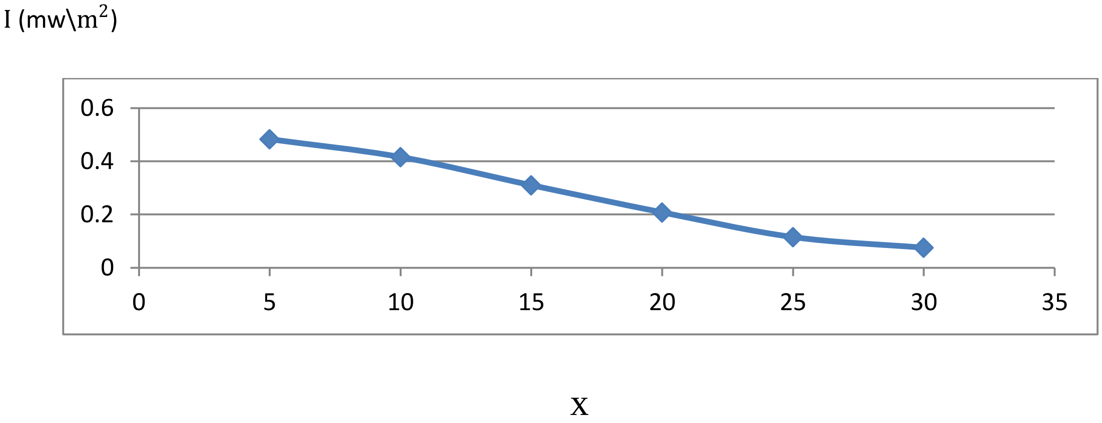


Figure (5.2. 8): relation between (X) and (I) of ZAIN tower (8) at Khartoum state

Table (5. 2. 9): Relation between (X) and (I) for ZAIN tower (9) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.263	0.154	0.134	0.101	0.084	0.075

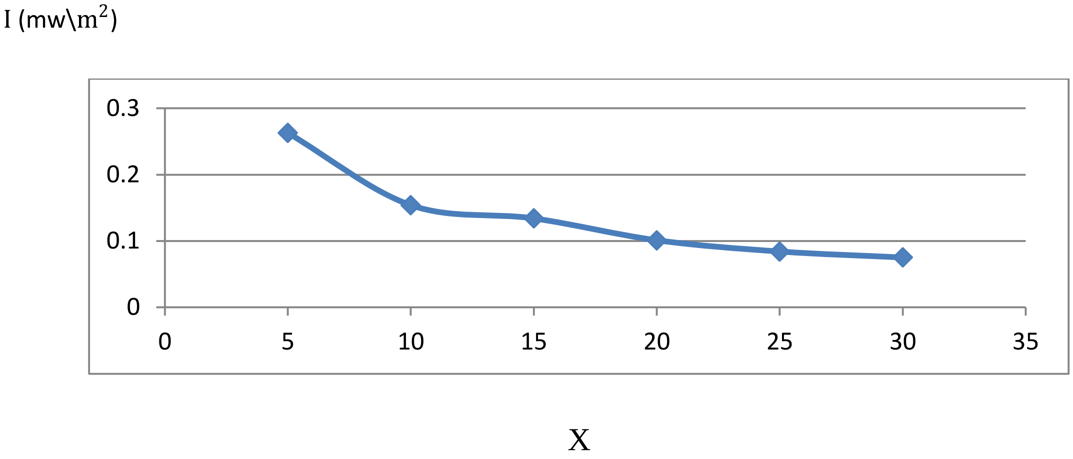


Figure (5.2. 9): relation between (X) and (I) of ZAIN tower (9) at Khartoum state

Table (5. 2. 10): Relation between (X) and (I) for ZAIN tower (10) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.133	0.098	0.077	0.072	0.042	0.035

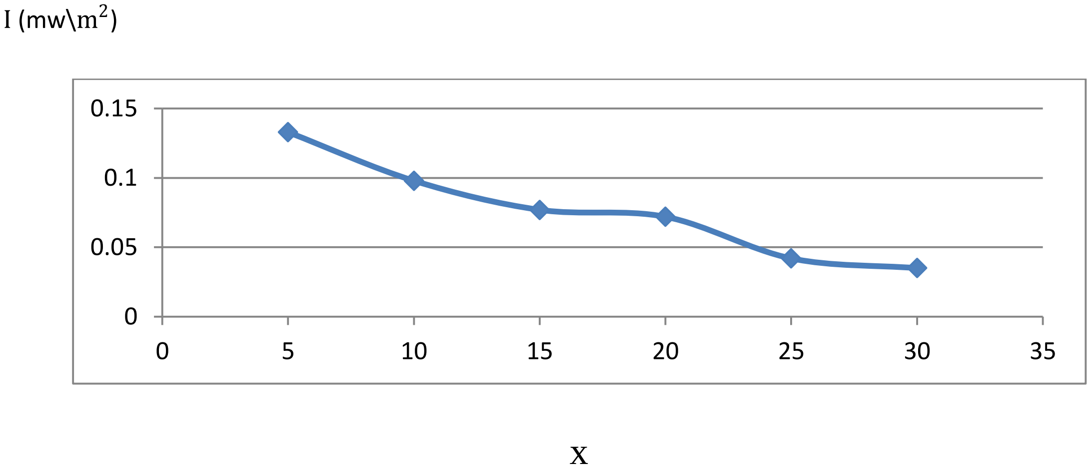
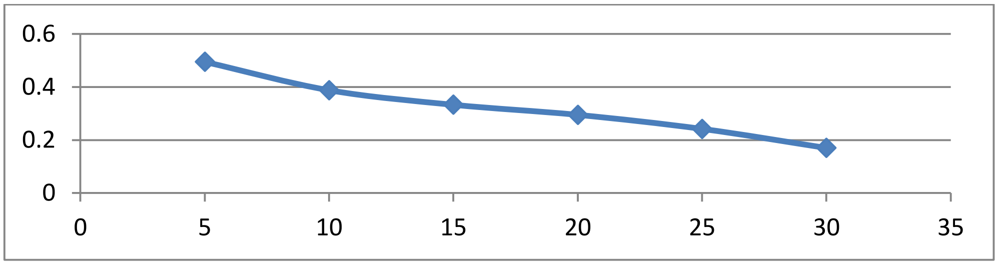


Figure (5. 2. 10): relation between (X) and (I) of ZAIN tower (10) at Khartoum state

Table (5. 2. 11): Relation between (X) and (I) for sudani tower (1) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.495	0.388	0.333	0.295	0.242	0.170

I (mw\\m^2)



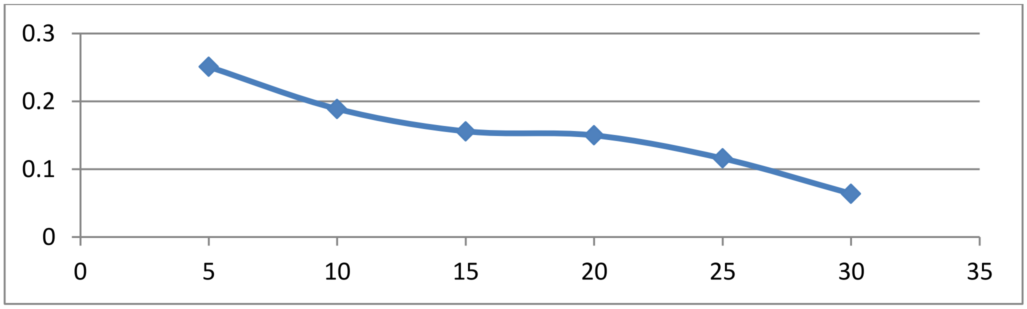
X

Figure (5.2. 11): relation between (X) and (I) of sudani tower (1) at Khartoum state

Table (5. 2. 12): Relation between (X) and (I) for sudani tower (2) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.251	0.189	0.156	0.150	0.116	0.064

I (mw\\m^2)



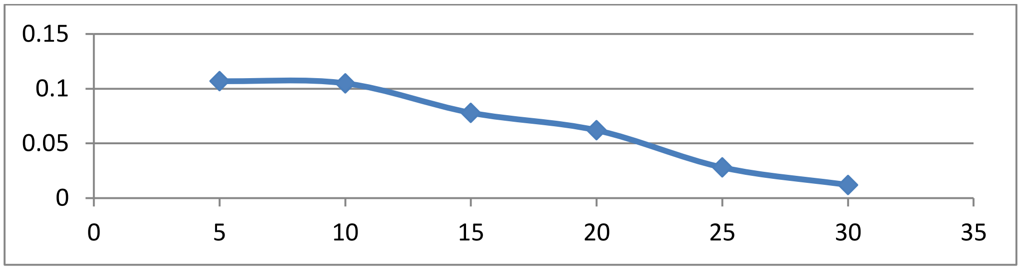
X

Figure (5.2. 12): relation between (X) and (I) of sudani tower (2) at Khartoum state

Table (5. 2. 13): Relation between (X) and (I) for sudani tower (3) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.107	0.105	0.078	0.062	0.028	0.012

I (mw\m^2)



X

Figure (5.2. 13): relation between (X) and (I) of sudani tower (3) at Khartoum state

Table (5. 2. 14): Relation between (X) and (I) for sudani tower (4) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.154	0.119	0.109	0.097	0.063	0.013

I (mw\m^2)

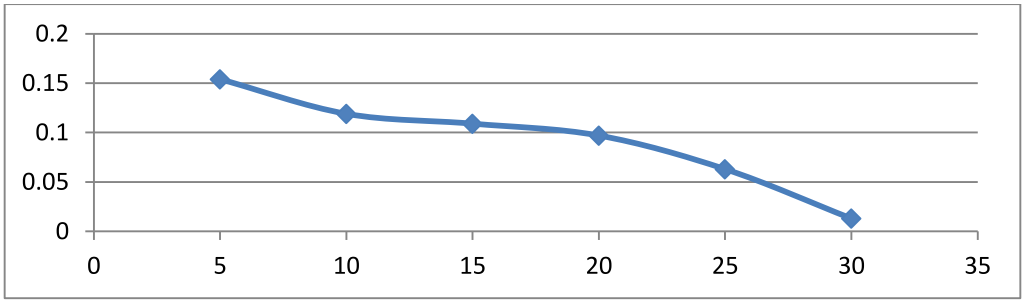
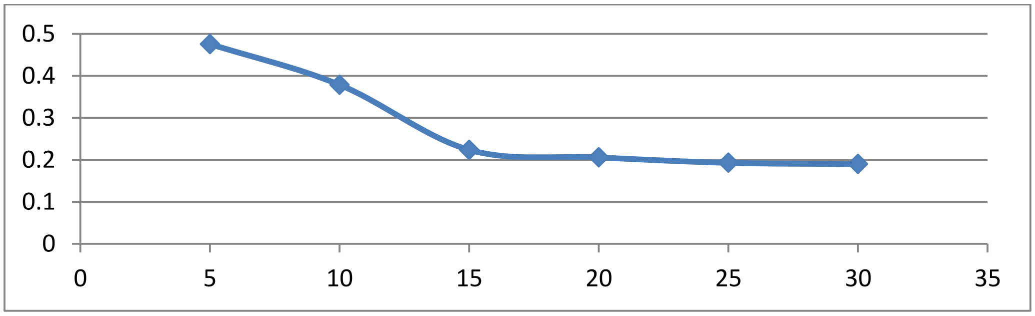


Figure (5.2. 14): relation between (X) and (I) of sudani tower (4) at Khartoum state

Table (5. 2. 15): Relation between (X) and (I) for sudani tower (5) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\text{I} \pm 1\text{mw}\backslash m^3$	0.476	0.379	0.224	0.206	0.193	0.190

I (mw\m^2)



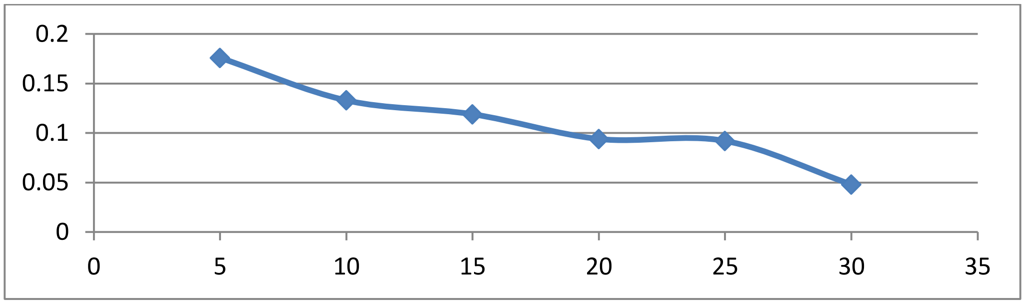
X

Figure (5.2. 15): relation between (X) and (I) of sudani tower (5) at Khartoum state

Table (5. 2. 16): Relation between (X) and (I) for sudani tower (6) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\text{I} \pm 1\text{mw}\backslash m^3$	0.176	0.133	0.119	0.094	0.092	0.048

I (mw\m^2)



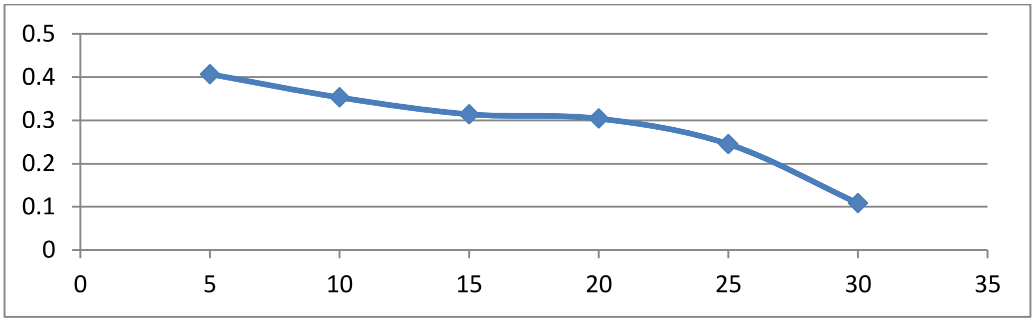
X

Figure (5.2. 16): relation between (X) and (I) of sudani tower (6) at Khartoum state

Table (5. 2. 17): Relation between (X) and (I) for sudani tower (7) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.407	0.353	0.314	0.304	0.245	0.108

I (mw\m^2)



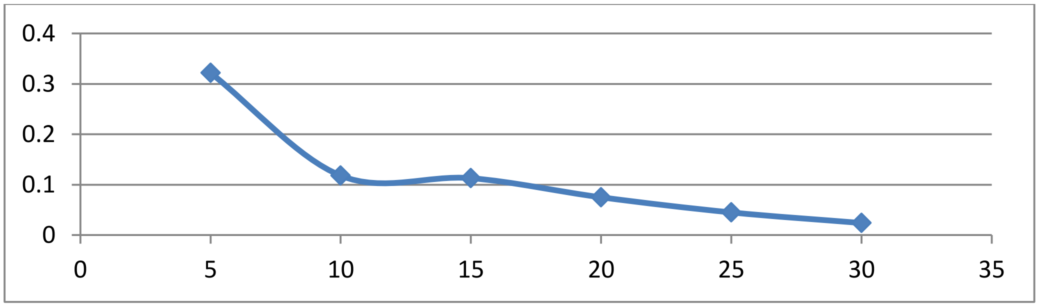
x

Figure (5.2. 17): relation between (X) and (I) of sudani tower (7) at Khartoum state

Table (5. 2. 18): Relation between (X) and (I) for sudani tower (8) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.322	0.118	0.113	0.075	0.045	0.024

I (mw\m^2)



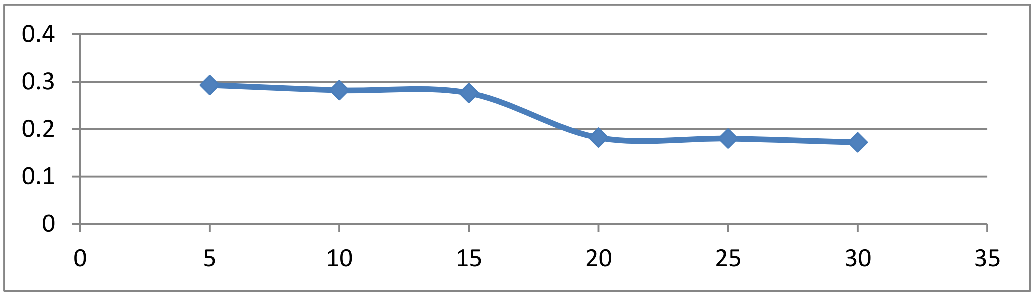
x

Figure (5.2. 18): relation between (X) and (I) of sudani tower (8) at Khartoum state

Table (5. 2. 19): Relation between (X) and (I) for sudani tower (9) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.293	0.282	0.276	0.182	0.180	0.172

I (mw\m^2)



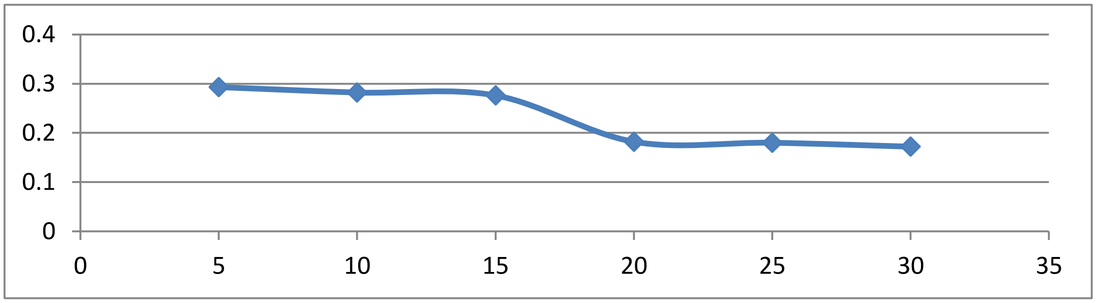
X

Figure (5.2. 19): relation between (X) and (I) of sudani tower (9) at Khartoum state

Table (5. 2. 20): Relation between (X) and (I) for sudani tower (10) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.240	0.098	0.077	0.077	0.016	0.014

I (mw\m^2)



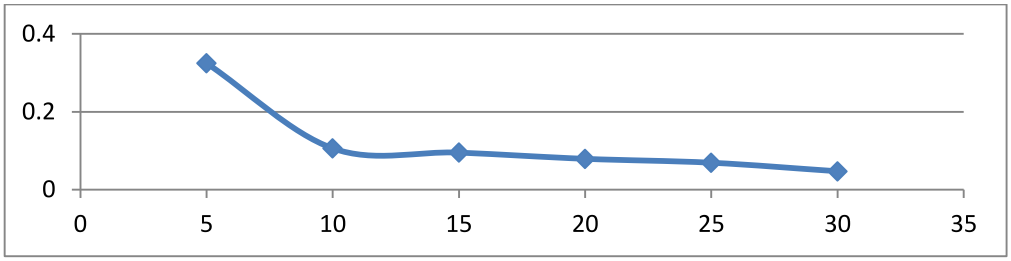
X

Figure (5.2. 20): relation between X and I of sudani tower (10) at Khartoum state

Table (5. 2. 21): Relation between (X) and (I) for MTN tower (1) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.325	0.106	0.095	0.079	0.069	0.047

(mw\m^2)



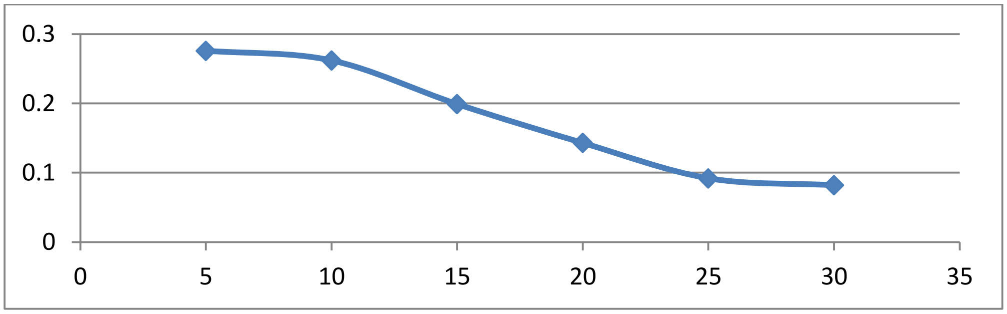
X

Figure (5.2. 21): relation between (X) and (I) of MTN tower (1) at Khartoum state

Table (5. 2. 22): Relation between (X) and (I) for MTN tower (2) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.276	0.262	0.199	0.143	0.092	0.082

I (mw\m^2)



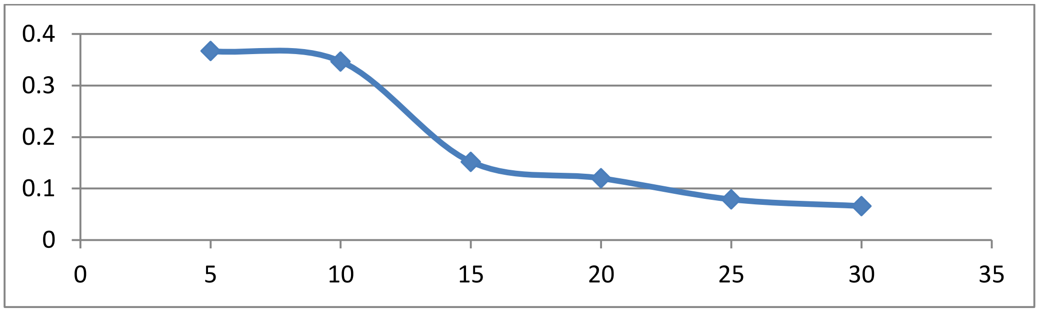
X

Figure (5.2. 22): relation between (X) and (I) of MTN tower (2) at Khartoum state

Table (5. 2. 23): Relation between (X) and (I) for MTN tower (3) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
$\mathrm{I} \pm 1 \mathrm{mw} \backslash m^3$	0.367	0.347	0.152	0.120	0.079	0.066

I (mw\m^2)



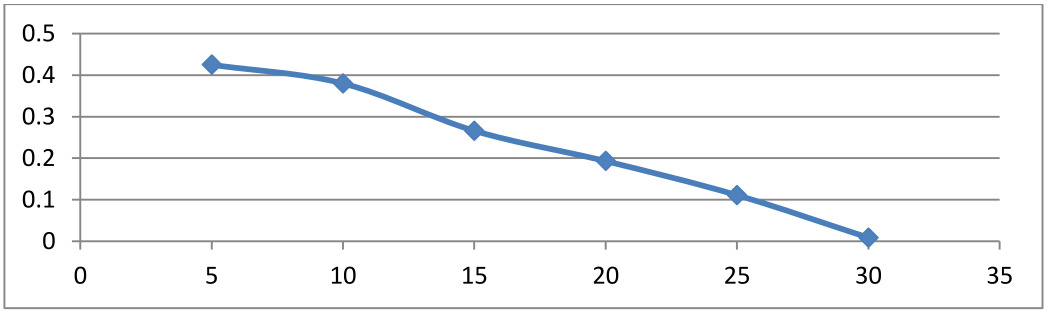
X

Figure (5.2. 23): relation between (X) and (I) of MTN tower (3) at Khartoum state

Table (5. 2. 24): Relation between (X) and (I) for MTN tower (4) at Khartoum.

$x \pm 10^{-3} m$	5	10	15	20	25	30
$\mathrm{I} \pm 1 \mathrm{mw} \backslash m^3$	0.425	0.380	0.266	0.193	0.111	0.008

I (mw\m^2)



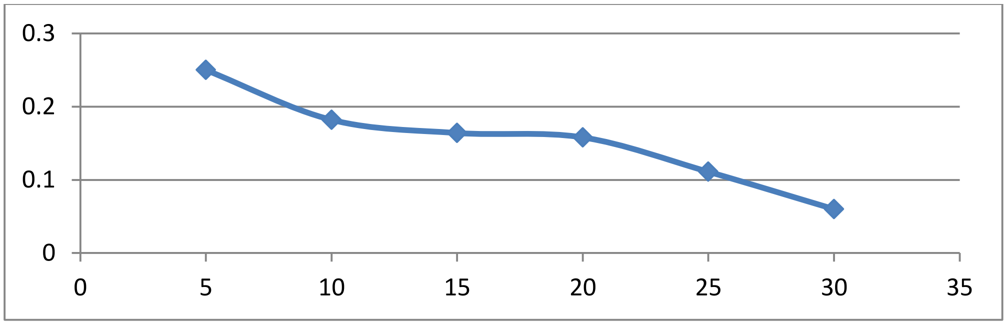
X

Figure (5.2. 24): relation between (X) and (I) of MTN tower (4) at Khartoum state

Table (5. 2. 25): Relation between (X) and (I) for MTN tower (5) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I ± 1mw\\m^3	0.250	0.182	0.164	0.158	0.111	0.060

I (mw\\m^2)



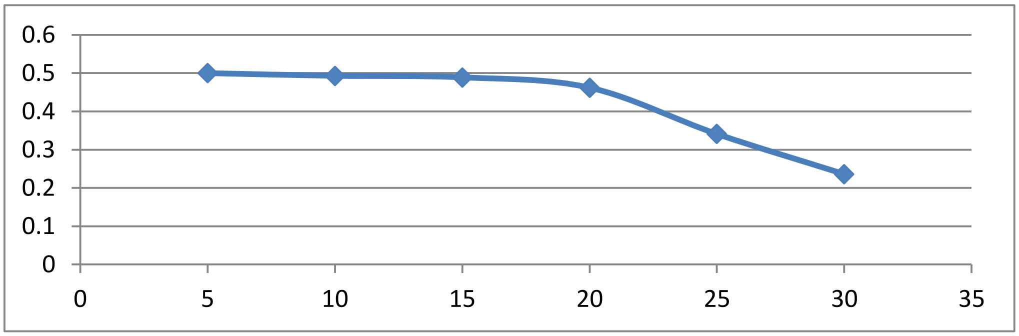
X

Figure (5.2. 25): relation between (X) and (I) of MTN tower (5) at Khartoum state

Table (5. 2. 26): Relation between (X) and (I) for MTN tower (6) at Khartoum state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I ± 1mw\\m^3	0.500	0.493	0.489	0.462	0.341	0.236

I (mw\\m^2)



X

Figure (5.2. 26): relation between (X) and (I) of MTN tower (6) at Khartoum state

Table (5. 2. 27): Relation between (X) and (I) for MTN tower (7) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.316	0.097	0.078	0.042	0.033	0.027

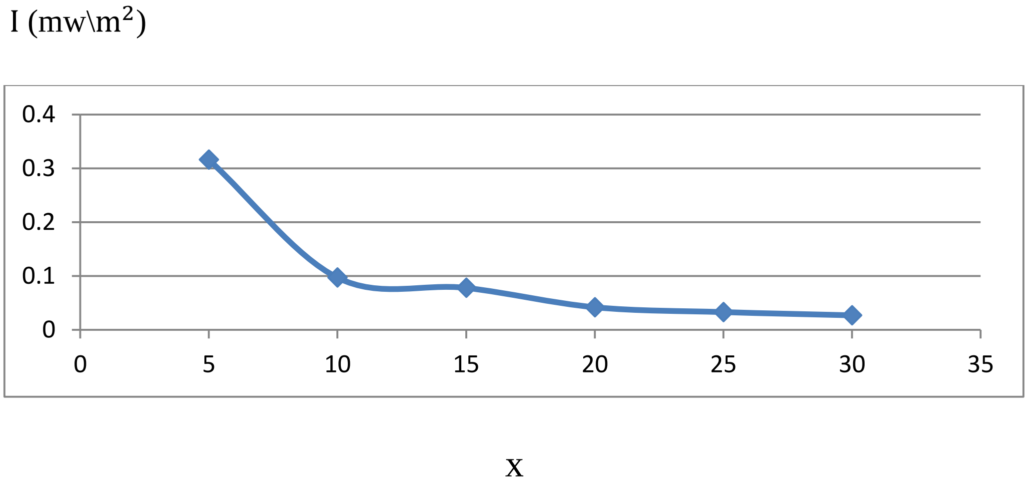


Figure (5.2. 27): relation between (X) and (I) of MTN tower (7) at Khartoum state

Table (5. 2. 28): Relation between (X) and (I) for MTN tower (8) at Khartoum state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.461	0.281	0.223	0.164	0.148	0.139

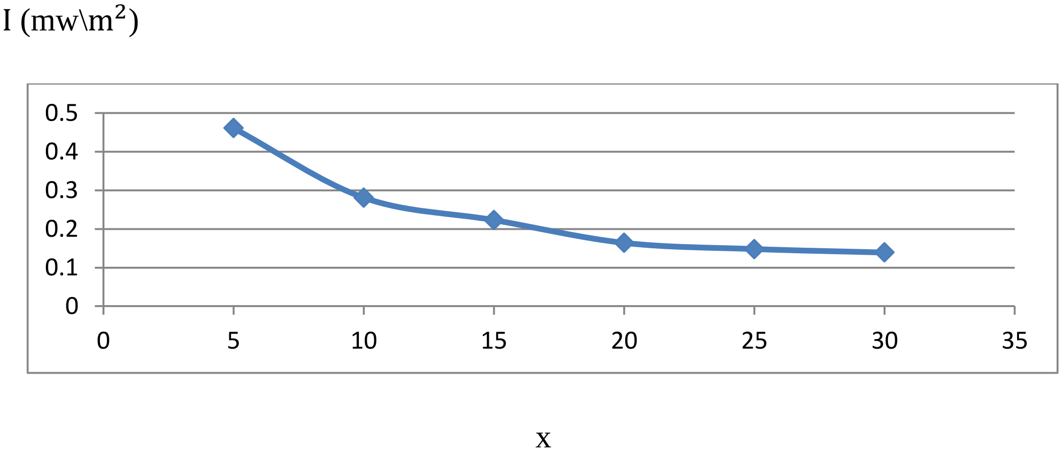
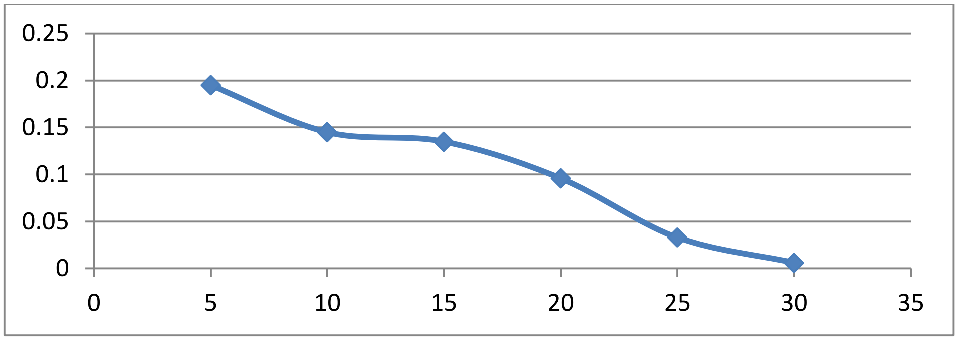


Figure (5.2. 28): relation between (X) and (I) of MTN tower (8) at Khartoum state

Table (5. 2. 29): Relation between (X) and (I) for MTN tower (9) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.195	0.145	0.135	0.096	0.033	0.006

I (mw\m^2)



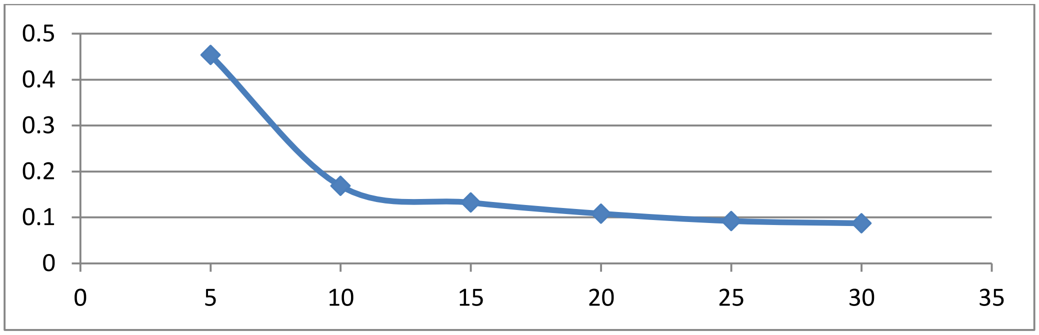
X

Figure (5.2. 29): relation between (X) and (I) of MTN tower (9) at Khartoum state

Table (5. 2. 30): Relation between (X) and (I) for MTN tower (10) at Khartoum.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.453	0.168	0.132	0.108	0.092	0.087

I (mw\m^2)



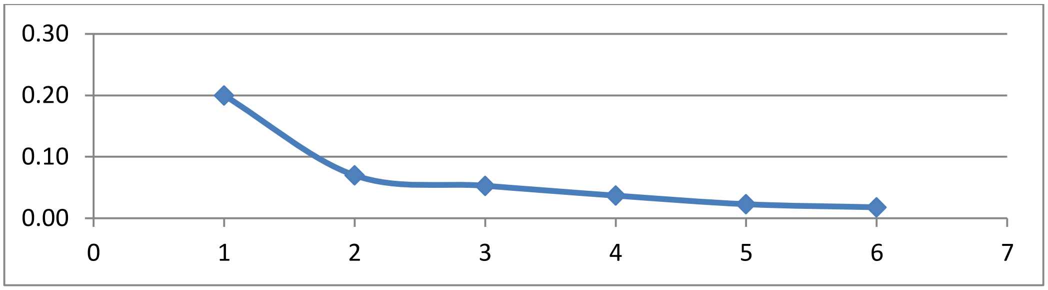
X

Figure (5.2. 30): relation between (X) and (I) of MTN tower (10) at Khartoum state

Table (5. 2. 31): Relation between (X) and (I) for ZAIN tower (1) at R.N state.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.200	0.070	0.053	0.037	0.023	0.018

I (mw\m^2)



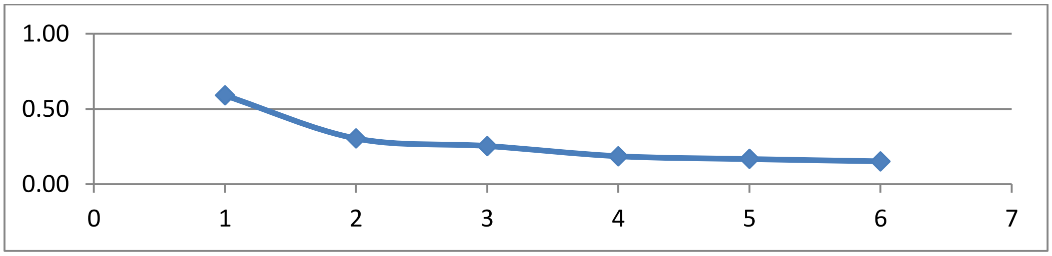
X

Figure (5.2. 31): relation between (X) and (I) of ZAIN tower (1) at R.N state

Table (5. 2. 32): Relation between (X) and (I) for ZAIN tower (2) at R.N state.

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.60	0.304	0.254	0.186	0.167	0.152

I (mw\m^2)



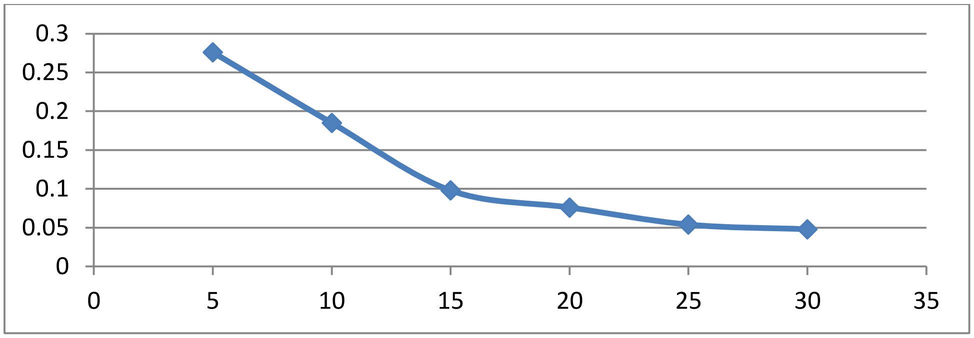
X

Figure (5.2. 32): relation between (X) and (I) of ZAIN tower (2) at R.N state

Table (5. 2. 33): Relation between (X) and (I) for ZAIN tower (3) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.276	0.185	0.098	0.076	0.054	0.048

I $(\mathrm{mw}\backslash\mathrm{m}^2)$



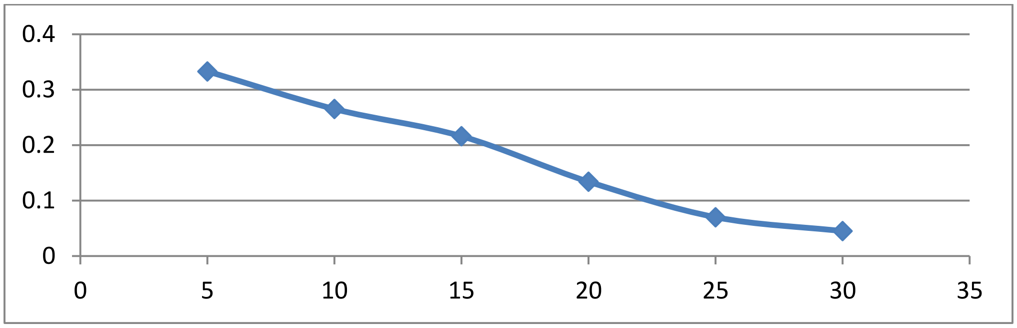
X

Figure (5.2. 33): relation between (X) and (I) of ZAIN tower (3) at R.N state

Table (5. 2. 34): Relation between (X) and (I) for ZAIN tower (4) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.333	0.265	0.216	0.134	0.070	0.045

I $(\mathrm{mw}\backslash\mathrm{m}^2)$



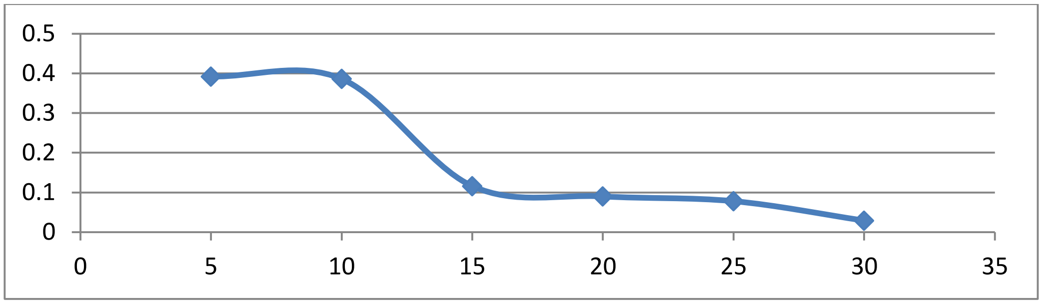
X

Figure (5.2. 34): relation between (X) and (I) of ZA IN tower (4) at R.N state

Table (5. 2. 35): Relation between (X) and (I) for ZAIN tower (5) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^{3}$	0.392	0.386	0.116	0.090	0.078	0.029

I (mw\m^2)



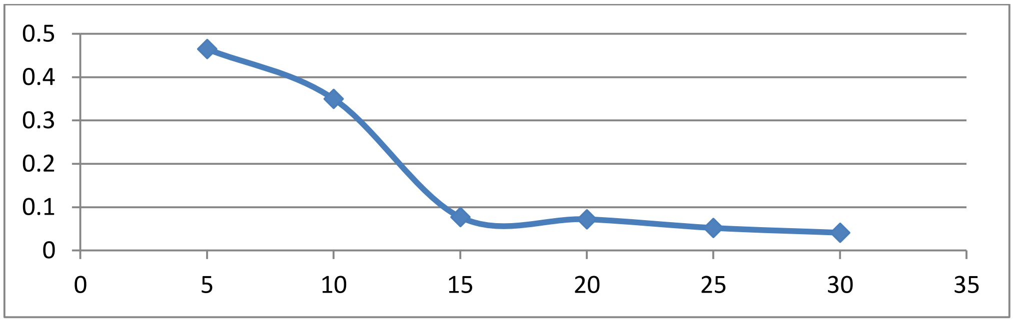
X

Figure (5.2. 35): relation between (X) and (I) of ZAIN tower (5) at R.N state

Table (5. 2. 36): Relation between (X) and (I) for ZAIN tower (6) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^{3}$	0.465	0.350	0.077	0.072	0.052	0.041

I (mw\m^2)



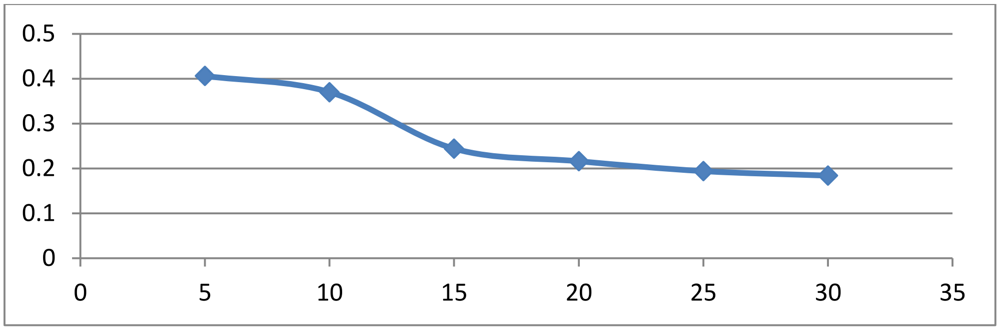
X

Figure (5.2. 36): relation between (X) and (I) of ZA IN tower (6) at R.N state

Table (5. 2. 37): Relation between (X) and (I) for ZAIN tower (7) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.406	0.370	0.244	0.216	0.194	0.184

I (mw\m^2)



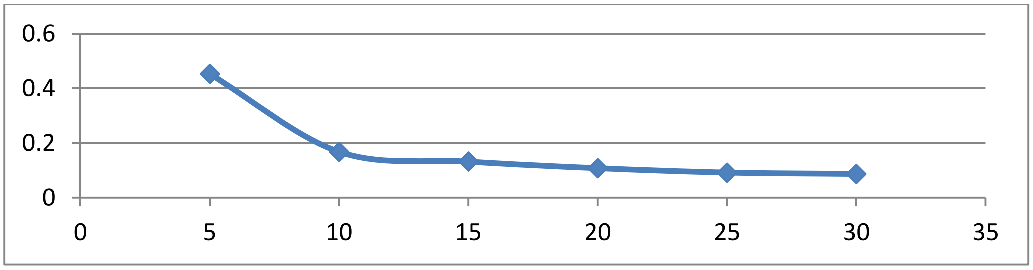
X

Figure (5.2. 37): relation between X and I of ZA IN tower (7) at R.N state

Table (5. 2. 38): Relation between (X) and (I) for ZAIN tower (8) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.453	0.168	0.132	0.108	0.092	0.087

I (mw\m^2)



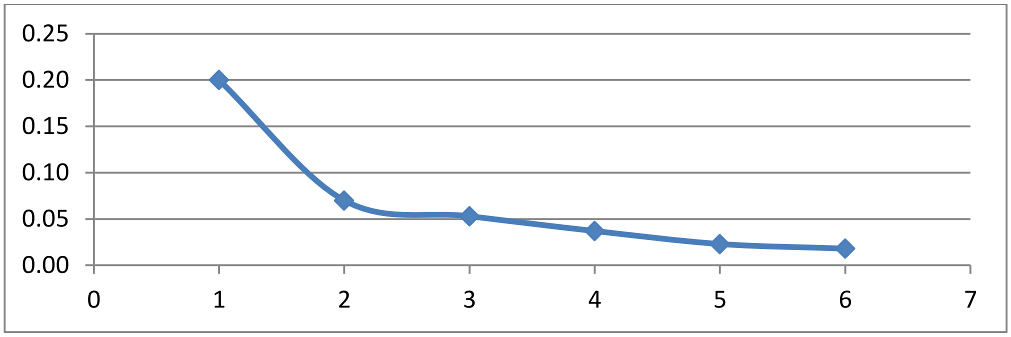
X

Figure (5.2. 38): relation between (X) and (I) of ZAIN tower (8) at R.N state

Table (5. 2. 39): Relation between (X) and (I) for ZAIN tower (9) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.200	0.070	0.053	0.037	0.023	0.018

I (mw\m^2)



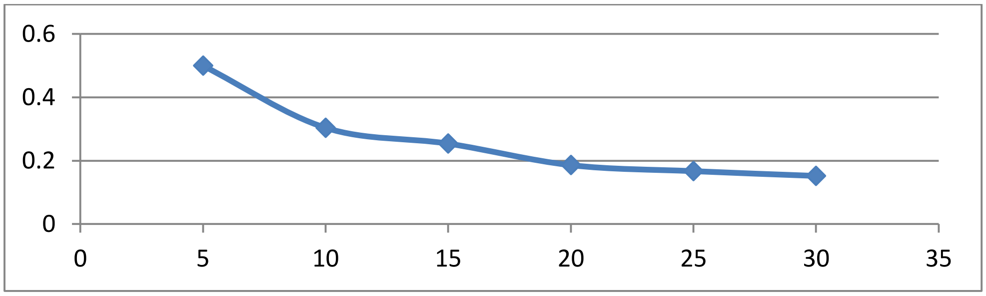
X

Figure (5.2. 39): relation between (X) and (I) of ZAIN tower (9) at R.N state

Table (5. 2. 40): Relation between (X) and (I) for ZAIN tower (10) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.500	0.304	0.254	0.186	0.167	0.152

I (mw\m^2)



X

Figure (5.2. 40): relation between (X) and (I) of ZAIN tower (10) at R.N state

Table (5. 2. 41): Relation between (X) and (I) for sudani tower (1) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.402	0.377	0.335	0.328	0.312	0.261

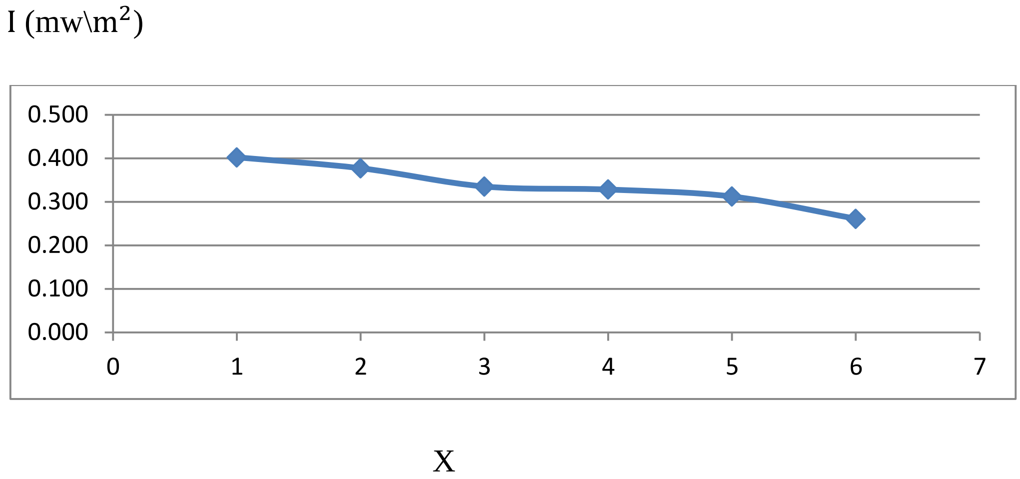


Figure (5.2. 41): relation between (X) and (I) of sudani tower (1) at R.N state

Table (5. 2. 42): Relation between (X) and (I) for sudani tower (2) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.081	0.054	0.048	0.036	0.031	0.007

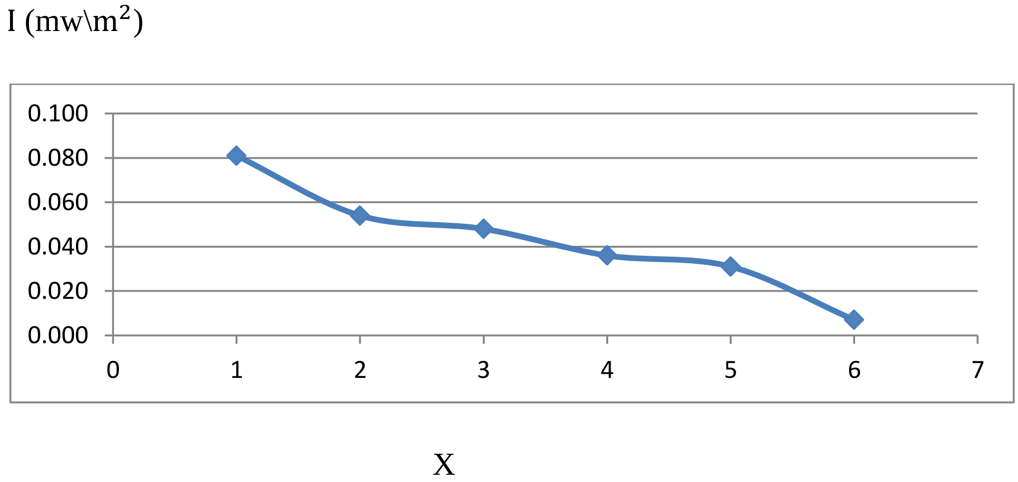
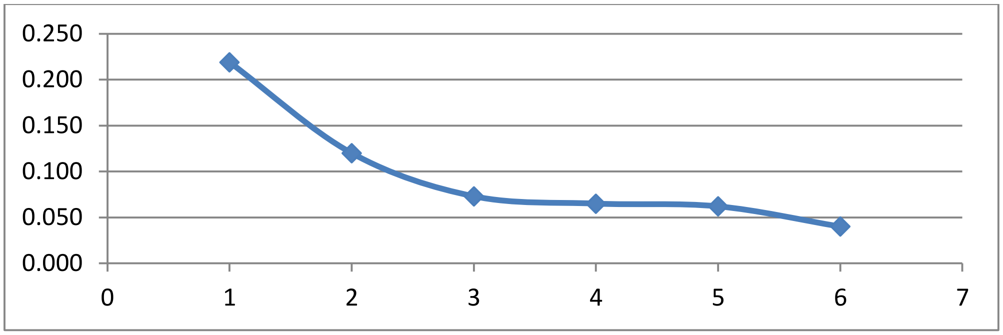


_Figure (5.2. 42): relation between (X) and (I) of sudani tower (2) at R.N state

Table (5. 2. 43): Relation between (X) and (I) for sudani tower (3) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.219	0.120	0.073	0.065	0.062	0.040

I (mw\m^2)



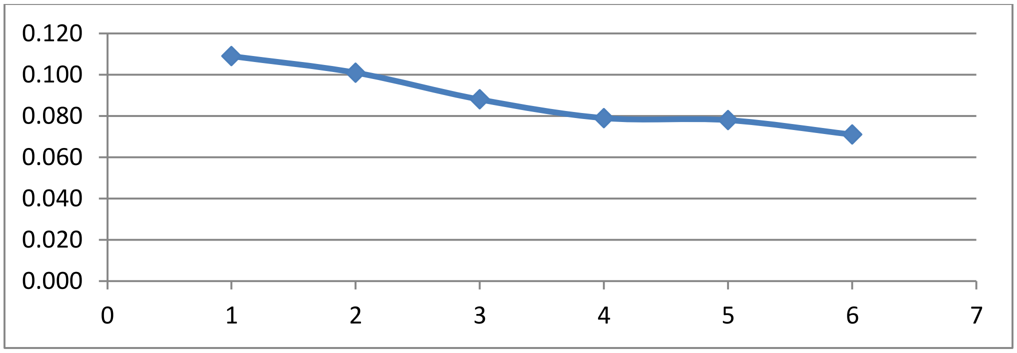
X

Figure (5.2. 43): relation between X and I of sudani tower (3) at R.N state

Table (5. 2. 44): Relation between (X) and y (I) for sudani tower (4) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.109	0.101	0.088	0.079	0.078	0.071

I (mw\m^2)



X

Figure (5.2. 44): relation between (X) and (I) of sudani tower (4) at R.N state

Table (5. 2. 45): Relation between (X) and (I) for sudani tower (5) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.314	0.150	0.020	0.013	0.007	0.004

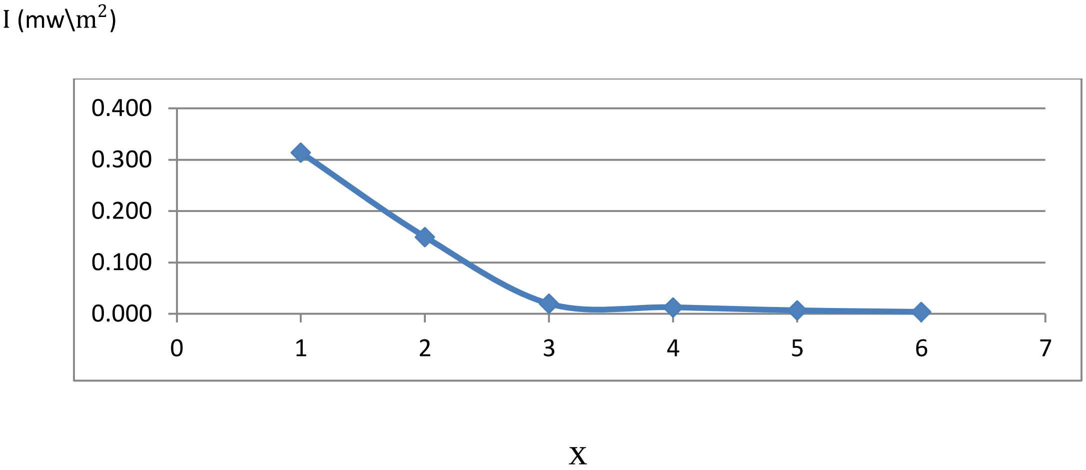


Figure (5.2. 45): relation between (X) and (I) of sudani tower (5) at R.N state

Table (5. 2. 46): Relation between (X) and (I) for sudani tower (6) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.481	0.367	0.323	0.128	0.065	0.054

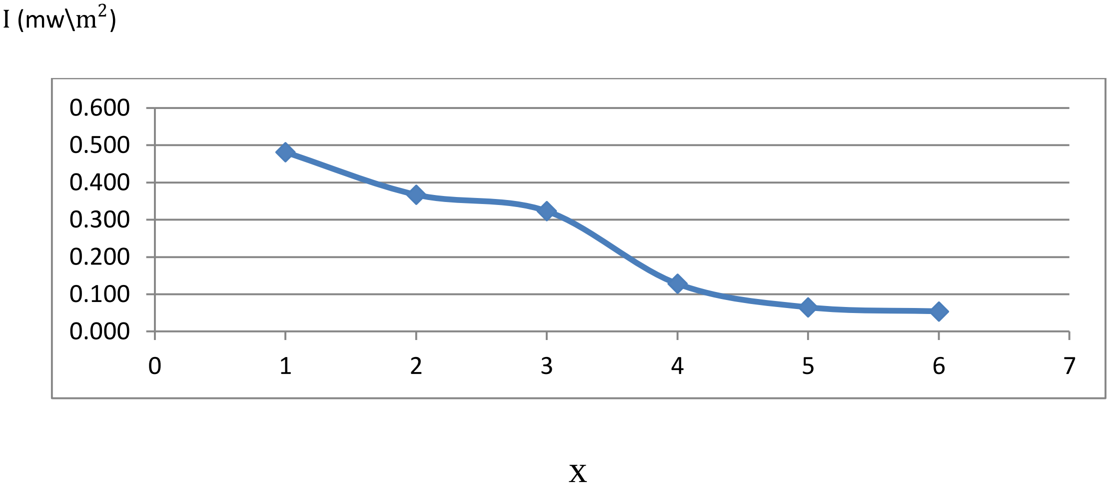


Figure (5.2. 46): relation between (X) and (I) of sudani tower (6) at R.N state

Table (5. 2. 47): Relation between (X) and (I) for sudani tower (7) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.154	0.153	0.124	0.087	0.053	0.053

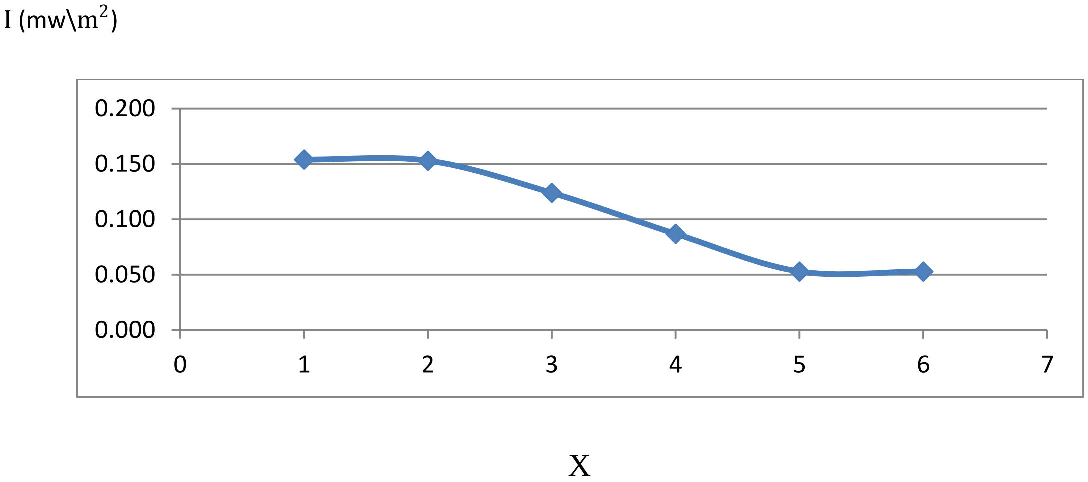


Figure (5.2. 47): relation between (X) and (I) of sudani tower (7) at R.N state

Table (5. 2. 48): Relation between (X) and (I) for sudani tower (8) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.057	0.025	0.007	0.006	0.006	0.004

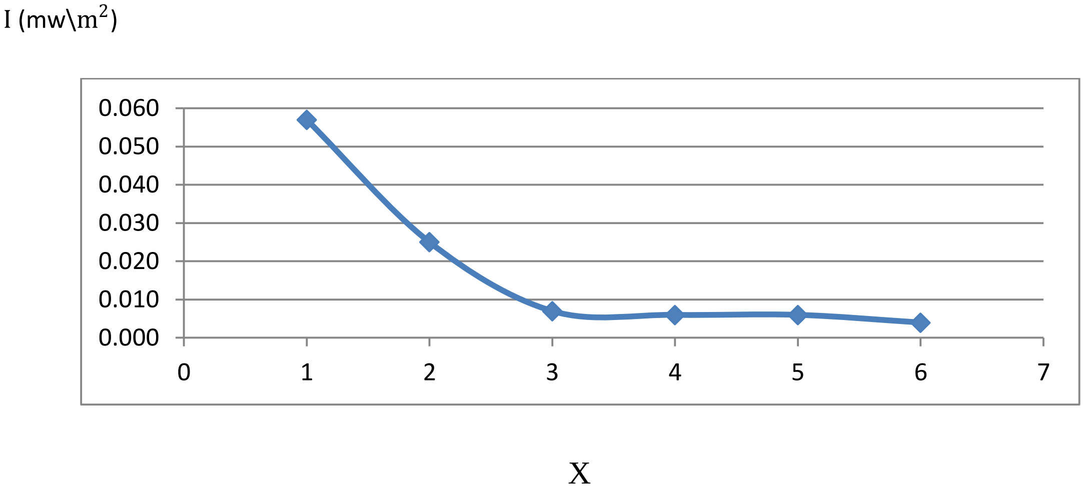


Figure (5.2. 48): relation between (X) and (I) of sudani tower (8) at R.N state

Table (5. 2. 49): Relation between (X) and (I) for sudani tower (9) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.083	0.066	0.038	0.034	0.027	0.018

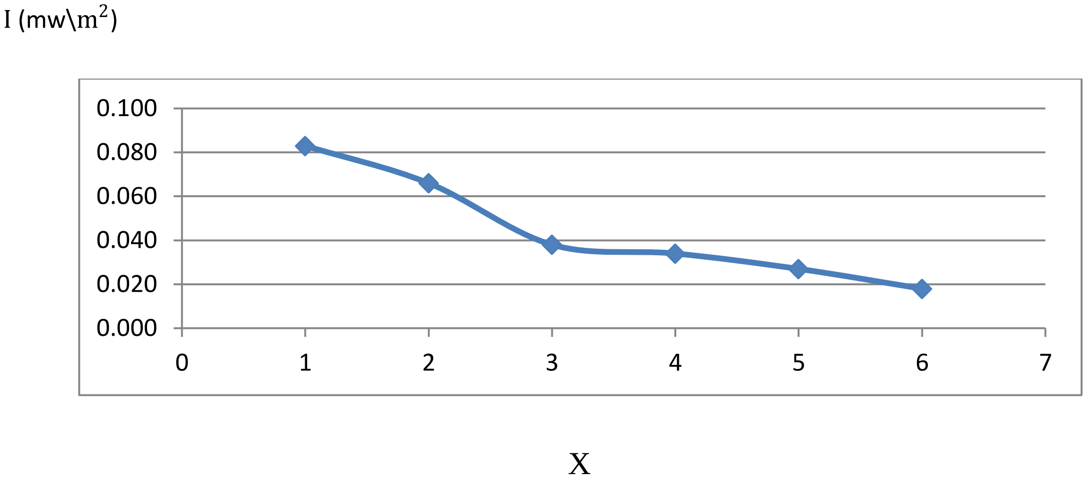


Figure (5.2. 49): relation between (X) and (I) of sudani tower (9) at R.N state

Table (5. 2. 50): Relation between (X) and (I) for sudani tower (10) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.050	0.037	0.033	0.032	0.031	0.007

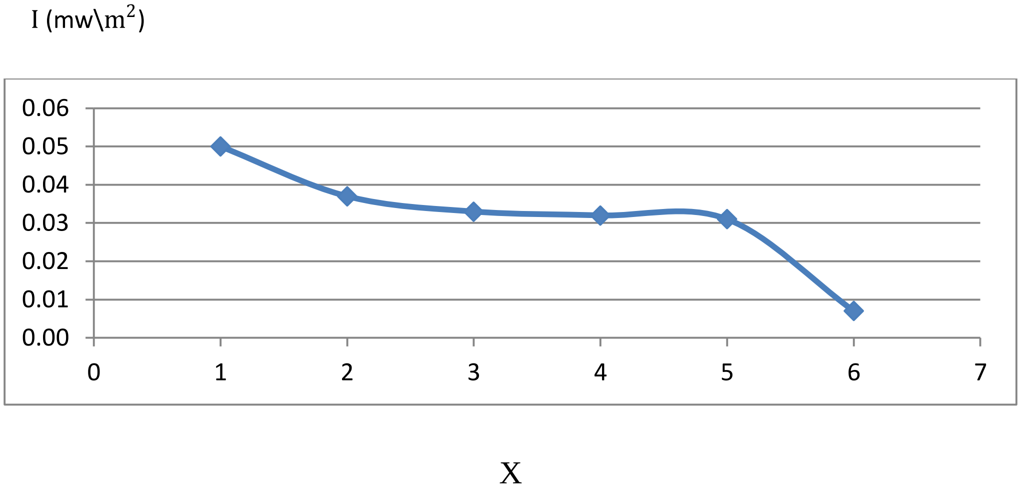


Figure (5.2. 50): relation between (X) and (I) of sudani tower (10) at R.N state

Table (5. 2. 51): Relation between (X) and (I) for MTN tower (1) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1\text{mw}\backslash m^3$	0.026	0.023	0.019	0.017	0.013	0.008

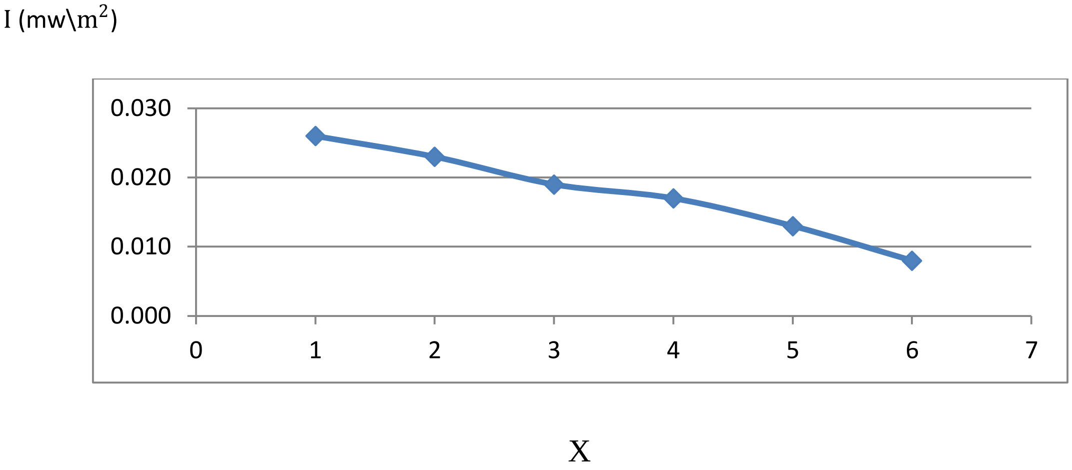


Figure (5.2. 51): relation between X and I of sudani tower (1) at R.N state

Table (5. 2. 52): Relation between (X) and (I) for MTN tower (2) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1\text{mw}\backslash m^3$	0.108	0.102	0.077	0.054	0.024	0.015

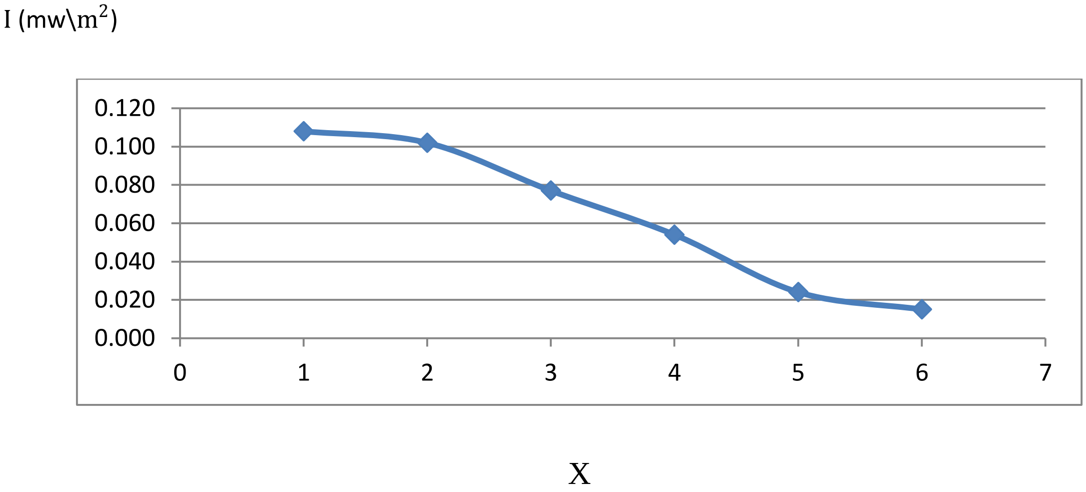


Figure (5.2. 52): relation between X and I of sudani tower (2) at R.N state

Table (5. 2. 53): Relation between (X) and (I) for MTN tower (3) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30

$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.042	0.027	0.019	0.014	0.012	0.007

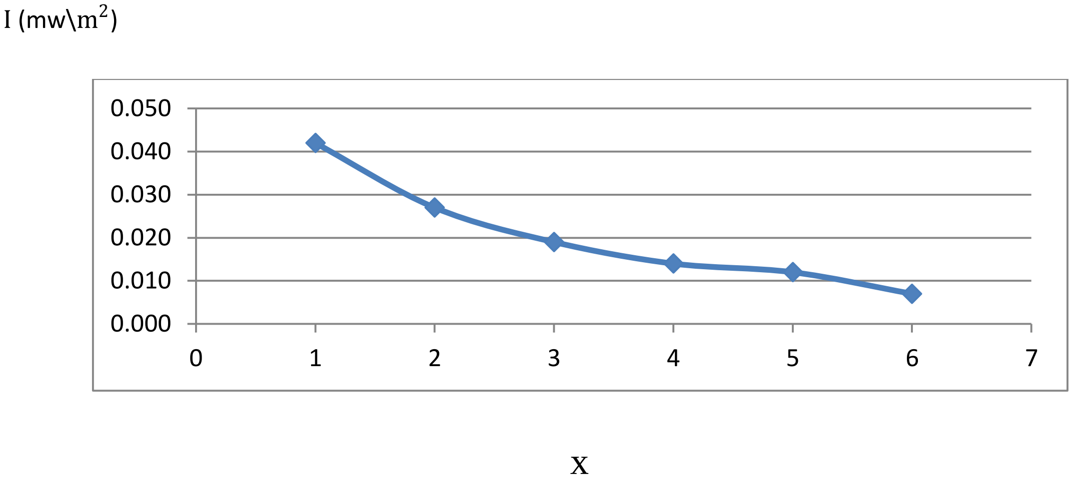


Figure (5.2. 53): relation between X and I of sudani tower (3) at R.N state

Table (5.2. 54): Relation between (X) and (I) for MTN tower (4) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.067	0.055	0.033	0.025	0.022	0.020

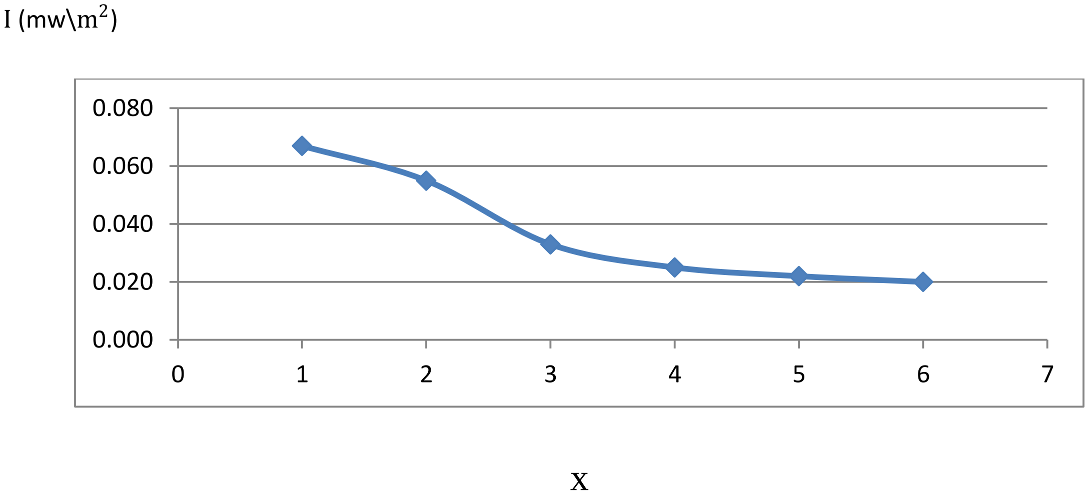


Figure (5.2. 54): relation between X and I of sudani tower (4) at R.N state

Table (5.2. 55): Relation between (X) and (I) for MTN tower (5) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.510	0.306	0.260	0.253	0.168	0.149

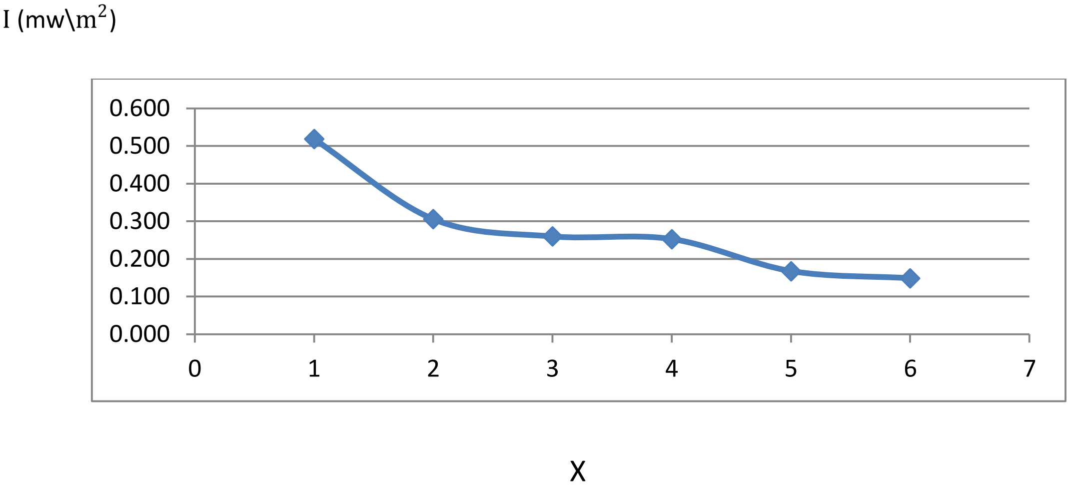


Figure (5.2. 55): relation between X and I of sudani tower (5) at R.N state

Table (5.2. 56): Relation between (X) and (I) for MTN tower (6) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.013	0.012	0.009	0.008	0.005	0.004

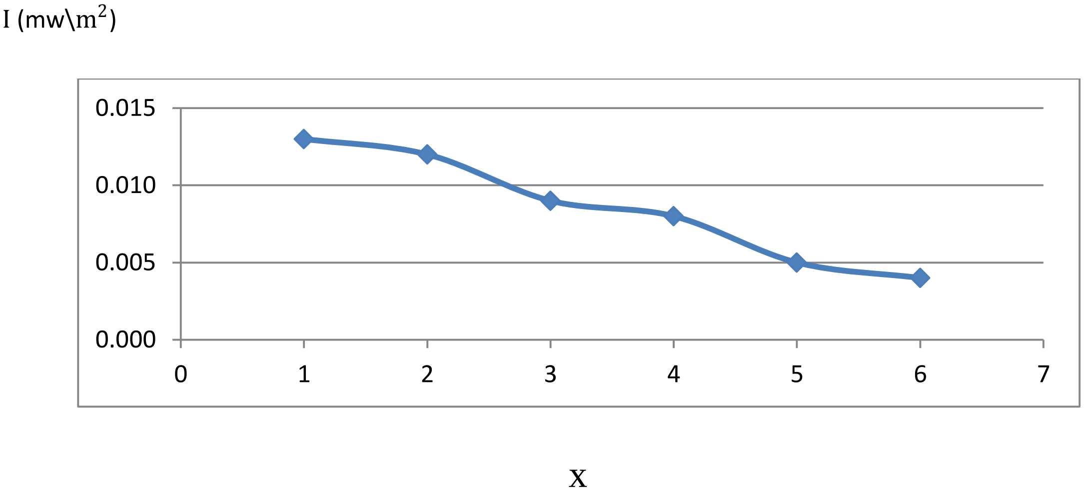


Figure (5.2. 56): relation between X and I of sudani tower (6) at R.N state

Table (5.2. 57): Relation between (X) and (I) for MTN tower (7) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.024	0.021	0.015	0.012	0.006	0.006

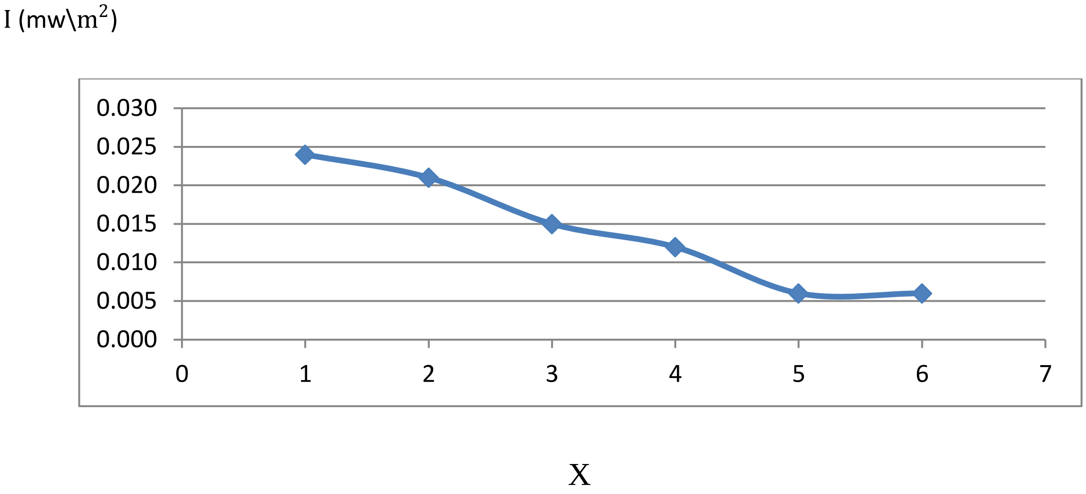


Figure (5.2. 57): relation between X and I of sudani tower (7) at R.N state

Table (5.2. 58): Relation between (X) and (I) for MTN tower (8) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.107	0.069	0.065	0.050	0.041	0.020

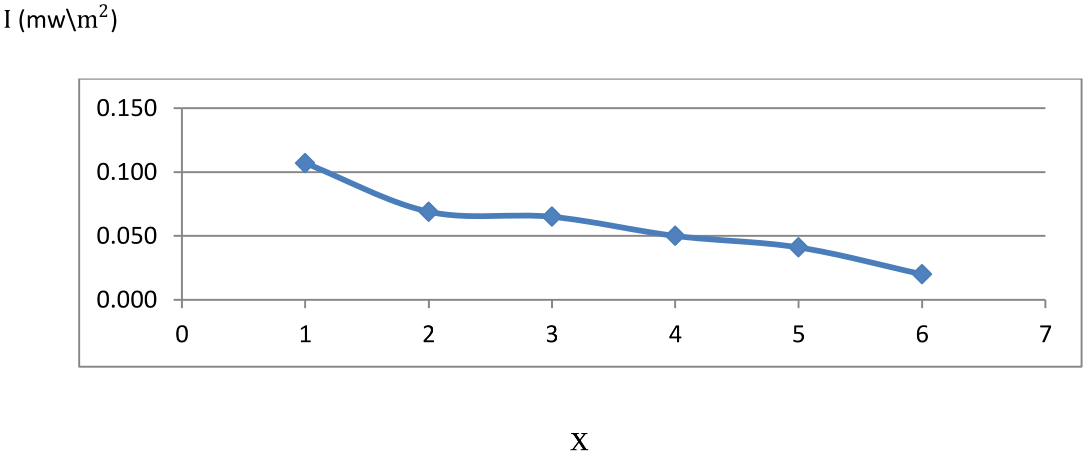


Figure (5.2. 58): relation between X and I of sudani tower (8) at R.N state

Table (5.2. 59): Relation between (X) and (I) for MTN tower (9) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.479	0.343	0.310	0.276	0.230	0.206

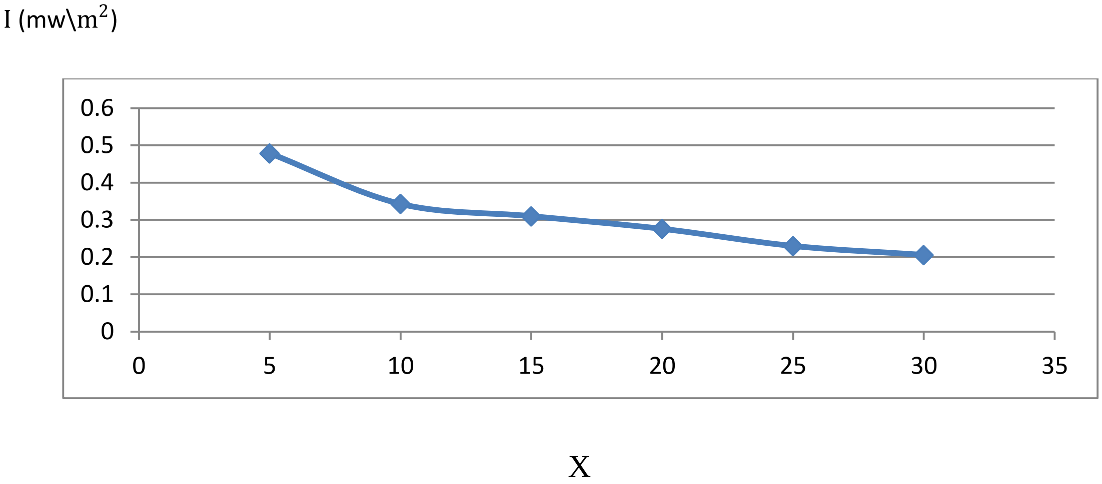


Figure (5.2. 59): relation between X and I of sudani tower (9) at R.N state

Table (5.2. 60): Relation between (X) and (I) for MTN tower (10) at R.N state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.387	0.221	0.189	0.169	0.148	0.122

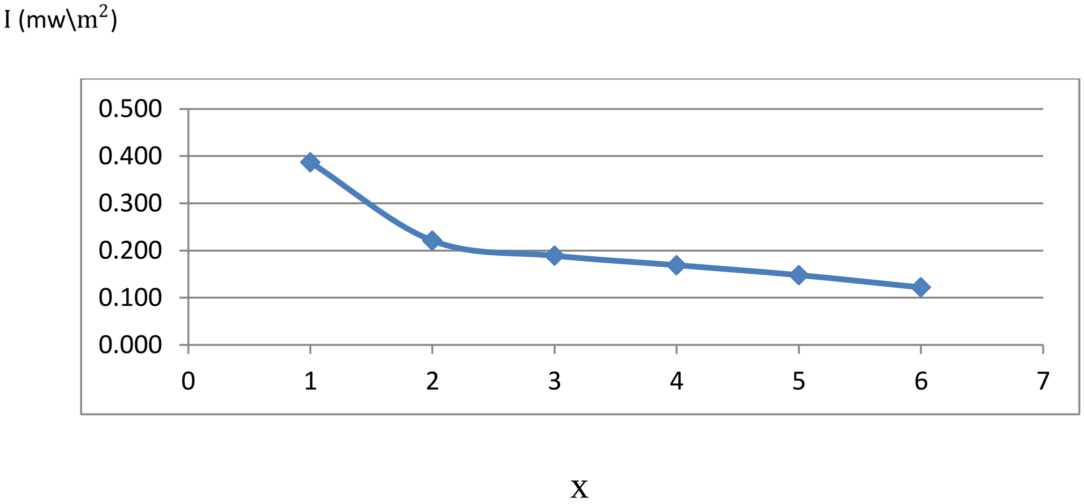


Figure (5.2. 60): relation between X and I of sudani tower (10) at R.N state

Table (5.2. 61): Relation between (X) and (I) for zain tower (1) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.310	0.173	0.088	0.042	0.029	0.05

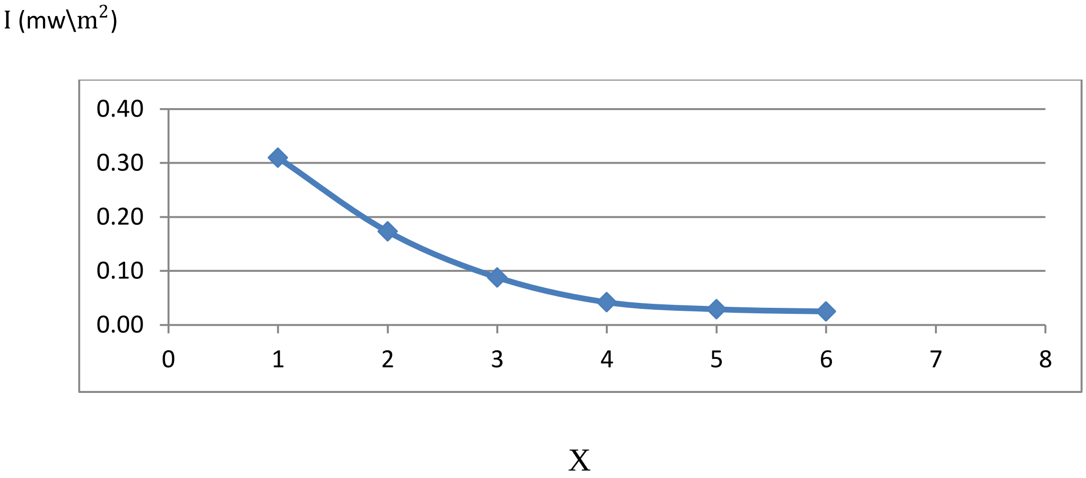


Figure (5.2. 61): relation between X and I of zain tower (1) at R.sea state

Table (5.2. 62): Relation between (X) and (I) for zain tower (2) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\m^3	0.173	0.057	0.013	0.012	0.011	0.005

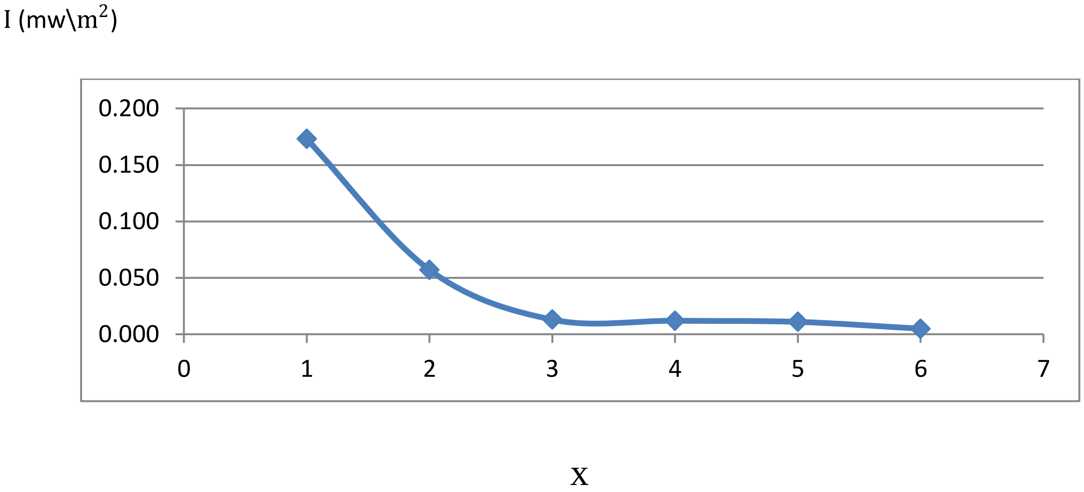


Figure (5.2. 62): relation between X and I of zain tower (2) at R.sea state

Table (5.2. 63): Relation between (X) and (I) for zain tower (3) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30

$I \pm 1mw\backslash m^3$	0.204	0.177	0.167	0.115	0.110	0.090

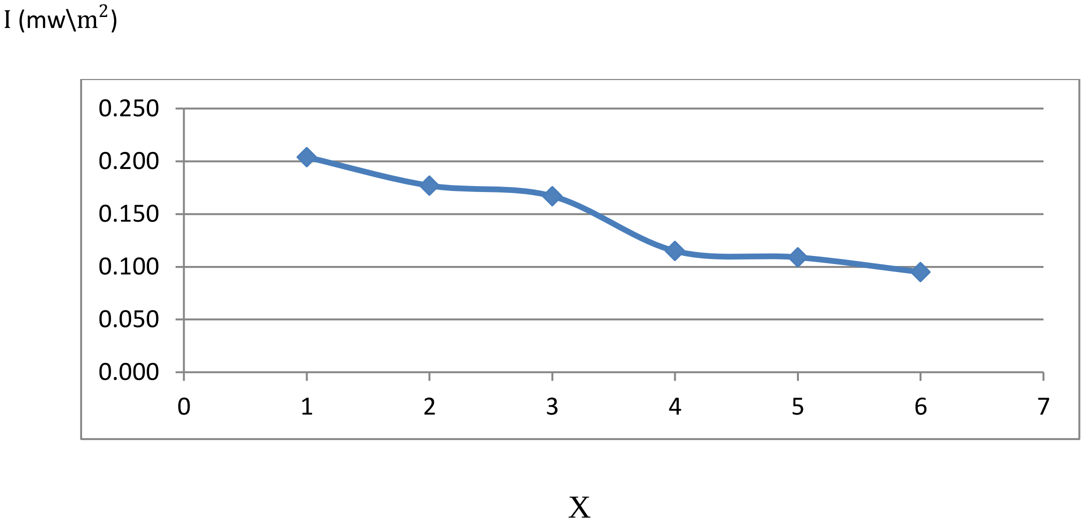


Figure (5.2. 63): relation between X and I of zain tower (3) at R.sea state

Table (5.2. 64): Relation between (X) and (I) for zain tower (4) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.063	0.047	0.033	0.027	0.017	0.012

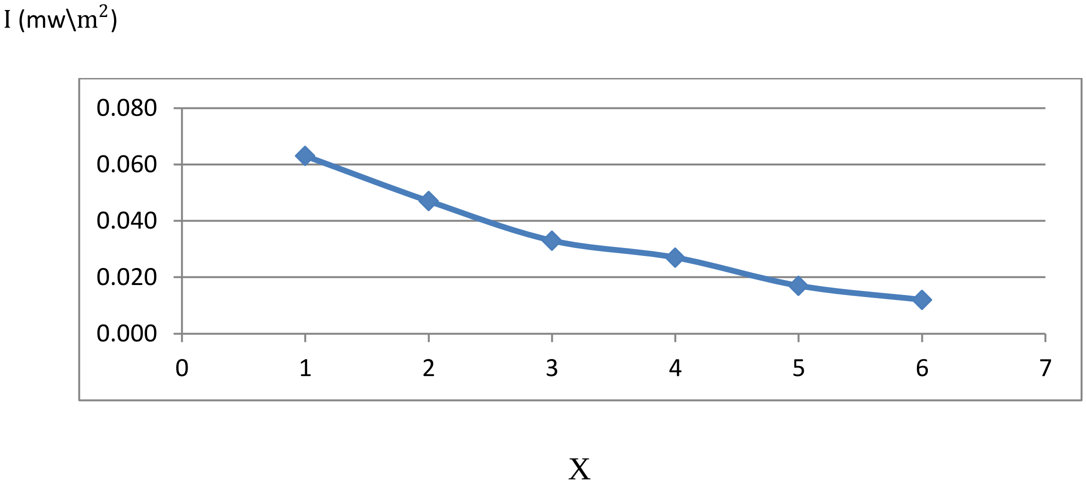


Figure (5.2. 64): relation between X and I of zain tower (4) at R.sea state

Table (5.2. 65): Relation between (X) and (I) for zain tower (5) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30

$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.470	0.130	0.054	0.047	0.018	0.016

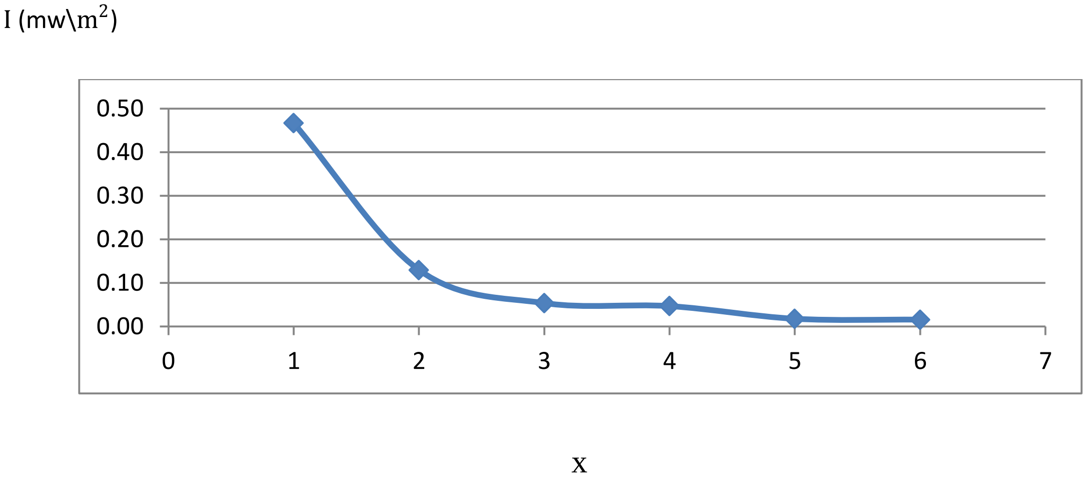


Figure (5.2. 65): relation between X and I of zain tower (5) at R.sea state

Table (5.2. 66): Relation between (X) and (I) for zain tower (6 at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.018	0.012	0.005	0.004	0.004	0.003

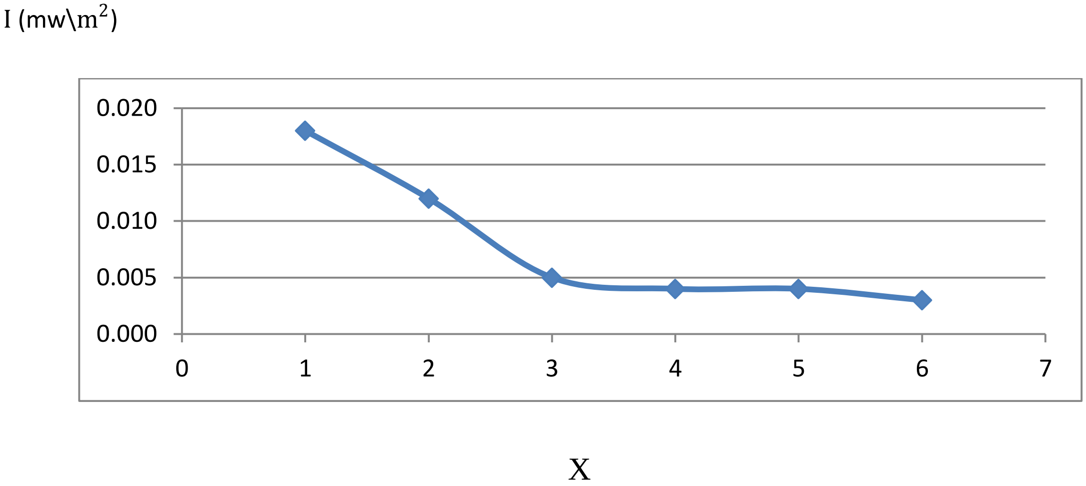


Figure (5.2. 66): relation between X and I of zain tower (6) at R.sea state

Table (5.2. 67): Relation between (X) and (I) for zain tower (7) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.118	0.017	0.017	0.012	0.010	0.001

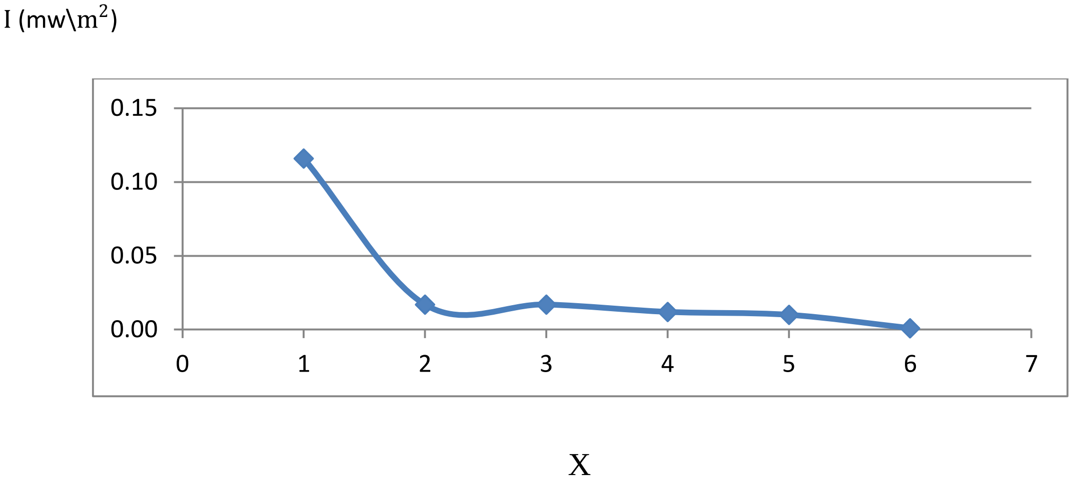


Figure (5.2. 67): relation between X and I of zain tower (7) at R.sea state

Table (5.2. 68): Relation between (X) and (I) for zain tower (8) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.026	0.023	0.018	0.009	0.009	0.004

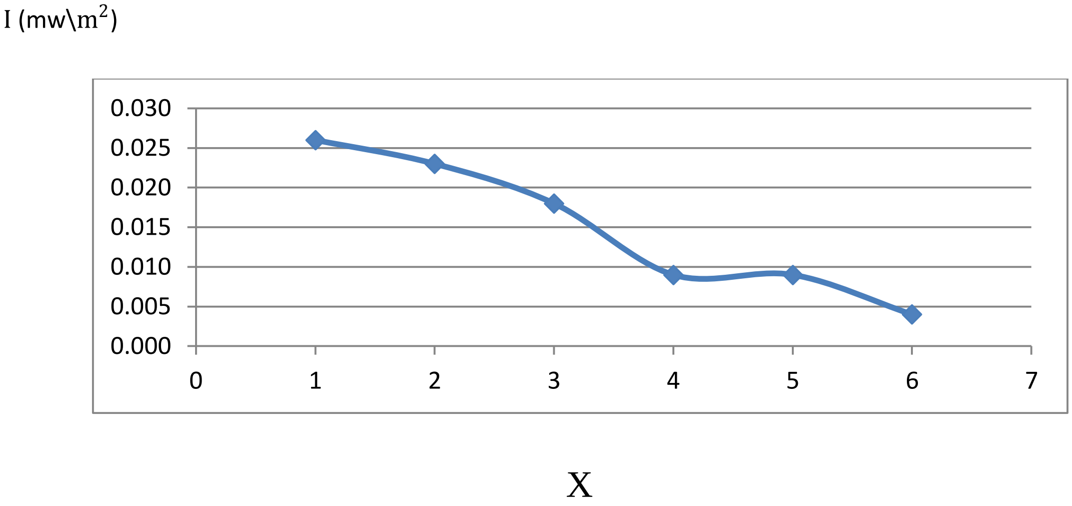


Figure (5.2. 68): relation between X and I of zain tower (8) at R.sea state

Table (5.2. 69): Relation between (X) and (I) for zain tower (9) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.290	0.105	0.101	0.073	0.034	0.031

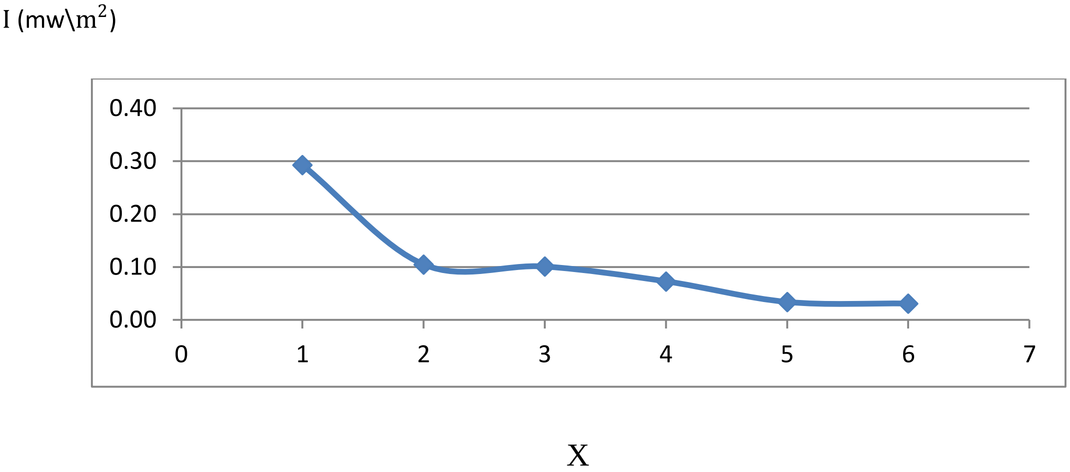


Figure (5.2. 69): relation between X and I of zain tower (9) at R.sea state

Table (5.2.70): Relation between (X) and (I) for zain tower (10) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.049	0.048	0.043	0.040	0.016	0.010

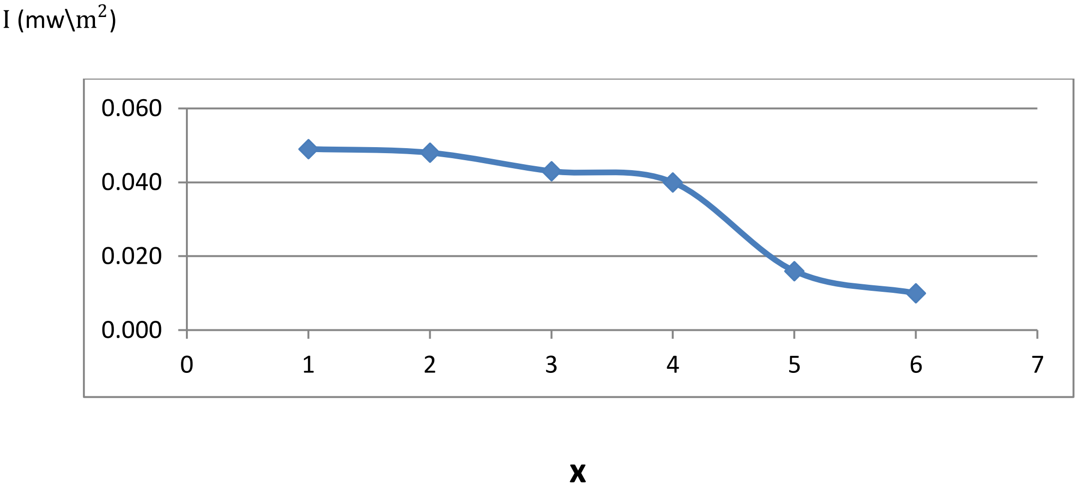


Figure (5.2. 70): relation between X and I of zain tower (10) at R.sea state

Table (5.2.71): Relation between (X) and (I) for sudani tower (1) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.470	0.204	0.060	0.053	0.048	0.046

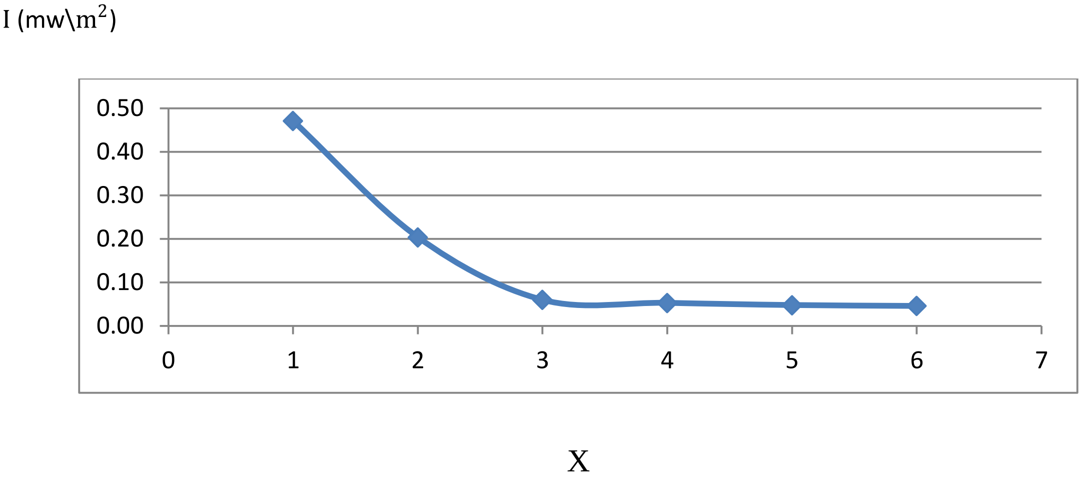


Figure (5.2. 71): relation between X and I of sudani tower (1) at R.sea state

Table (5.2.72): Relation between (X) and (I) for sudani tower (2) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.256	0.136	0.113	0.090	0.086	0.056

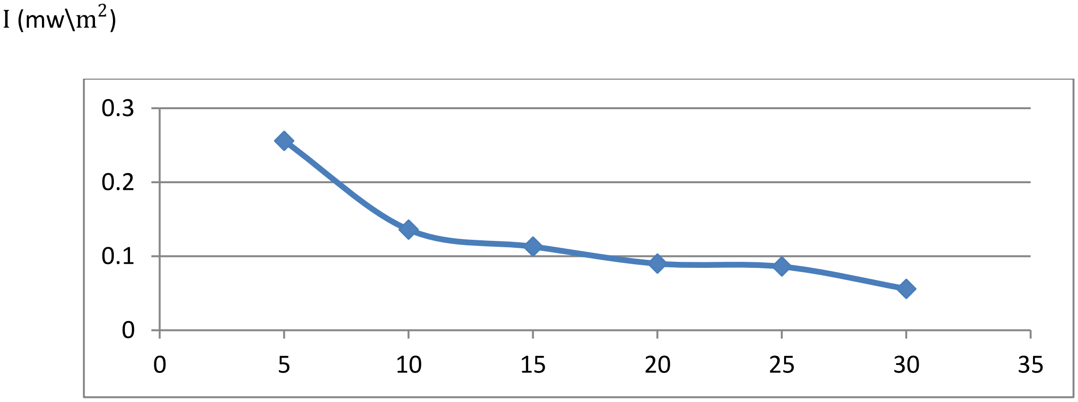
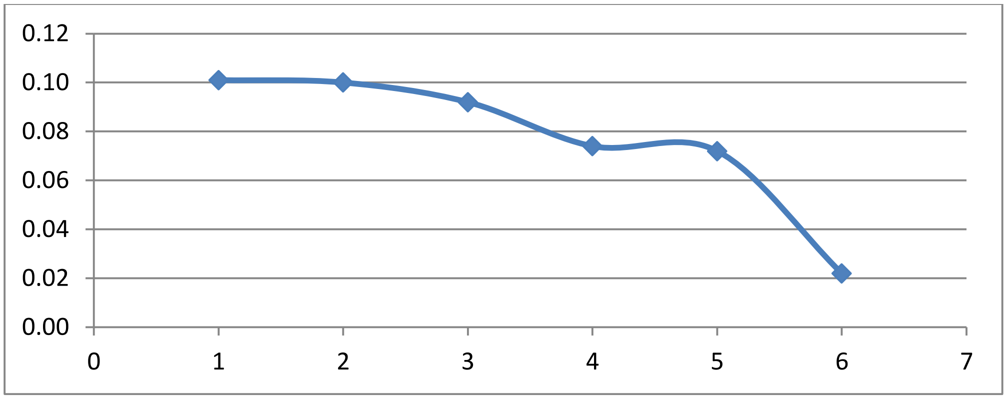


Figure (5.2. 72): relation between X and I of sudani tower (2) at R.sea state

Table (5.2.73): Relation between (X) and (I) for sudani tower (3) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.100	0.100	0.092	0.074	0.072	0.022

I (mw\m^2)

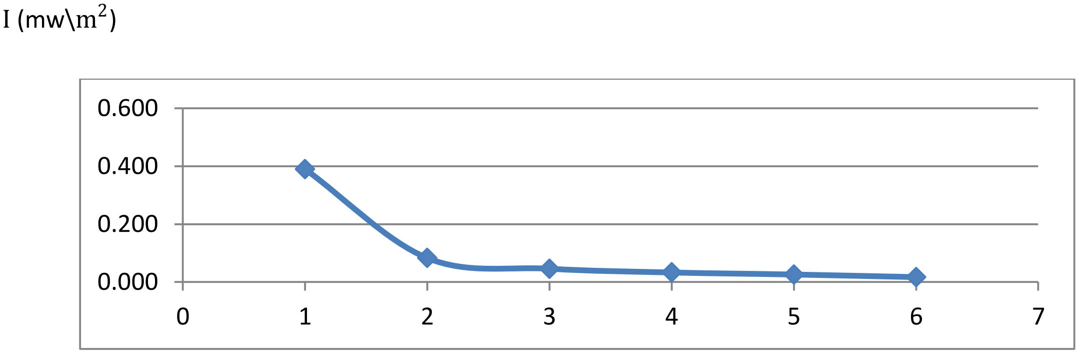


X

Figure (5.2. 73): relation between X and I of sudani tower (3) at R.sea state

Table (5.2.74): Relation between (X) and (I) for sudani tower (4) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.390	0.083	0.046	0.033	0.026	0.017



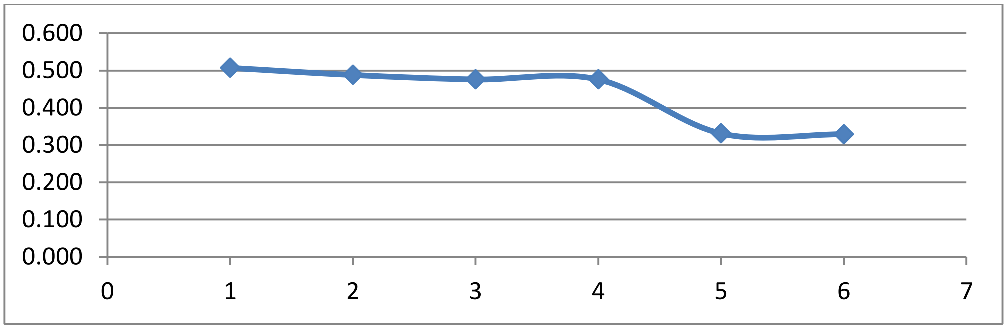
X

Figure (5.2. 74): relation between X and I of sudani tower (4) at R.sea state

Table (5.2.75): Relation between (X) and (I) for sudani tower (5) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw} \backslash m^3$	0.500	0.488	0.476	0.476	0.331	0.329

I (mw\m^2)



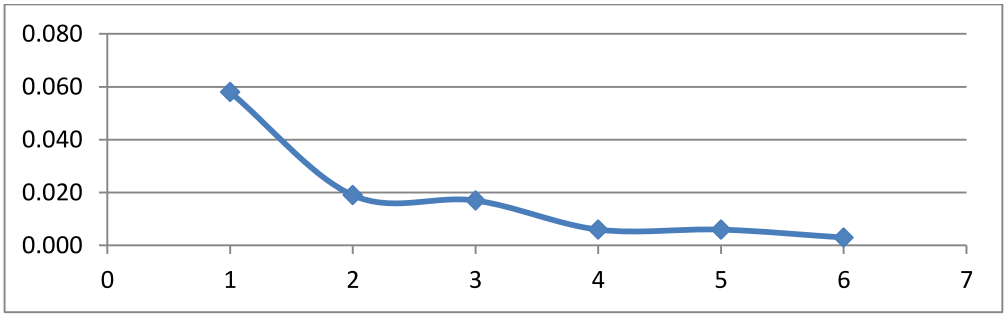
X

Figure (5.2. 75): relation between X and I of sudani tower (5) at R.sea state

Table (5.2.76): Relation between (X) and (I) for sudani tower (6) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.058	0.019	0.017	0.006	0.006	0.003

I (mw\m^2)



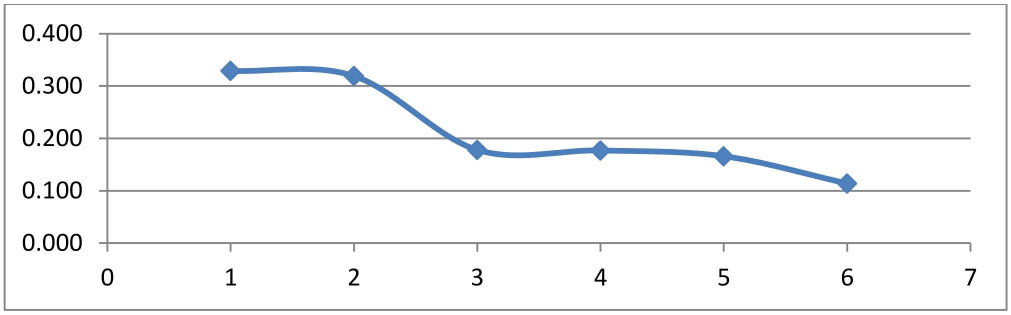
X

Figure (5.2. 76): relation between X and I of sudani tower (6) at R.sea state

Table (5.2.77): Relation between (X) and (I) for sudani tower (7) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$I \pm 1mw\backslash m^3$	0.329	0.319	0.178	0.177	0.166	0.114

I (mw\m^2)



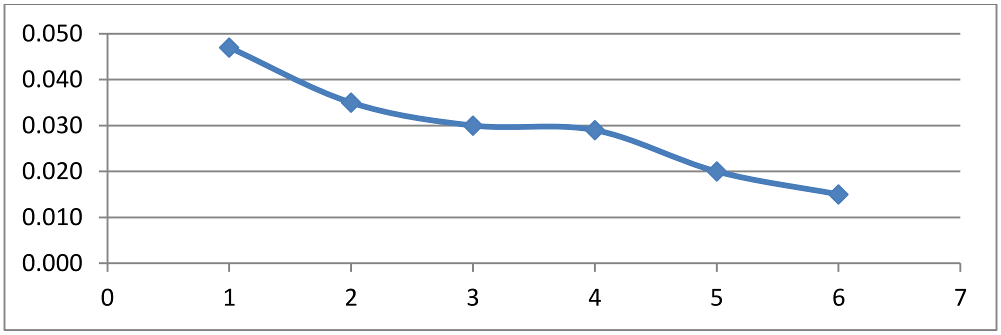
X

Figure (5.2. 77): relation between X and I of sudani tower (7) at R.sea state

Table (5.2.78): Relation between (X) and (I) for sudani tower (8) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.047	0.035	0.030	0.029	0.020	0.015

I (mw\m^2)



X

Figure (5.2. 78): relation between X and I of sudani tower (8) at R.sea state

Table (5.2.79): Relation between (X) and (I) for sudani tower (9) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.098	0.093	0.056	0.053	0.050	0.021

I (mw\m^2)

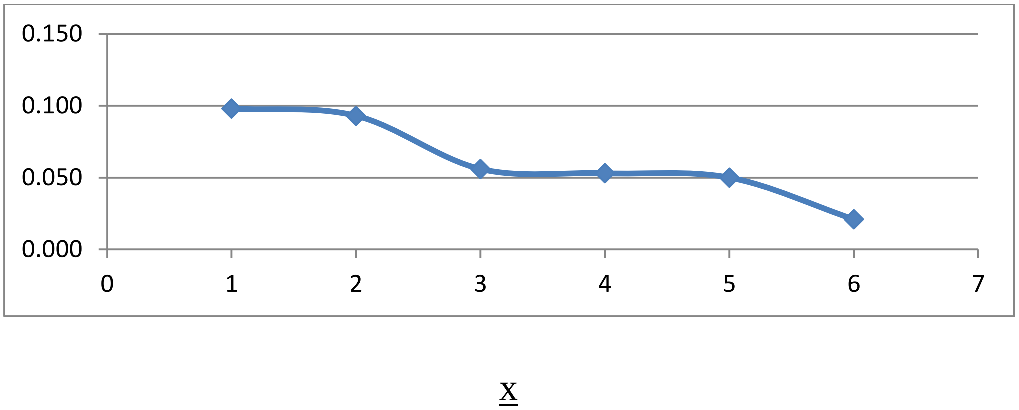


Figure (5.2. 79): relation between X and I of sudani tower (9) at R.sea state

Table (5.2.80): Relation between (X) and (I) for sudani tower (10) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.068	0.055	0.054	0.047	0.046	0.036

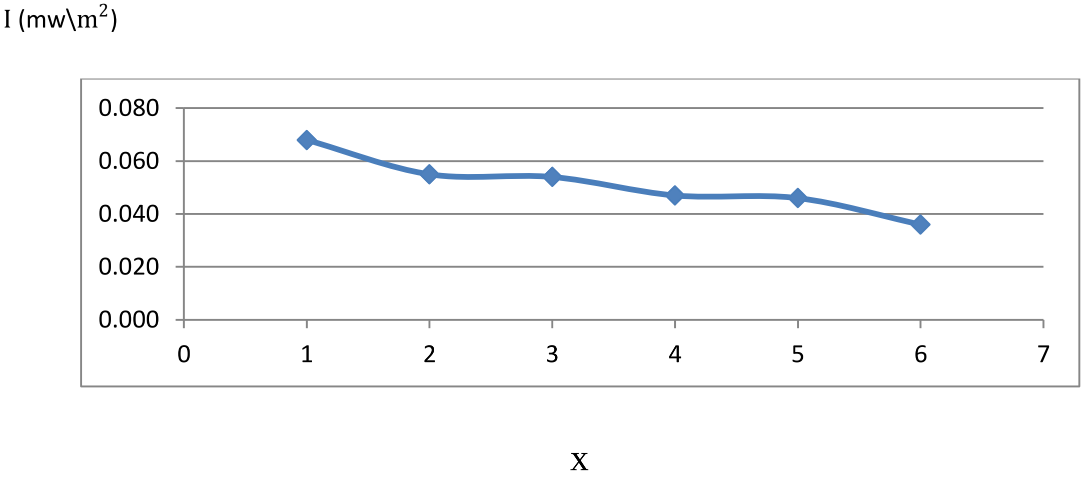
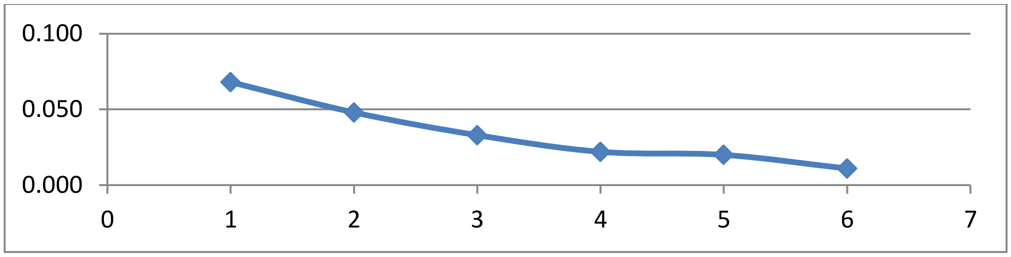


Figure (5.2. 80): relation between X and I of sudani tower (10) at R.sea state

Table (5.2.81): Relation between (X) and (I) for MTN tower (1) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.068	0.048	0.033	0.022	0.020	0.011

I (mw\m^2)



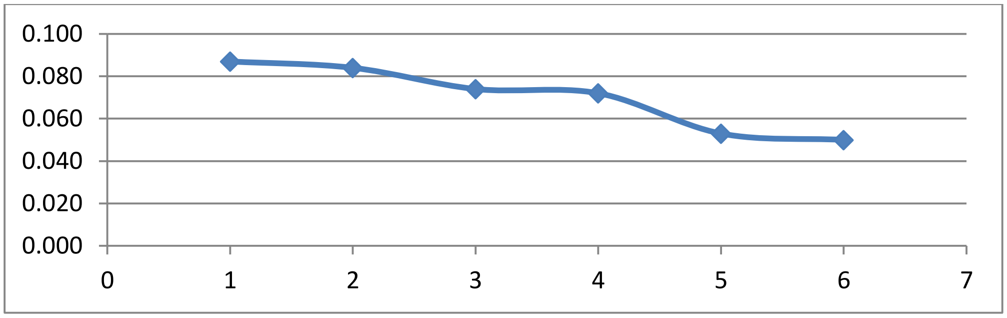
X

Figure (5.2. 81): relation between X and I of MTN tower (1) at R.sea state

Table (5.2.82): Relation between (X) and (I) for MTN tower (2) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.087	0.084	0.074	0.072	0.053	0.050

I (mw\m^2)



X

Figure (5.2. 82): relation between X and I of MTN tower (2) at R.sea state

Table (5.2.83): Relation between (X) and (I) for MTN tower (3) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^3$	0.134	0.133	0.103	0.069	0.056	0.029

I (mw\m^2)

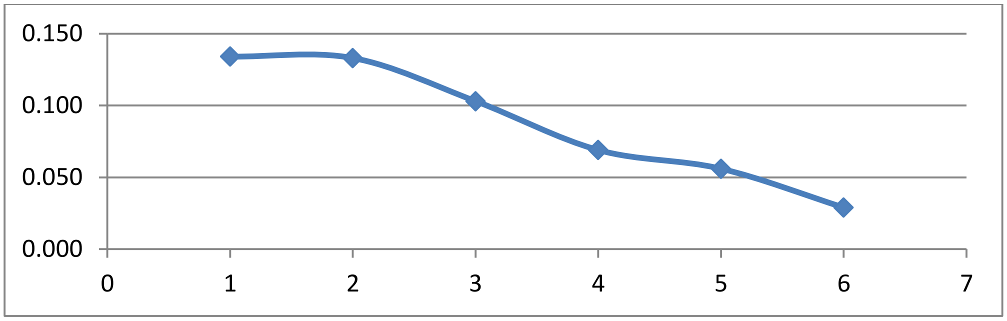


Figure (5.2. 83): relation between X and I of MTN tower (3) at R.sea state

Table (5.2.84): Relation between (X) and (I) for MTN tower (4) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.056	0.054	0.044	0.042	0.039	0.027

I (mw\m^2)

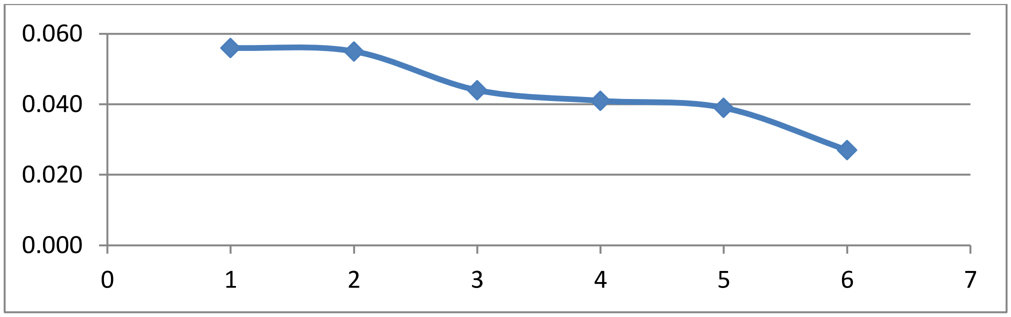
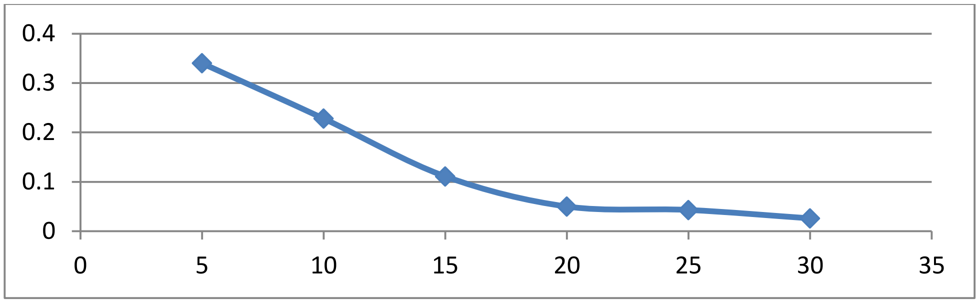


Figure (5.2. 84): relation between X and I of MTN tower (4) at R.sea state

Table (5.2.85): Relation between (X) and (I) for MTN tower (5) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
$\mathrm{I} \pm 1\mathrm{mw}\backslash m^{3}$	0.340	0.228	0.111	0.050	0.043	0.026

I (mw\m^2)



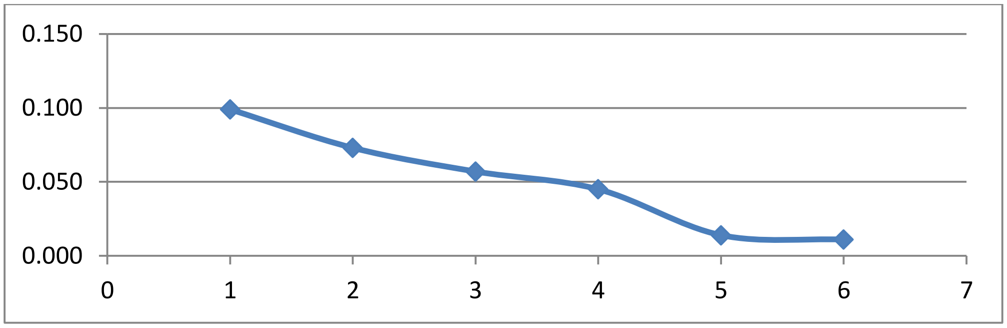
X

Figure (5.2. 85): relation between X and I of MTN tower (5) at R.sea state

Table (5.2.86): Relation between (X) and (I) for MTN tower (6) at R.sea state

$x \pm 10^{-3} m$	5	10	15	20	25	30
$\mathrm{I} \pm 1 \mathrm{mw} \backslash m^3$	0.099	0.073	0.057	0.045	0.014	0.011

I (mw\m^2)



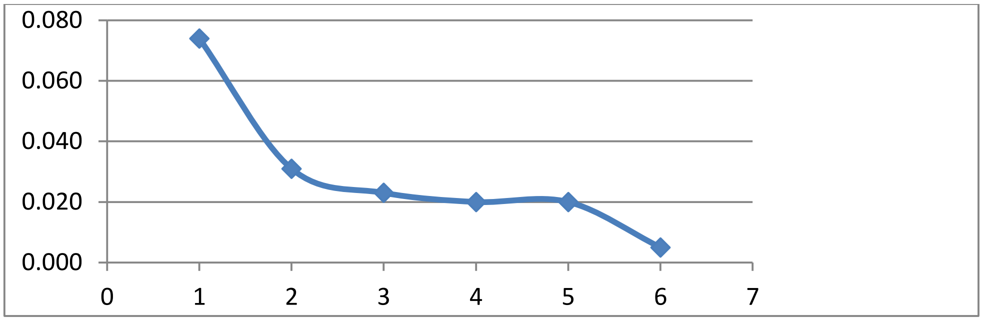
x

Figure (5.2. 86): relation between X and I of MTN tower (6) at R.sea state

Table (5.2.87): Relation between (X) and (I) for MTN tower (7) at R.sea state

$x \pm 10^{-3} m$	5	10	15	20	25	30
$\mathrm{I} \pm 1 \mathrm{mw} \backslash m^3$	0.074	0.031	0.023	0.020	0.020	0.005

I (mw\m^2)



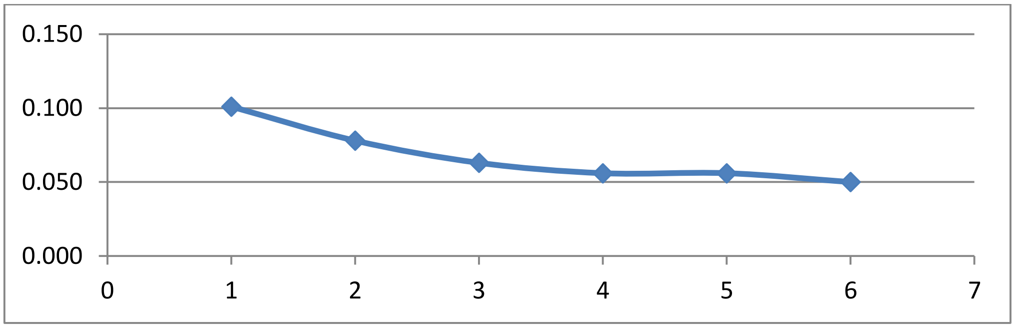
X

Figure (5.2. 87): relation between X and I of MTN tower (7) at R.sea state

Table (5.2.88): Relation between (X) and (I) for MTN tower (8) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.101	0.078	0.063	0.056	0.056	0.050

I (mw\m^2)



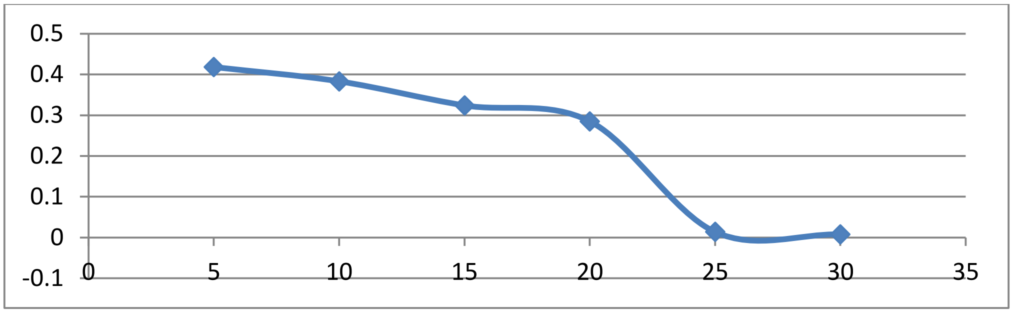
X

Figure (5.2. 88): relation between X and I of MTN tower (8) at R.sea state

Table (5.2.89): Relation between (X) and (I) for MTN tower (9) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.418	0.383	0.324	0.285	0.014	0.008

I (mw\m^2)



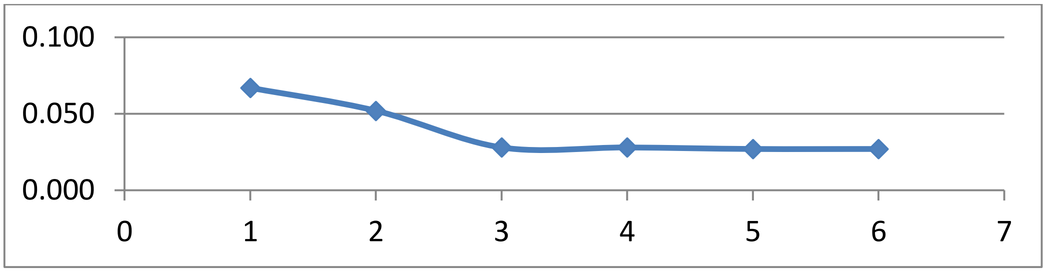
X

Figure (5.2. 89): relation between X and I of MTN tower (9) at R.sea state

Table (5.2.90): Relation between (X) and (I) for MTN tower (10) at R.sea state

$x \pm 10^{-3}m$	5	10	15	20	25	30
I $\pm$ 1mw\\m^3	0.067	0.052	0.028	0.028	0.027	0.027

I (mw\m^2)



X

Figure (5.2. 90): relation between X and I of MTN tower (10) at R.sea state

Table (5.2. 91): shows the relation between the horizontal distance (X) and radiation intensity (I).

X	10	20	30	40	50	60	70	80	90	100
I	0.01	0.0025	0.0011	0.0006	0.0004	0.0003	0.0002	0.00015	0.00012	0.0001

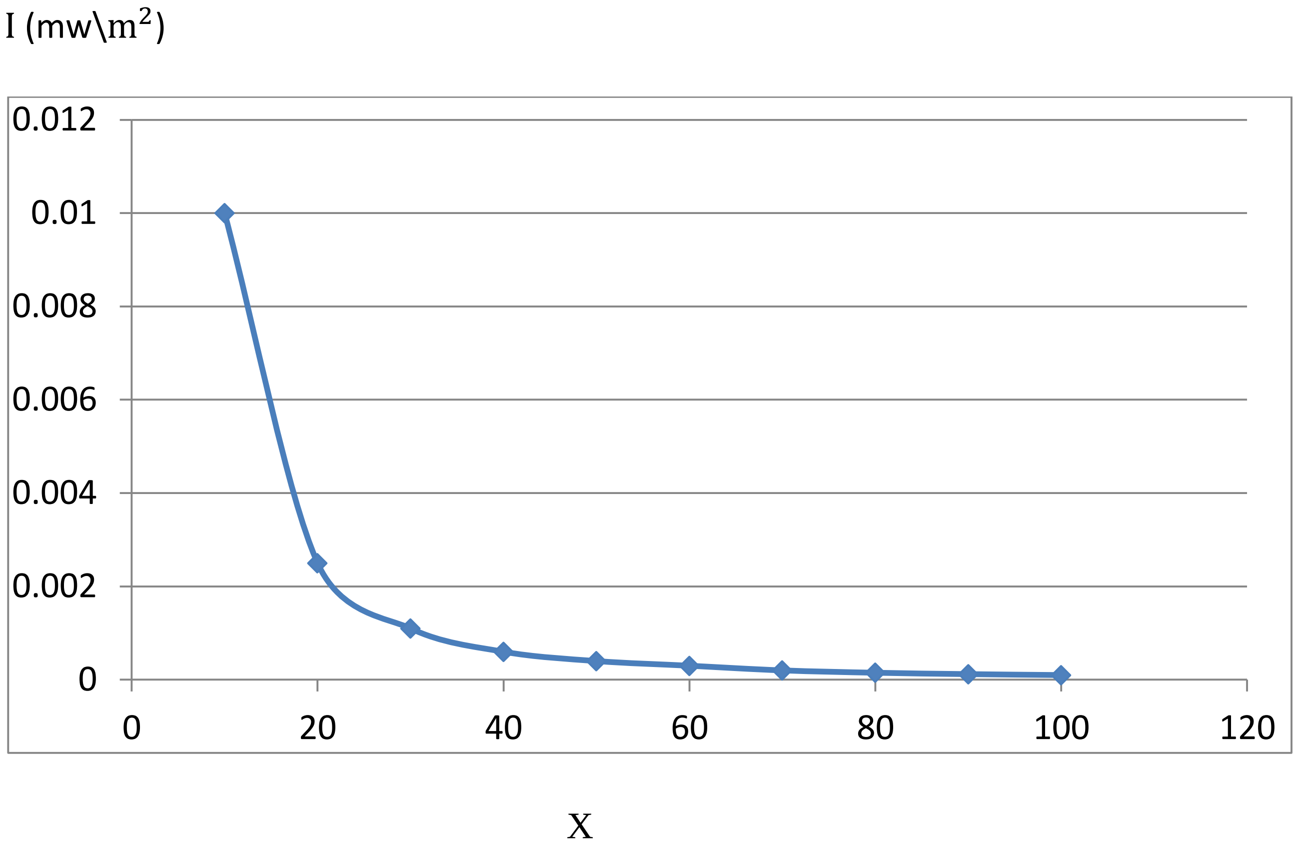


Figure (5.2. 91): shows the relation between the horizontal distance (X) and radiation intensity (I).

Table (5.2. 92): shows the relation between height of the tower (H) and radiation Intensity (I) of zain towers at Khartoum state, when horizontal distance is (5 m).

$h \pm 10^{-3}m$	13	15	20	22	25	30
$I \pm 1mw\backslash m^3$	0.118	0.128	0.131	0.223	0.366	0.512

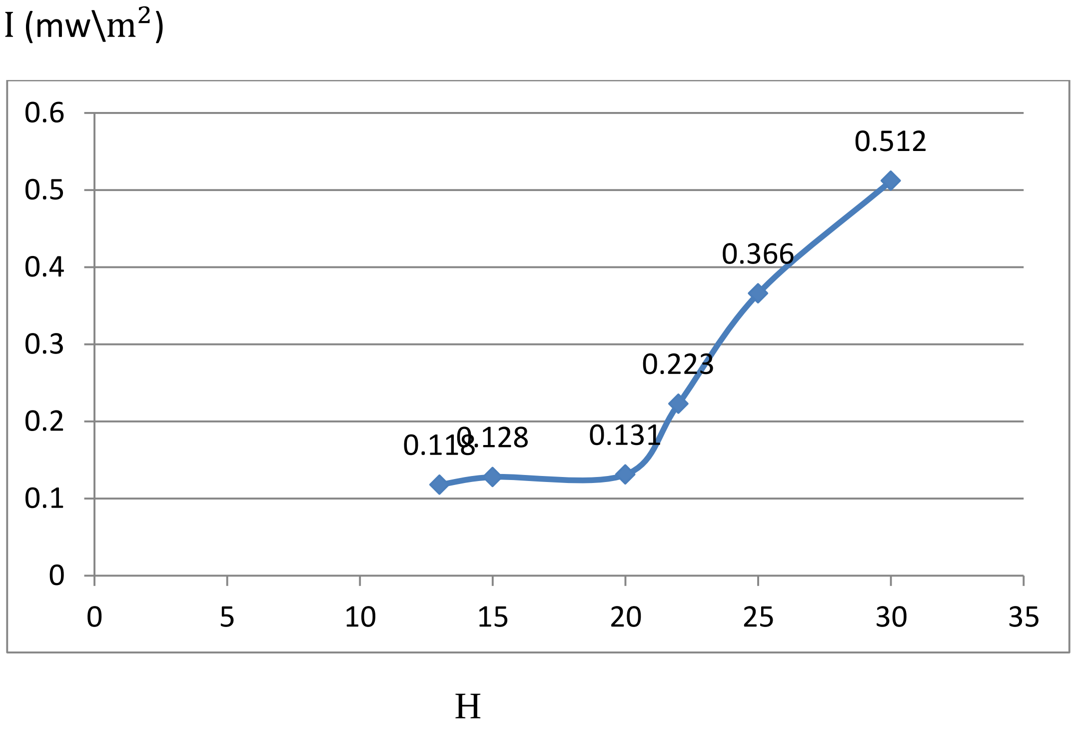


Figure (5.2. 92): shows the relation between height of the tower (H) and radiation Intensity (I) of zain towers at Khartoum state, when horizontal distance is (5 m).

Table (5.2. 93): shows the relation between the height of the tower (H) and radiation Intensity (I) of sudani tower at Khartoum state, when horizontal distance is (5 m).

$x \pm 10^{-3}m$	10	15	20	22	27	30
I $\pm$ 1mw\\m^3	0.104	0.176	0.347	0.448	0.545	0.630

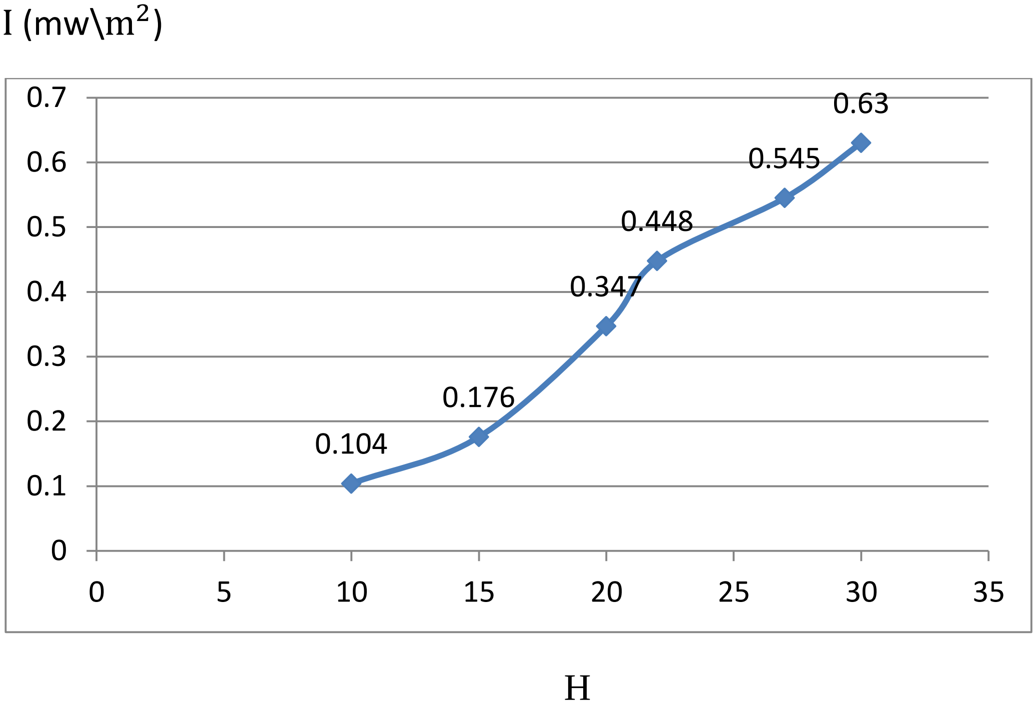


Figure (5.2. 93): shows the relation between height of the tower (H) and radiation Intensity (I) of sudani tower at Khartoum state, when horizontal distance is (5 m).

Table (5.2. 94): shows the relation between the height of the tower (H) and radiation Intensity (I) of MTN tower at Khartoum state, when horizontal distance is (5 m).

$x \pm 10^{-3}m$	5	10	15	17	20	22
I $\pm$ 1mw\\m^3	0.131	0.325	0.408	0.553	0.631	0.665

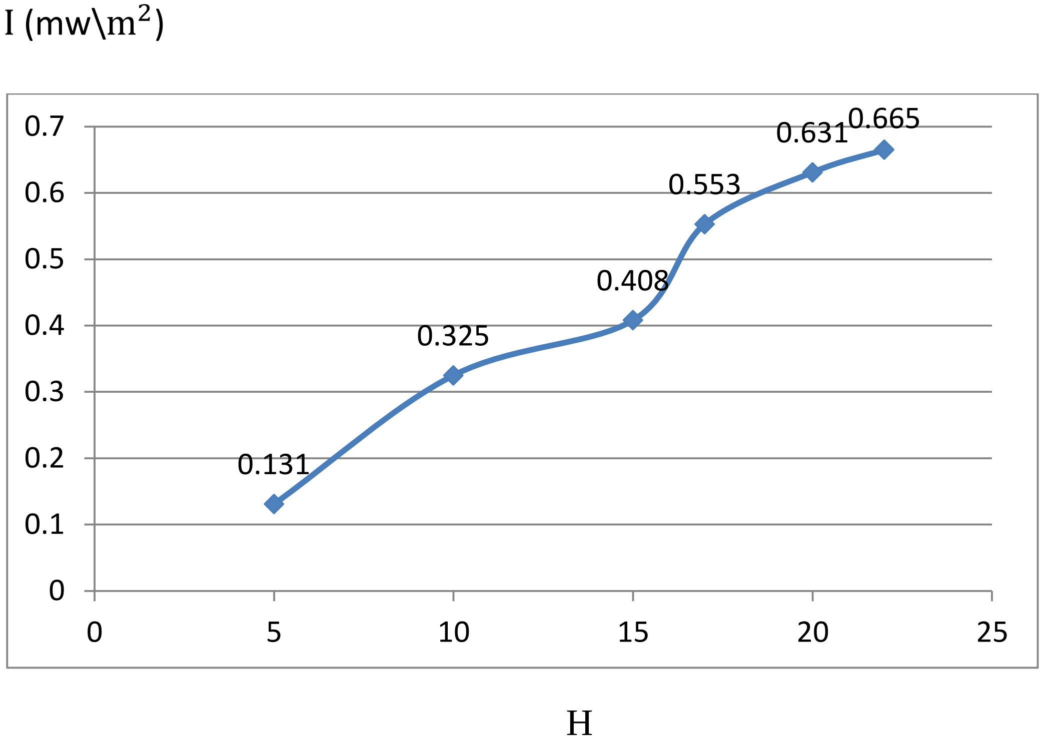


Figure (5.2. 94): shows the relation between height of the tower (H) and radiation Intensity (I) of MTN tower at Khartoum state, when horizontal distance is (5 m).

Table (5.2. 95): shows the relation between height of the tower (H) and radiation Intensity (I) of zain tower at River Nile state, when horizontal distance is (5m).

$x \pm 10^{-3}m$	15	20	25	30	35	40
I $\pm$ 1mw\m^3	0.012	0.015	0.025	0.032	0.040	0.050

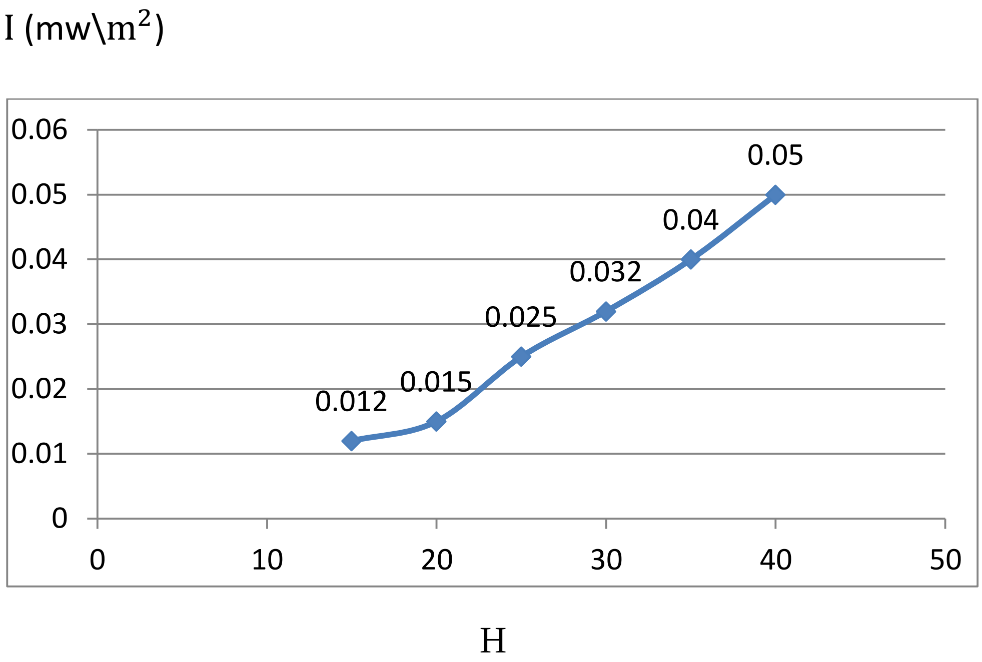


Figure (5.2. 95): shows the relation between height of the tower (H) and radiation Intensity (I) of zain tower at River Nile state,, when horizontal distance is (5m).

Table (5.2. 96): shows the relation between height of the tower (H) and radiation Intensity (I) of sudani tower at River Nile state, when horizontal distance is (5m).

$x \pm 10^{-3}m$	20	25	30	32	35	40
$I \pm 1mw\backslash m^3$	0.020	0.035	0.055	0.060	0.065	0.075

I (mw\m^2)

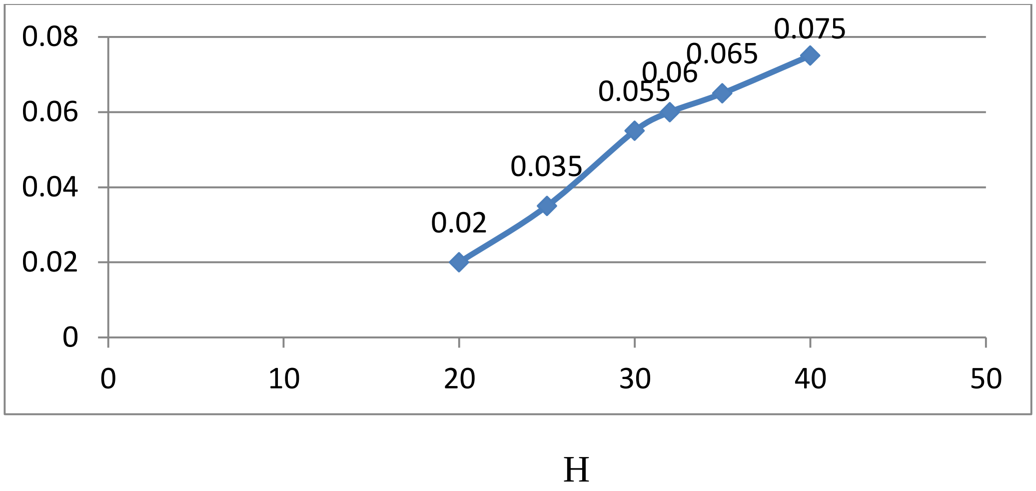
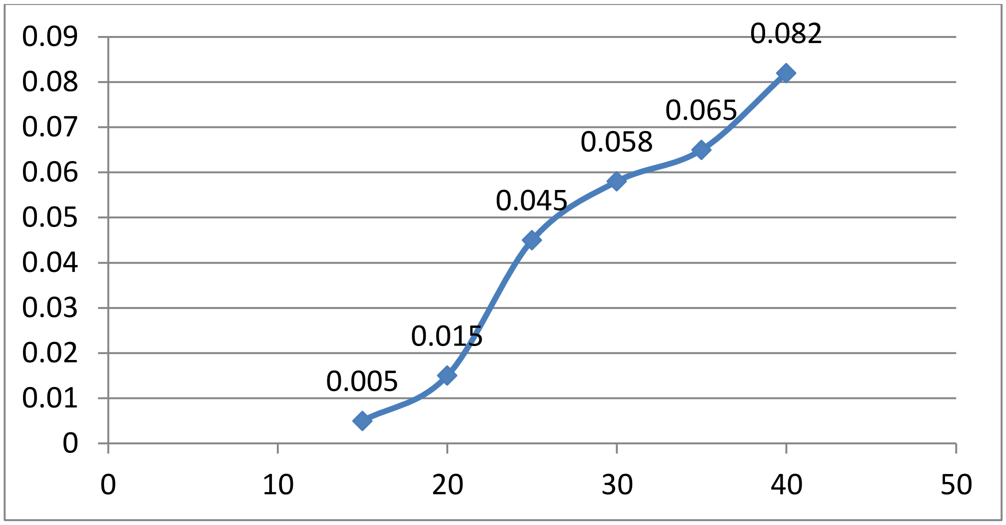


Figure (5.2. 96): shows the relation between height of the tower (H) and radiation Intensity (I) of sudani tower at River Nile state, when horizontal distance is (5m).

Table (5.2. 97): shows the relation between height of the tower (H) and radiation Intensity (I) of MTN tower at River Nile state, when horizontal distance is (5m).

$h \pm 10^{-3} m$	15	20	25	30	35	40
I $\pm$ 1mw\ m^3	0.005	0.015	0.045	0.058	0.065	0.082

I (mw\m^2)



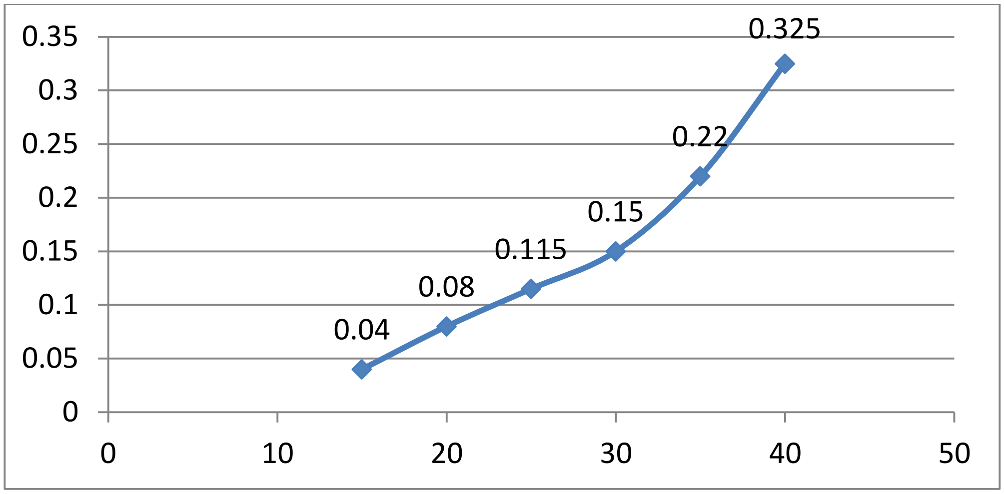
H

Figure (5.2. 97): shows the relation between height of the tower (H) and radiation Intensity (I) of MTN tower at River Nile state, when horizontal distance is (5m).

Table (5.2. 98): shows the relation between height of the tower (H) and radiation Intensity (I) of zain tower at Red Sea state, when horizontal distance is (5m).

$x \pm 10^{-3}m$	15	20	25	30	35	40
I $\pm$ 1mw\\m^3	0.040	0.080	0.115	0.150	0.220	0.325

I (mw\m^2)



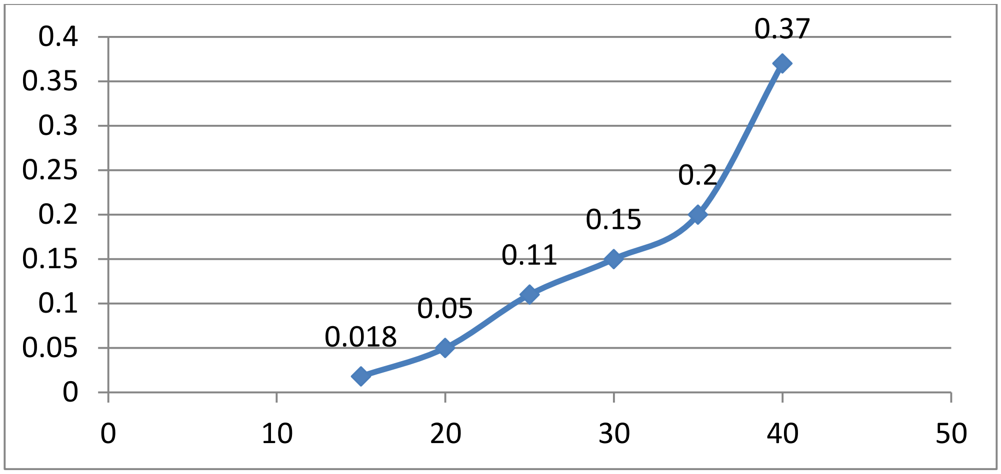
H

Figure (5.2. 98): shows the relation between height of the tower (H) and radiation Intensity (I) of zain tower at Red Sea state, when horizontal distance is (5 m).

Table (5.2. 99): shows the relation between height of the tower (H) and radiation Intensity (I) of sudani tower at Red Sea state, when horizontal distance is (5m).

$x \pm 10^{-3}m$	15	20	25	30	35	40
I $\pm$ 1mw\\m^3	0.018	0.050	0.110	0.150	0.200	0.370

I (mw\\m^2)



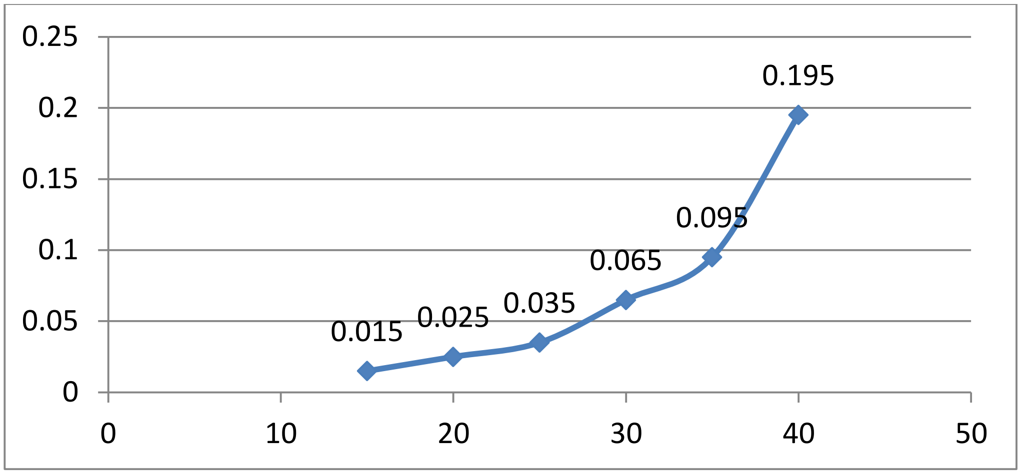
H

Figure (5.2. 99): shows the relation between height of the tower (H) and radiation Intensity (I) of sudani tower at Red Sea state, when horizontal distance is (5m).

Table (5.2. 100): shows the relation between height of the tower (H) and radiation Intensity (I) of MTN tower at Red Sea state, when horizontal distance is (5m).

$h \pm 10^{-3} m$	15	20	25	30	35	40
I $\pm$ 1mw\\m^3	0.015	0.025	0.035	0.065	0.095	0.195

I (mw\m^2)



H

Figure (5.2. 100): shows the relation between height of the tower (H) and radiation Intensity (I) of MTN tower at Red Sea state, when horizontal distance is (5m).

Fig (5. 2.101): shows the overall EMR emitted from the three states (Khartoum, River Nile and Red sea). It's observed that Khartoum state hasThe highest EMR levels as compared to Nile River and Red sea state.

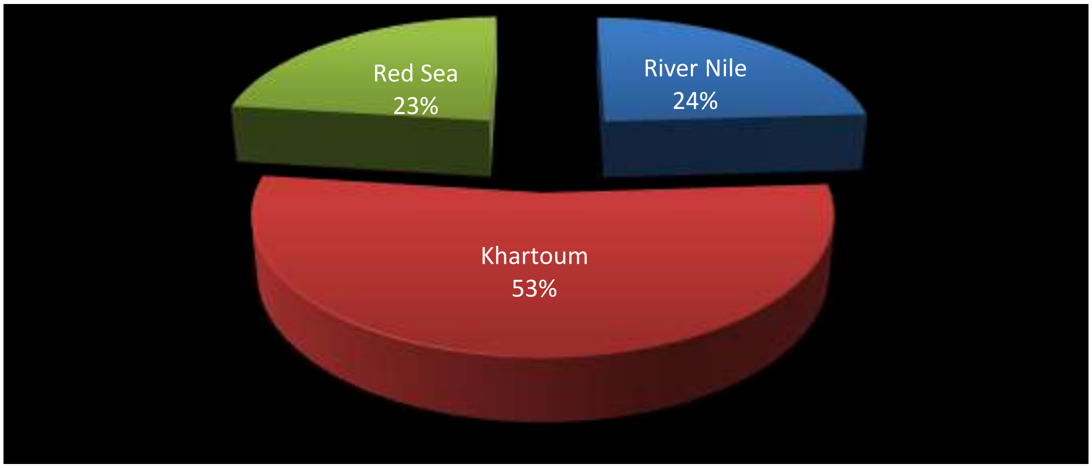
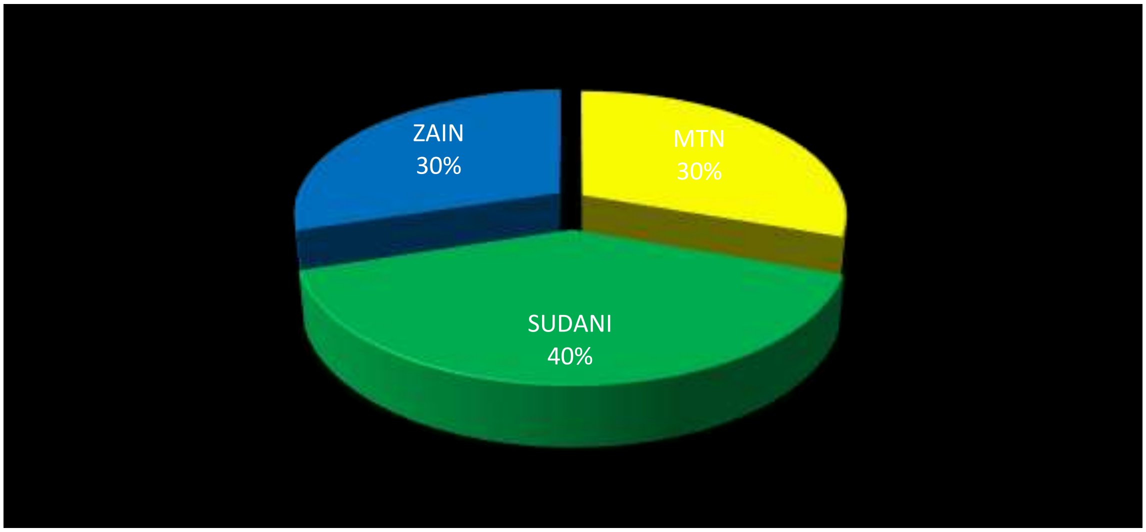


Fig (5. 2.102): shows the overall EMR emitted by the three companies. It’s observed that Sudani Company has the highest EMR levels as compared to zain and MTN Company.



(5. 3) Ddiscussion

The analysis of the results of radioactive power emitted from the telecommunication towers in Khartoum, River Nile, and Red sea states shows some interesting features.

A total amount of 360 samples were collected from the three states, 120 samples from each. Within each individual state, a number of 40 samples were collected from ZAIN Company and similar samples were also collected from SUDANI and MTN companies.

Since these samples are very large and each 40 towers give similar results, only 10 towers from 40 were selected to represent a certain company in a certain state.

All these samples were subjected to the radioactive power examination using international standard radiometers as well as the well-established NARDA measurements and technology. This is in an attempt to determine the radiation intensity emitted from these towers as a function of horizontal distance as well as towers heights.

The comparison of these results among different companies and states were also studied, view of figures (5.2.1,…,10) for zain towers, figures

(5.2.11,…,20) for sudani towers and figures (5.2.21,…,30) for MTN which relates intensity to horizontal distance in Khartoum state. Comparison of the radiation intensities for all examined powers in Khartoum shows that the radiation intensity to be higher in SUDANI Company followed by MTN and least amount of radiations was observed emitted from ZAIN Company. This indicates that ZAIN company showed the least power and hence more safety to the biological units around. Based on some engineering consultations received, this is attributed to the fact that ZAIN utilized better and safer technology.

Interesting similar results were observed in other two states (river Nile and red sea), when tested, I, e, ZAIN is better in all states as compared to MTN and SUDANI. Again this substantially our explanation that ZAIN Company used better instruments and technology. When a search for the individual’s results was made, the variations are almost closer between ZAIN and MTN. However, SUDANI Company is always having bigger radiations power as compared to the two other companies. But still it is within international recommended dose.

One suggests that the higher power emitted from SUDANI was detected because the SUDANI towers have no attenuator coat from the radiation

is used by this company (Abdellatif and Mubarak Dirar, 2012).

As for MTN Company reasonable amount of power (almost closer to ZAIN) was observed. In river Nile and Red sea states almost similar results were observed (ZAIN is least, followed by MTN and SUDANI), {see figures (5.2.31,… 90)}. This is explained by the fact that similar management and operating System is adopted by the companies in these three states.

It was also observed that the radioactive powers detected among the three companies collectively is highest in Khartoum state with comparing by the other two states (River Nile and Red sea), this is explained by the fact that in Khartoum state there is a big numbers of towers distributed through the difference localities which emit a huge amount of radiations power.

When the tower height was made constant, bigger amount of radiations were detected right away closer to the tower and remain smaller when the distance from the tower is increased,{see figures (5.2.1,…,90)}, this agree with the theoretical relation in figure (5.2.91).

This is explained by the fact that when the particles of radiations was travelling to the far distance it lost some of its power, as it distribute it

self radially thus the area in which radiation spread it self-increases.

The variation of intensity emitted from towers with their height was examined in Khartoum state only for 50 towers.

Since the results for towers are similar, only (3) towers were selected from zain, sudani and MTN respectively. It observed that when we use a constant distance from the tower , more radiations power were detected for the highest tower when measured, these relations agree with the theoretical one in figure (5.2.94…95.96)

(5. 4) Conclusion

One of the most risk factors associated with the telecommunications towers in Sudan is the possibility of the adverse biological influences of the EMR emitted from towers. So far, there are no previous studies indicated the existence of these effects.

As these biological effects are no longer yet proved, this study was designed and conducted to verify these effects. The results obtained indicated there are some limited biological effects due to these EMR with different levels depending on the companies studied. However, all the EMR detected were seen within the internationally permissible dose (0.5 mw/cm2). Based on findings of this study, the EMR are not harmful to the biological units in the humans. However some preventive measures should planned and implemented to overcome the possible future risk, these measures should be made according to the international regulations, based on the golden rule (prevention is better than cure).

(5. 5) Recommendations

According to the analysis of this study results, the following recommendations can be mentioned:

1. The telecommunications companies are urged to use the metallic cover on the towers to minimize the radiation to the least level.
2. The telecommunications companies should ask to abide to the technical international specifications during applications and operations of their stations.
3. Establishment of management sections concerned with the environmental issues, inside The telecommunications companies
4. Applications of the standard safety measures for workers dealing with the building and maintenance of the towers.
5. Establishment of legislations to protect people against the radiation.
6. Establishment of research centers dealing with study and research for the adverse effects of EMR emitted from telecommunications towers.
7. Encourgered of the researches project and post graduates student to conduct search in the field.

(5. 6) Future work

Since this study reveal the health side effects due to Cellular tower Radiations to human beings living near wireless Cellular transmission towers, developing the model for safety Zone determination where the RF radiation side effects are Minimum or negligible is important.

As these side effects are Functions of time or distance, the model will require Consideration of other parameters like time exposure which was shown by some studies to be one of the factors that can cause biological hazard even for law radiation levels.

REFERENCES

1. B. Blake Levitt and H. Lai, 2010 "Biological effects from Exposure to electromagnetic radiation emitted by cell Tower base stations and other antenna arrays, NRC Research Press, vol. 18, pp. 369–395.
2. N. Kumar and G. Kumar, 2009 "Biological effects of cell tower radiation on human body," ISMOT, Delhi, India, pp. 678-679.

3. M. Abdelati, 2005 "Electromagnetic Radiation from Mobile Phone Base Stations at Gaza," Journal of the Islamic University of Gaza (Natural Science Series), vol. 13, pp. 129-146.
4. Peter Monk, 2003. Finite Element Methods for Maxwell's Equations. Oxford University Press, Oxford UK. p. 1 ff. ISBN 0-19-850888-3.
5. Thomas B. A. Senior & John Leonidas Volakis, 1995. (Approximate Boundary Conditions in Electromagnetics). Institution of Electrical Engineers. London UK. p. 261 ff. ISBN 0-85296-849-
6. T Hagstrom (Björn Engquist & Gregory A. Kriegsmann, Eds.) 1997. Computational Wave Propagation. Springer, Berlin. p. 1 ff. ISBN 0-387-94874-0.
7. Henning F. Harmuth & Malek G. M. Hussain (1994). Propagation of Electromagnetic Signals, World Scientific, Singapore. ISBN 981-02-1689-0.
8. David M Cook (2002). The Theory of the Electromagnetic Field. Courier Dover Publications, Mineola NY. p. 335 ff. ISBN 0-486-42567-3.
9. Carmichael, H. J. 2009 "Einstein and the Photoelectric Effect" (PDF). Quantum Optics Theory Group, University of Auckland, Retrieved 22 December.
10. S. F. Mahmoud (1991), Electromagnetic Waveguides: Theory and Applications, Institution of Electrical Engineers, London UK. Chapter 2. ISBN 0-86341-232-7.
11. Independent Expert Group on Mobile Phones, Report of the Group (The Stewart Report), May 2000. Mobile Phones and Health.
12. R, 2006. Magnetic field exposure and long - term survival among children with leukemia, British Journal of Cancer, 94,161-164.

13. Allan H. Frey, 1988. Evolution and Results of Biological Research with low-Intensity Nonionizing Radiation, Modern Bioelectricity, 785- 837, Also Geoffrey Lean Warning: Using a mobile phone while pregnant can seriously damage your baby, 2008. Karinen A,

14. Heinävaara S, Nylund R, Leszczynski D, 2008, Mobile honeradiationmight protein expression in human Skin, BMCGenomics, Finland, 9:77 http://www.biomedcentral.com/content/pdf/1471-2164-77.pdf

15. Gandhi et al, 1996. IEEE (Transactions on Microwave Theory and Techniques). Foliart DE, Pollock BH, Mezei G, Iriye R, Silva JM, Epi KL, Kheifets L, Link MP, Kavet

16. Atay T, Aksoy BA, Aydogan NH, Baydar ML, Yildiz M, Ozdemir R, 2009.Effect of Electromagnetic Field Induced by Radio Frequency Waves at 900 to 1800 MHz on Bone Mineral Density of Iliac Bone Wings, The Journal of Craniofacial Surgery, 20(5):1556-60.

17.S. B. H. M Chandran, J Vigneshwar, M Fazil Ahmed, E Balaji, Gayatri Kaur and Sunisha Sugunan, 2012 "A survey on the impact of radiation emitted by the cell phone tower on human subjects," International Journal of Life Science Biotechnology & Pharma Research, vol. 1.

18. J. L. Phillips, et al., 1998. "DNA damage in Molt-4 Tlymphoblastoid cells exposed to cellular telephone radiofrequency fields in vitro," Bio electrochemistry and Bioenergetics, vol. 45, pp. 103-110.

19. Ioannis N. Magras and T. D. Xenos, 1997. "RF Radiation–Induced Changes in the Prenatal Development of Mice," Bio electromagnetics, vol. 18, pp. 455–461.
20. Leif G. Saford, et al., 2003. "Nerve Cell Damage in Mammalian Brain after Exposure to Microwaves from GSM Mobile Phones," Environmental Health Perspectives, vol. 1 111.
21. K. A. Hossmann and D. Hermann, 2003. "Effects of electromagnetic radiation of mobile phones on the central nervous system," Bio electromagnetics, vol. 24, pp. 49-62.
22. S. M. Michaelson and J. C. Lin, 1987. "Neuroendocrine Effects," in Biological Effects and Health Implications of Radiofrequency Radiation, Ed: Springer, pp. 425-449.
23. Hardell Lennart. ET. Al, 2009. "Epidemiological evidence for an association between use of wireless phones and tumor diseases," Pathophysiology vol. 595.
24. Blackman, "Effects of ELF fields on calcium-ion efflux from brain tissue in vitro”,," Radiation Research, pp. 510-520, 1982.
25. H. Lai, Singh, NP, 1997. "Melatonin and a spin-trap compound block radiofrequency electromagnetic radiation-induced DNA strand breaks in rat brain cells," Bio electromagnetics, vol. 18, pp. 446-454, a.
26. Simkó, 2007. "Cell type specific redox status is responsible for diverse electromagnetic field effects," Current Medicinal Chemistry, vol. 14, pp. 1141- 1152.
27. X. T. Magras IN, 1997. "RF radiation-induced changes in the prenatal development of mice," Bio electromagnetics vol. 18, pp. 455-461.

28. A. Agarwal, et al, 2008. "Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study," Fertility and sterility, vol. 89, pp. 124-128.

29. L. E. Charles, ET al.2003, "Electromagnetic fields, polychlorinated biphenyls, and prostate cancer mortality in electric utility workers," American journal of epidemiology, vol. 157, pp. 683-691.

30. G. Abdel-Rassoul, ET al.2007, "Neurobehavioral effects among inhabitants around mobile phone base stations," Neurotoxic ology, vol. 28, pp. 434-440, 2007.

31. A. H. Frey, 1988. "Evolution and results of biological research with low- intensity nonionizing radiation," Modern Bioelectricity, pp. 785-837.

32. G. Altamura, ET al.1997, "Influence of digital and analogue cellular telephones on implanted pacemakers," European Heart al, vol. 18, pp. 1632-1641.

33. Aran JM, Carrere N, Chalan Y, Dulou PE, Larrieu S, Letenneur L, Veyret B, and Dulon D,2004.(Effects of exposure of the ear to GSM microwaves: in vivo and in vitro experimental studies Into J Audiology), 43, 245-254.

34. Bak M, Sliwinska-Kowalska M, Zmyslony M,2003.(Magnetic field emitted by mobile phones on brainstem auditory potentials in young volunteers.IntJ Occupy Med Environ Health) , 16, 201-208.

35. Beckman KB, Ames BN.1998. (The free radical theory of aging matures). Physiology, Re, 78, 547-581.

36. Berg G, Schüz J, Samkange-Zeeb F, Blettner M.2005, (Assessment of radiofrequency exposure from cellular telephone daily use in an epidemiological study): German Validation study of the international

case- control study of cancers of the brain-- INTERPHONE-Study, J Expo Anal Environ Epidemiology, 15, 217-224.

37. Bernhardt JH, Matthes R, McKinlay A, Vecchia P, Veyret B (eds) 2003.(Exposure to Static and LowFrequency Electromagnetic Fields, Biological Effects and Health Consequences) (0-100 kHz) - Review of the Scientific Evidence and Health Consequences. International Commission on Non-Ionizing Radiation Protection. Munich.
38. Bernhardt JH, Matthes R, Repacholi MH (Eds.), 1996. (Non-Thermal effects of RF electromagnetic fields. Proceedings he International Seminar on Biological Effects of Non-Thermal Pulsed and Amplitude Modulated RF Electromagnetic Fields and Related Health Risks), International Commission on Non-Ionizing Radiation Protection, Munich, Germany.
39. Besset A, Espa F, Dauvilliers Y, Billiard M, de Seze R.2005. (No effect on cognitive function from daily mobile phone) e.bioelectromagnetics, 26, 102-108.
40. Braune S, Wrocklage C, Raczek J, Gailus T, Lucking CH. 1998. (Resting blood pressure increase during exposure to a radio-frequency electromagnetic field), Lancet, 351, 1857-1858.
41. Brocklehurst B, McLauchlan KA.1996. (Free radical mechanism for the effects of environmental electromagnetic fields on biological systems Into J Radiat Biol), 69, 3-24.
42. Finnie JW, Blumbergs PC, Manavis J, Utteridge TD,GebskiV,Swift JG, Vernon-Roberts B, Kuchel TR.(Effect of global system for mobile communication (GSM)-like radio frequency fields on vascular permeability in mouse brain),

43. 2001, 33, 338-340.Foster KR, Repacholi MH.2000. (Environmental impacts of electromagnetic fields from major electrical technologies), Geneva: WHO. http://www.who.int/peh-emf/publications/reports/en/env_impact_emf from_major_elect_tech_foster_repacholi.pdf (accessed 31 July 2006).2005, 336, 1144-1149.

44. Rongen E, Repacholi MH (eds).1999,(Health Effects of Electromagnetic Fields in the Frequency Range 300 Hz to 10 MHz Proceedings of the International Seminar on Health Effects of Electromagnetic Fields in the Frequency Range 300 Hz to 10 MHz), International Commission on Non-Ionizing Radiation Protection; Maastricht, The Netherlands,105-121.

45. Hossmann KA, Hermann DM.2003. (Effects of electromagnetic radiation of mobile phones on the central nervous system. Bio electromagnetics), 24, 49-62.

46. Inskip PD, Tarone RE, Hatch EE, Wilcosky TC, Shapiro WR, Selker RG, Fine HA, Black PM, Loeffler JS, Linet MS. 2001. (Cellular-telephone use and brain tumors).N ,Engle, 344, 79-86.

47. Juutilainen J, Eskelinen T. In vivo, 1999. Studies on the health effects of electromagnetic fields in the frequency range 300 Hz to 10 MHz in: Matthes R, van Rongen E, Repacholi MH (eds.). Health Effects of Electromagnetic Fields in the Frequency Range 300 Hz to 10 MHz Proceedings of the International Seminar on Health Effects of Electromagnetic Fields in the Frequency Range 300 Hz to 10 MHz, Maastricht, and The Netherlands.

48. ANSI C95.3 (1991) "American National Standard Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave".
49. ANSI/IEEE 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms, page 305.
50. ANSI/IEEE C95.1-1982, "American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz.
51. IEEE Communications Magazine, 2009, (Radiofrequency field exposure and cancer: what do the laboratory studies suggest Environ Health Perspective.) Vol.47, NO. 5, pp.82-87, Repacholi M H (1997), 105(Supply 6): 1565–1568.
52. International Commission on Non-Ionizing Radiation Protection: “Guidelines for Limiting Exposure to Time-varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz).” Health Physics, April 1998, vol. 74, number 4, pp. 494-522.
53. World Health Organization, Fact Sheet N°304 “Base Stations and Wireless Networks” (May 2006), www.who.int/peh-emf/publications/facts/factsheets/en/index.html

APPINDEX (1)

Table (1): results of radiation emitted from (40) towers of zain company at Khartoum state

Table (2): results of radiation emitted from (40) towers of SUDANI company at Khartoum state

NO	State	Comp	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	Khartoum	Sudani	0.264	0.189	0.16	0.156	0.149	0.133
[illegible]	Khartoum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Khartoum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Khartoum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Khartoum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Khartoum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	Khartoum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	Khartoum	ZAIN	0.044	0.035	0.032	0.027	0.018	0.004

Table (3): results of radiation emitted from (40) towers of MTN company at Khartoum state

NO.	State	Comp	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	Khartoum	MTN	0.325	0.106	0.095	0.079	0.069	0.045
2	Khartoum	MTN	0.276	0.262	0.216	0.143	0.092	0.082
3	Khartoum	MTN	0.367	0.347	0.152	0.12	0.047	0.012
4	Khartoum	MTN	0.505	0.151	0.103	0.053	0.048	0.044
5	Khartoum	MTN	0.586	0.545	0.49	0.445	0.386	0.156
6	Khartoum	MTN	0.631	0.545	0.406	0.385	0.382	0.277
7	Khartoum	MTN	0.087	0.083	0.053	0.039	0.038	0.027
8	Khartoum	MTN	0.436	0.415	0.346	0.189	0.134	0.144
9	Khartoum	MTN	0.454	0.34	0.32	0.29	0.032	0.05
10	Khartoum	MTN	0.548	0.462	0.366	0.225	0.213	0.115
11	Khartoum	MTN	0.419	0.354	0.266	0.205	0.127	0.116
12	Khartoum	MTN	0.215	0.14	0.084	0.063	0.043	0.015
13	Khartoum	MTN	0.117	0.096	0.093	0.087	0.068	0.022
14	Khartoum	MTN	0.509	0.413	0.392	0.390	0.34	0.29
15	Khartoum	MTN	0.525	0.380	0.266	0.254	0.111	0.089
16	Khartoum	MTN	0.110	0.08	0.062	0.41	0.04	0.08
17	Khartoum	MTN	0.405	0.376	0.154	0.148	0.122	0.098
18	Khartoum	MTN	0.197	0.174	0.169	0.133	0.081	0.078
19	Khartoum	MTN	0.233	0.221	0.184	0.131	0.122	0.077
20	Khartoum	MTN	0.54	0.47	0.329	0.285	0.195	0.147
21	Khartoum	MTN	0.538	0.404	0.334	0.319	0.146	0.119
22	Khartoum	MTN	0.458	0.34	0.264	0.25	0.182	0.111
23	Khartoum	MTN	0.492	0.386	0.229	0.216	0.178	0.09
24	Khartoum	MTN	0.493	0.462	0.449	0.336	0.324	0.147
25	Khartoum	MTN	0.408	0.368	0.221	0.134	0.099	0.043
26	Khartoum	MTN	0.402	0.335	0.276	0.262	0.207	0.076
27	Khartoum	MTN	0.271	0.223	0.186	0.145	0.082	0.075
28	Khartoum	MTN	0.316	0.242	0.178	0.133	0.127	0.097
29	Khartoum	MTN	0.522	0.433	0.345	0.252	0.234	0.194
30	Khartoum	MTN	0.461	0.223	0.179	0.148	0.123	0.061
31	Khartoum	MTN	0.465	0.45	0.152	0.077	0.072	0.041
32	Khartoum	MTN	0.506	0.189	0.186	0.141	0.117	0.086
33	Khartoum	MTN	0.351	0.268	0.243	0.143	0.13	0.112
34	Khartoum	MTN	0.122	0.089	0.088	0.067	0.042	0.022
35	Khartoum	MTN	0.047	0.032	0.031	0.024	0.018	0.004
36	Khartoum	MTN	0.03	0.029	0.014	0.009	0.004	0.001
37	Khartoum	MTN	0.06	0.039	0.035	0.014	0.012	0.011
38	Khartoum	MTN	0.195	0.145	0.135	0.095	0.045	0.033
39	Khartoum	MTN	0.553	0.168	0.132	0.108	0.092	0.087
40	Khartoum	MTN	0.416	0.394	0.384	0.316	0.244	0.184

Table (4): results of radiation emitted from (40) towers of ZAIN company at River Nile state.

NO	State	Com	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	River Nile	ZAIN	0.402	0.377	0.335	0.328	0.312	0.265
2	River Nile	ZAIN	0.59	0.304	0.254	0.186	0.167	0.152
3	River Nile	ZAIN	0.465	0.322	0.182	0.168	0.136	0.118
4	River Nile	ZAIN	0.09	0.033	0.027	0.022	0.019	0.005
5	River Nile	ZAIN	0.2	0.07	0.053	0.037	0.023	0.018
6	River Nile	ZAIN	0.34	0.21	0.166	0.151	0.101	0.03
7	River Nile	ZAIN	0.07	0.065	0.06	0.052	0.035	0.018
8	River Nile	ZAIN	0.13	0.128	0.112	0.084	0.074	0.064
9	River Nile	ZAIN	0.164	0.131	0.067	0.033	0.023	0.007
10	River Nile	ZAIN	0.081	0.054	0.048	0.036	0.031	0.007
11	River Nile	ZAIN	0.023	0.014	0.006	0.005	0.001	0.001
12	River Nile	ZAIN	0.057	0.052	0.042	0.041	0.039	0.026
13	River Nile	ZAIN	0.219	0.120	0.073	0.065	0.062	0.04
14	River Nile	ZAIN	0.109	0.101	0.088	0.08	0.079	0.071
15	River Nile	ZAIN	0.042	0.025	0.02	0.020	0.018	0.011
16	River Nile	ZAIN	0.314	0.15	0.02	0.013	0.007	0.004
17	River Nile	ZAIN	0.206	0.114	0.096	0.033	0.023	0.006
18	River Nile	ZAIN	O.173	0.159	0.054	0.04	0.038	0.018
19	River Nile	ZAIN	0.481	0.367	0.323	0.128	0.056	0.054
20	River Nile	ZAIN	0.277	0.205	0.162	0.016	0.007	0.003
21	River Nile	ZAIN	0.154	0.153	0.124	0.087	0.053	0.053
22	River Nile	ZAIN	0.036	0.027	0.021	0.013	0.011	0.005
23	River Nile	ZAIN	0.057	0.024	0.007	0.006	0.006	0.004
24	River Nile	ZAIN	0.084	0.057	0.029	0.02	0.016	0.011
25	River Nile	ZAIN	0.073	0.028	0.017	0.013	0.011	0.005
26	River Nile	ZAIN	0.273	0.227	0.112	0.030	0.028	0.02
27	River Nile	ZAIN	0.135	0.123	0.112	0.024	0.016	0.013
28	River Nile	ZAIN	0.551	0.110	0.052	0.019	0.018	0.013
29	River Nile	ZAIN	0.023	0.019	0.014	0.012	0.01	0.009
30	River Nile	ZAIN	0.498	0.36	0.297	0.018	0.013	0.005
31	River Nile	ZAIN	0.242	0.153	0.089	0.034	0.021	0.02
32	River Nile	ZAIN	0.057	0.046	0.037	0.023	0.021	0.007
33	River Nile	ZAIN	0.116	0.070	0.064	0.039	0.021	0.021
34	River Nile	ZAIN	0.321	0.189	0.089	0.033	0.02	0.004
35	River Nile	ZAIN	0.158	0.059	0.053	0.027	0.011	0.001
36	River Nile	ZAIN	0.072	0.044	0.031	0.01	0.005	0.001
37	River Nile	ZAIN	0.064	0.023	0.016	0.01	0.004	0.001
38	River Nile	ZAIN	0.449	0.122	0.066	0.044	0.005	0.001
39	River Nile	ZAIN	0.05	0.045	0.03	0.02	0.011	0.001
40	River Nile	ZAIN	0.071	0.044	0.035	0.011	0.001	0.001

Table (5): results of radiation emitted from (40) towers of SUDANI company at River Nile state.

NO	State	Com	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	River Nile	SUDANI	0.426	0.281	0.26	0.188	0.126	0.081
2	River Nile	SUDANI	0.04	0.028	0.02	0.015	0.011	0.008
3	River Nile	SUDANI	0.091	0.077	0.069	0.054	0.048	0.045
4	River Nile	SUDANI	0.424	0.283	0.252	0.2	0.179	0.152
5	River Nile	SUDANI	0.083	0.066	0.045	0.038	0.03	0.018
6	River Nile	SUDANI	0.295	0.174	0.13	0.121	0.115	0.05
7	River Nile	SUDANI	0.175	0.159	0.135	0.12	0.093	0.035
8	River Nile	SUDANI	0.457	0.384	0.356	0.284	0.242	0.188
9	River Nile	SUDANI	0.05	0.037	0.033	0.032	0.031	0.007
10	River Nile	SUDANI	0.270	0.2	0.181	0.18	0.116	0.081
11	River Nile	SUDANI	0.186	0.043	0.128	0.401	0.801	1.3
12	River Nile	SUDANI	0.015	0.032	0.022	0.027	0.059	0.045
13	River Nile	SUDANI	0.05	0.032	0.061	0.033	0.091	0.06
14	River Nile	SUDANI	0.874	0.995	0.828	1.263	1.448	2.914
15	River Nile	SUDANI	0.187	0.114	0.209	0.126	0.091	0.411
16	River Nile	SUDANI	0.017	0.015	0.014	0.014	0.006	0.003
17	River Nile	SUDANI	0.046	0.209	0.033	0.045	0.031	0.026
18	River Nile	SUDANI	0.068	0.062	0.048	0.033	0.022	0.004
19	River Nile	SUDANI	0.054	0.056	0.046	0.044	0.058	0.134
20	River Nile	SUDANI	0.011	0.025	0.02	0.022	0.035	0.064
21	River Nile	SUDANI	0.076	0.051	0.033	0.015	0.017	0.075
22	River Nile	SUDANI	0.047	0.022	0.017	0.014	0.05	0.017
23	River Nile	SUDANI	0.02	0.065	0.05	0.069	0.041	0.107
24	River Nile	SUDANI	0.018	0.055	0.043	0.012	0.042	0.029
25	River Nile	SUDANI	0.024	0.021	0.015	0.012	0.006	0.006
26	River Nile	SUDANI	0.013	0.012	0.009	0.008	0.005	0.004
27	River Nile	SUDANI	0.068	0.035	0.164	0.056	0.056	0.156
28	River Nile	SUDANI	0.393	0.37	0.329	0.456	0.262	0.315
29	River Nile	SUDANI	0.253	0.519	0.168	0.306	0.26	0.149
30	River Nile	SUDANI	0.026	0.032	0.058	0.037	0.052	0.075
31	River Nile	SUDANI	0.062	0.042	0.045	0.082	0.085	0.054
32	River Nile	SUDANI	0.021	0.03	0.072	0.093	0.124	0.143
33	River Nile	SUDANI	0.055	0.022	0.025	0.02	0.067	0.033
34	River Nile	SUDANI	0.024	0.021	0.012	0.004	0.004	0.001
35	River Nile	SUDANI	0.084	0.093	0.07	0.066	0.039	0.041
36	River Nile	SUDANI	0.054	0.015	0.052	0.019	0.03	0.02
37	River Nile	SUDANI	0.102	0.108	0.077	0.054	0.024	0.015
38	River Nile	SUDANI	0.014	0.012	0.019	0.042	0.007	0.027
39	River Nile	SUDANI	0.021	0.028	0.018	0.024	0.077	0.064
40	River Nile	SUDANI	0.013	0.008	0.023	0.017	0.019	0.026

Table (6): results of radiation emitted from (40) towers of MTN company at River Nile state.

NO	State	Com	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	River Nile	MTN	0.23	0.206	0.276	0.343	0.579	0.31
2	River Nile	MTN	0.92	0.461	0.766	0.746	1.616	1.059
3	River Nile	MTN	0.022	0.018	0.013	0.026	0.012	0.029
4	River Nile	MTN	0.387	0.221	0.148	0.189	0.169	0.122
5	River Nile	MTN	0.042	0.18	0.202	0.051	0.488	0.215
6	River Nile	MTN	0.029	0.173	0.088	0.042	0.025	0.31
7	River Nile	MTN	0.021	0.067	0.091	0.033	0.018	0.012
8	River Nile	MTN	0.039	0.05	0.004	0.047	0.005	0.006
9	River Nile	MTN	0.03	0.034	0.051	0.216	0.406	0.129
10	River Nile	MTN	0.101	0.107	0.118	0.118	0.1	0.079
11	River Nile	MTN	0.013	0.107	0.018	0.016	0.036	0.045
12	River Nile	MTN	0.012	0.032	0.015	0.082	0.013	0.033
13	River Nile	MTN	0.38	0.238	0.207	0.12	0.05	0.04
14	River Nile	MTN	1.816	2.424	1.524	4.036	3.662	2.52
15	River Nile	MTN	0.07	0.057	0.066	0.038	0.043	0.055
16	River Nile	MTN	0.091	0.101	0.123	0.097	0.025	0.049
17	River Nile	MTN	0.173	0.057	0.005	0.011	0.013	0.012
18	River Nile	MTN	0.081	0.092	0.05	0.007	0.021	0.01
19	River Nile	MTN	0.026	0.033	0.061	0.055	0.042	0.021
20	River Nile	MTN	0.034	0.081	0.013	0.037	0.01	0.015
21	River Nile	MTN	0.069	0.138	0.016	0.047	0.131	0.093
22	River Nile	MTN	0.204	0.077	0.067	0.115	0.109	0.219
23	River Nile	MTN	0.063	0.033	0.012	0.027	0.047	0.017
24	River Nile	MTN	0.467	0.13	0.054	0.016	0.047	0.018
25	River Nile	MTN	0.013	0.01	0.04	0.012	0.05	0.016
26	River Nile	MTN	0.012	0.004	0.003	0.005	0.04	0.018
27	River Nile	MTN	0.031	0.062	0.012	0.034	0.048	0.052
28	River Nile	MTN	0.039	0.074	0.033	0.048	0.032	0.037
29	River Nile	MTN	0.004	0.018	0.004	0.023	0.014	0.016
30	River Nile	MTN	0.005	0.004	0.009	0.013	0.02	0.011
31	River Nile	MTN	0.009	0.079	0.033	0.103	0.108	0.007
32	River Nile	MTN	0.045	0.024	0.026	0.18	0.17	0.025
33	River Nile	MTN	0.049	0.029	0.018	0.022	0.029	0.018
34	River Nile	MTN	0.073	0.068	0.053	0.064	0.028	0.021
35	River Nile	MTN	0.001	0.005	0.03	0.027	0.012	0.038
36	River Nile	MTN	0.014	0.01	0.044	0.025	0.03	0.001
37	River Nile	MTN	0.054	0.48	0.012	0.006	0.001	0.1
38	River Nile	MTN	0.026	0.023	0.009	0.001	0.018	0.009
39	River Nile	MTN	0.076	0.070	0.068	0.062	0.044	0,023
40	River Nile	MTN	0.112	0.10	0.092	0.074	0.052	0.008

Table (7) : results of radiation emitted from (40) towers of ZAIN in Red sea state.

NO	State	Comp.	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	Red sea	ZAIN	0.064	0.066	0.269	0.036	0.116	0.048
2	Red sea	ZAIN	0.061	0.031	0.039	0.089	0.073	0.041
3	Red sea	ZAIN	0.045	0.082	0.056	0.004	0.012	0.008
4	Red sea	ZAIN	0.073	0.293	0.101	0.105	0.034	0.031
5	Red sea	ZAIN	0.069	0.024	0.071	0.514	0.036	0.041
6	Red sea	ZAIN	0.048	0.049	0.043	0.04	0.016	0.01
7	Red sea	ZAIN	0.048	0.06	0.046	0.471	0.204	0.053
8	Red sea	ZAIN	0.086	1.056	0.136	0.113	0.09	0.056
9	Red sea	ZAIN	0.074	0.101	0.072	0.1	0.092	0.022
10	Red sea	ZAIN	0.017	0.033	0.046	0.083	0.39	0.026
11	Red sea	ZAIN	0.331	0.476	0.476	0.329	0.488	0.507
12	Red sea	ZAIN	0.012	0.052	0.021	0.019	0..042	0.035
13	Red sea	ZAIN	0.3	0.646	0.362	0.05	0.052	0.04
14	Red sea	ZAIN	0.011	0.017	0.052	0.044	0.037	0.101
15	Red sea	ZAIN	0.058	0.019	0.017	0.006	0.006	0.003
16	Red sea	ZAIN	0.022	0.052	0.04	0.019	0.035	0.011
17	Red sea	ZAIN	0.089	0.111	0.029	0.034	0.016	0.028
18	Red sea	ZAIN	0.109	0.092	0.019	0.019	0.01	0.024
19	Red sea	ZAIN	0.166	0.177	0.329	0.319	0.178	0.114
20	Red sea	ZAIN	0.197	0.054	0.118	0.212	0.07	0.122
21	Red sea	ZAIN	0.019	0.039	0.012	0.006	0.011	0.01
22	Red sea	ZAIN	0.252	0.05	0.023	0.012	0.013	0.027
23	Red sea	ZAIN	0.18	0.061	0.105	0.26	0.167	0.092
24	Red sea	ZAIN	0.078	0.721	0.01	0.016	0.004	0.004
25	Red sea	ZAIN	0.035	0.039	0.044	0.017	0.025	0.017
26	Red sea	ZAIN	0.036	0.225	0.179	0.135	0.22	0.067
27	Red sea	ZAIN	0.174	0.159	0.279	0.172	0.331	0.297
28	Red sea	ZAIN	0.146	0.21	0.18	0.2	0.223	0.229
29	Red sea	ZAIN	0.181	0.621	0.226	0.016	0.061	0.061
30	Red sea	ZAIN	0.079	0.057	0.086	0.014	0.006	0.011
31	Red sea	ZAIN	0.009	0.024	0.119	0.02	0.033	0.062
32	Red sea	ZAIN	0.084	0.106	0.042	0.012	0.035	0.011
33	Red sea	ZAIN	0.166	0.207	0.088	0.041	0.036	0.027
34	Red sea	ZAIN	0.019	0.009	0.012	0.016	0.016	0.031
35	Red sea	ZAIN	0.107	0.082	0.063	0.025	0.028	0.017
36	Red sea	ZAIN	0.047	0.035	0.03	0.029	0.02	0.015
37	Red sea	ZAIN	0.077	0.189	0.217	0.067	0.054	0.047
38	Red sea	ZAIN	0.027	0.011	0.012	0.016	0.012	0.017
39	Red sea	ZAIN	0.01	0.086	0.098	0.025	0.041	0.036
40	Red sea	ZAIN	0.29	0.06	0.01	0.016	0.001	0.012

Table (8): results of radiation emitted from (40) towers of SUDANI company at Red sea state.

No	State	Comp	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	Red sea	SUDANI	0.056	0.021	0.098	0.093	0.053	0.05
2	Red sea	SUDANI	0.047	0.054	0.068	0.055	0.046	0.036
3	Red sea	SUDANI	0.044	0.47	0.79	0.082	0.047	0.047
4	Red sea	SUDANI	0.017	0.045	0.048	0.38	0.029	0.054
5	Red sea	SUDANI	0.02	0.086	0.033	0.048	0.022	0.011
6	Red sea	SUDANI	0.044	0.039	0.055	0.056	0.041	0.027
7	Red sea	SUDANI	0.029	0.103	0.133	0.134	0.069	0.056
8	Red sea	SUDANI	0.261	0.187	0.102	0.17	0.179	0.261
9	Red sea	SUDANI	0.017	0.02	0.012	0.019	0.007	0.006
10	Red sea	SUDANI	0.035	0.014	0.019	0.01	0.008	0.009
11	Red sea	SUDANI	0.024	0.035	0.042	0.051	0.049	0.047
12	Red sea	SUDANI	0.014	0.021	0.037	0.016	0.037	0.032
13	Red sea	SUDANI	0.048	0.086	0.102	0.109	0.08	0.97
14	Red sea	SUDANI	0.046	0.035	0.159	0.024	0.021	0.026
15	Red sea	SUDANI	.0.84	0.111	0.026	0.228	0.05	0.043
16	Red sea	SUDANI	0.036	0.093	0.077	0.087	0.1	0.011
17	Red sea	SUDANI	0.011	0.073	0.099	0.057	0.045	0.014
18	Red sea	SUDANI	0.274	0.405	0.34	0.37	0.298	0.356
19	Red sea	SUDANI	0.025	0.032	0.045	0.098	0.052	0.046
20	Red sea	SUDANI	0.022	0.045	0.025	0.049	0.032	0.025
21	Red sea	SUDANI	0.23	0.72	0.643	1.15	0.606	0.727
22	Red sea	SUDANI	0.267	0.4	0.743	0.352	1.172	0.347
23	Red sea	SUDANI	0.056	0.078	0.056	0.101	0.063	0.056
24	Red sea	SUDANI	0.02	0.031	0.074	0.023	0.02	0.005
25	Red sea	SUDANI	0.01	0.022	0.017	0.053	0.06	0.032
26	Red sea	SUDANI	0.208	0.119	0.163	0.184	0.117	0.177
27	Red sea	SUDANI	0.013	0.025	0.04	0.028	0.084	0.127
28	Red sea	SUDANI	0.165	0.098	0.091	0.092	0.149	0.119
29	Red sea	SUDANI	0.011	0.013	0.018	0.024	0.01	0.033
30	Red sea	SUDANI	0.01	0.012	0.023	0.031	0.02	0.039
31	Red sea	SUDANI	0.077	0.111	0.034	0.083	0.157	0.132
32	Red sea	SUDANI	0.019	0.056	0.039	0.034	0.024	0.032
33	Red sea	SUDANI	0.039	0.05	0.045	0.049	0.053	0.035
34	Red sea	SUDANI	0.05	0.087	0.074	0.084	0.072	0.053
35	Red sea	SUDANI	0.066	0.01	0.008	0.01	0.004	0.017
36	Red sea	SUDANI	0.201	0.353	0.398	0.4	0.746	0.202
37	Red sea	SUDANI	0.501	0.003	0.014	0.026	0.007	0.017
38	Red sea	SUDANI	0.154	0.088	0.048	0.056	0.041	0.067
39	Red sea	SUDANI	0.06	0.067	0.07	0.068	0.068	0.08
40	Red sea	SUDANI	0.021	0.015	0.016	0.003	0.001	0.005

Table (9) results of radiation emitted from (40) towers of MTN company at Red sea state.

NO	State	Comp.	D (5m)	D (10m)	D (15m)	D (20m)	D (25m)	D (30m)
1	Red sea	MTN	0.008	0.014	0.385	0.583	0.424	0.718
2	Red sea	MTN	0.028	0.027	0.028	0.067	0.028	0.052
3	Red sea	MTN	0.031	0.117	0.202	0.227	0.099	0.053
4	Red sea	MTN	0.013	0.028	0.03	0.038	0.027	0.037
5	Red sea	MTN	0.011	0.066	0.052	0.049	0.115	0.057
6	Red sea	MTN	0.005	0.109	0.11	0.116	0.205	0.044
7	Red sea	MTN	0.043	0.026	0.04	0.03	0.056	0.035
8	Red sea	MTN	0.026	0.027	0.053	0.056	0.09	0.011
9	Red sea	MTN	0.073	0.398	0.046	0.042	0.055	0.056
10	Red sea	MTN	0.069	1.684	0.114	0.051	0.033	0.05
11	Red sea	MTN	0.065	0.08	0.035	0.041	0.026	0.011
12	Red sea	MTN	0.22	0.143	0.098	0.077	0.083	0.085
13	Red sea	MTN	0.016	0.019	0.043	0.03	0.02	0.012
14	Red sea	MTN	0.025	0.025	0.023	0.02	0.051	0.012
15	Red sea	MTN	0.04	0.051	0.041	0.054	0.057	0.062
16	Red sea	MTN	0.022	0.071	0.031	0.044	0.025	0.013
17	Red sea	MTN	0.041	0.091	0.06	0.154	0.41	0.066
18	Red sea	MTN	0.004	0.016	0.06	0.023	0.029	0.064
19	Red sea	MTN	0.01	0.01	0.014	0.016	0.032	0.011
20	Red sea	MTN	0.106	0.044	0.081	0.095	0.087	0.036
21	Red sea	MTN	0.027	0.047	0.038	0.011	0.026	0.015
22	Red sea	MTN	0.012	0.042	0.086	0.039	0.046	0.027
23	Red sea	MTN	0.075	0.022	0.014	0.042	0.109	0.085
24	Red sea	MTN	0.026	0.016	0.005	0.004	0.033	0.02
25	Red sea	MTN	0.105	0.039	0.04	0.065	0.122	0.054
26	Red sea	MTN	0.064	0.019	0.036	0.089	0.099	0.085
27	Red sea	MTN	0.047	0.092	0.101	0.04	0.008	0.025
28	Red sea	MTN	0.005	0.011	0.014	0.158	0.131	0.211
29	Red sea	MTN	0.018	0.041	0.047	0.029	0.051	0.027
30	Red sea	MTN	0.044	0.053	0.063	0.129	0.084	0.194
31	Red sea	MTN	0.052	0.047	0.051	0.049	0.039	0.04
32	Red sea	MTN	0.006	0.009	0.009	0.007	0.008	0.018
33	Red sea	MTN	0.055	0.017	0.021	0.006	0.015	0.008
34	Red sea	MTN	0.017	0.057	0.045	0.018	0.042	0.064
35	Red sea	MTN	0.061	0.046	0.071	0.085	0.107	0.089
36	Red sea	MTN	0.049	0.199	0.179	0.028	0.054	0.084
37	Red sea	MTN	0.095	0.058	0.076	0.038	0.04	0.031
38	Red sea	MTN	0.004	0.016	0.12	0.68	0.481	0.288
39	Red sea	MTN	0.125	0.093	0.128	0.037	0.085	0.055
40	Red sea	MTN	0.013	0.014	0.011	0.001	0.043	0.008