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EFFECTS OF RADIATION EMITTED FROM VISUAL DISPLAY TERMINALS ON THE ORAL HEALTH STATUS

By

HAZEM HUSSEIN KAZEM

Ass. Lecturer of orthodontics

National Center for Radiation Research and Technology

(NCRRT)

A Thesis Submitted for Doctor of philosophy

In

Environmental Sciences

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Abstract

Hazem Hussein Kazem

Effects of Radiation Emitted From Visual Display Terminals on the Oral Health Status

National Center for Radiation Research and Technology

(NCRRT)

This study was designed to investigate the effects of exposure to radiation emitted from visual display terminals (VDTs) on the oral health status; a cross sectional study was carried out on 100 participants both males and females with age ranging between 22- 40 years working in various places in Cairo. They were divided into two groups; the first consists of 50 subjects working in front of VDTs eight hours min. daily, min. 5 days/ week, 2 years or more, and the other group 50 subjects working away from any VDTs. Both groups were subjected to both oral and dental examinations, including soft tissues assessment by using gingival index (GI) and hard tissues assessment by using decayed, missed, filled (DMF) index. Saliva analysis was done including pH analysis by pH meter cyberscan 500 and trace elements analysis by ion chromatography and salivary immunoglobulin A (sIgA) analysis by ELISA, body temperature by using digital thermometer. The values were compared between both groups and also between before and after exposure in the exposed group. The results demonstrated that the difference in the mean values of either GI or DMF or pH or anions and cations or sIgA levels between exposed and non exposed groups or even between before and after exposure in the exposed group was found to be statistically insignificant. On the other hand there were significant changes in the mean values of body temperature between exposed and non-exposed group and also between before and after exposure in the exposed group. Accordingly, within the limits of this study we can conclude that radiation emitted from VDTs affects body temperature, but do not have any effect on oral health including; hard or soft tissues or salivary components. This might be explained by the radiation with very low energy emitted from VDTs.

Contents

List of Abbreviations

A/m	**:**	Ampere per meter
BD	**:**	Bright Display
C	**:**	Velocity
Ca	**:**	Calcium
CRT	**:**	Cathode Ray Tube
Cu	**:**	Copper
CWT	**:**	Color-Word Test
D.M.F	**:**	Decayed, Missed, Filled
DD	**:**	Dark Display
DNA	**:**	Deoxyribonucleic Acid
e.	**:**	electron
E.L.F	**:**	Extremely Low Frequency
e.m	**:**	Electromagnetic
e v	**:**	electron volt
EGF	**:**	Epidermal Growth Factor
ELISA	**:**	Enzyme Linked Immunosorbent Assays
EMF	**:**	Electromagnetic field
F	**:**	Fluoride
Fe	**:**	Iron
g/L	**:**	Gram per liter
GHz	**:**	Giga Hertz
GI	**:**	Gingival Index
Gy	**:**	Gray
HOK	**:**	Human Oral Keratinocytes
Hz	**:**	Hertz
ICNIRP	**:**	International Commission on Non Ionizing Radiation Protection
ICRP	**:**	International Commission on Radiological Protection
IF	**:**	Intermediate Frequency
IgA	**:**	Immunoglobulin A
IgG	**:**	Immunoglobulin G

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Introduction

Introduction

Nowadays, the use of radiation is considered an essential requirement in our daily life, the harmful effects of radiation have been established since the beginning of the 20th century, the extensive use of radiation in medicine, science, nuclear energy and other fields has resulted in the need to study the effects of radiation on health in both immediate and long term, in spite of the strict adherence to modern standards of protections that help in using radiations safely without any risk, complete avoidance of exposure to radiation is impossible, man and his environment are irradiated constantly by many sources including cosmic rays, as well as radiation emitted by radioactive materials present on earth, building material, water and atmosphere.

A basic knowledge of the fundamental physical principles of all types of radiations were studied in order to understand its biological effects, the study of the biological effects of electromagnetic fields is a matter of controversy, it draws from physical, biological, chemical, medical and environmental health items, with the increase of different types of radiation used, it is imperative to understand their implications for human health in order to assess the health effects of their use on people.

Human is constantly exposed to both natural and artificial sources of non ionizing radiation, electromagnetic waves emitted from visual display terminals are considered one of the main sources

of non ionizing radiation, as a result of technological advancement, these terminals became widely utilized nowadays among people in large scales and in different careers whether on the professional or personal level, this is evidenced by the number of computer users or internet users which reaches 6 million on 31 December 2007 exclusively in Egypt and 1,319,872,109 all over the world **(Internet world stats, 2007).**

Previous research has studied the effect of radiation emitted from visual display terminals on the general health of the human body e.g. eye conditions, skin reactions, pregnancy, psychological state and muscular-skeletal conditions.

Accordingly, similar studies of the VDTs exposure hazards on the oral health status should be carried, as this is a vital issue for both occupational and general population.

Aim of the Study

Aim of the Study

The aim of the study was to evaluate the possible effects of exposure to electromagnetic waves radiated from visual display terminals on the pathological conditions and physiological function of the oral cavity.

Review of Literature

Basic Background of Radiation

The use of radiations is considered nowadays an essential requirement in our daily life, with strict adherence to modern standards of protection; radiations can be used safely without any risk. Moreover, a basic knowledge of the fundamental physical principles of all types of radiations must be studied in order to understand its biological effects.

Human body is generally exposed to radiations falling on earth naturally from sun and other cosmic sources or nuclear explosions, beside those emanating from terrestrial nature radioactive sources as Potassium-40, Uranium, Thorium or artificially produced reactors, accelerators, X-ray machines, radio-cobalt units, laser, light sources, ultraviolet lamps and visual display terminals **(Potten, 1985).**

1. Types of radiations

Radiations could be also classified according to their types as follows:

I) Particulate or Corpuscular Radiation:

It is in the form of rapidly moving charged or neutral subatomic particles as alpha, electrons, protons and neutrons or charged ions or nuclei with wide range and mass.

A) Alpha Particles which are helium nuclei that have been stripped of their electrons and emit significant amounts of radiation. They can travel centimeters through air but cannot penetrate intact barriers or skin. External coverings, such as scrub suits or clothing,

can effectively block their emitted radiation. Alpha particles are most harmful if they are inhaled, ingested, or absorbed through open wounds. They can penetrate epithelial tissue to a depth of 50 μm, deep enough to cause cellular damage. Alpha particles cannot be detected with standard Geiger counters. Plutonium, radium, and uranium are examples of radioisotopes that emit alpha radiation.

B) Beta Particles which are high-energy electrons that are emitted from the nuclei of unstable atoms such as (cesium-137, iodine-131). The major sources of beta particles are linear accelerator and isotopes. Beta particles can travel several meters through air and can penetrate to the germinal layer of the skin where they can cause damage (similar to a thermal burn), particularly if they are permitted to remain on the skin. Beta particles have been proved to be effective in radiotherapy of malignant tumors; beside they offer an ideal solution for avoiding damage to underlying structures.

C) Neutrons are particles that have a mass of one atomic Dalton but are electrically neutral. The lack of charge permits deep penetration into tissue. Sources of neutrons include nuclear reactors and linear accelerators **(Prasad, 1974).**

II) Electromagnetic radiation

It is the spectrum of radiations which characterized by a wide range of wave lengths with different energies. It extends from gamma "γ" rays of extremely short wave length followed by x-rays, ultraviolet (UV), visible light, infra-red (IR), short and long radio

waves. Waves of electromagnetic fields travel in straight lines from their source and are characterized by the following parameters:

The wavelength 'λ' is the distance between successive peaks. The frequency 'υ' is the number of waves produced per second. The velocity 'C' is the distance traveled by the waves per second speed of light. It is related to according to the following relation: $C = \lambda \upsilon$

All types of electromagnetic waves have the same velocity of light which in vacuum or air equals 2.9979×10^8 m/sec. They differ from each other in the wavelength which inversely proportional to the frequency. The variation in λ and υ causes change in wave property on account of Plank's quantum theory which considers each electromagnetic wave as a small quantity of energy known as quantum or photon. The energy E of a quantum is expressed as follows: $E = h \upsilon$.

Where h is Plank's constant equals 6.6×10^{-27} erg sec. and the unit of energy is electron volt (ev) equivalent to 1.6×10^{-12} erg **(WHO 1997).**

Accordingly, electromagnetic radiation is a form of energy as thermal or nuclear energy and its absorption by atoms or molecules leads to a various biological responses. Higher radiation activities are linked with their greater photon energies corresponding to larger frequencies i.e. shorter wave lengths.

Gamma	X-ray	Ultraviolet	Visible Light	Infrared	Microwave	Radiowaves

Figure (A) Electromagnetic Spectrum

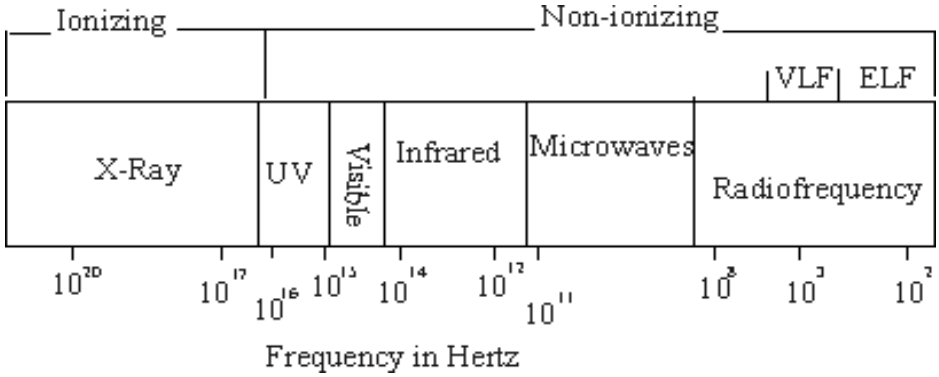

Figure (B) The Spectrum of Electromagnetic Radiation (WHO 1997)

Types of electromagnetic radiations are characterized by their range of wave lengths as illustrated in figure (A). It consists of various regions extending from gamma rays with wave length of the order of picometer (10^{-12} m) followed by X-rays, ultraviolet (UV), visible light, infra-red (IR), short radio waves then long radiowaves in the kilometer range (10^{3}).

A) Ionizing radiation

During the last century many people have been exposed to man-made ionizing radiation, primarily medical X-rays and some medical uses of radioactivity (nuclear medicine). These radiations are classified as "ionizing radiation" because they can knock electrons off atoms in our body causing them to be electrically charged or ionized. Ionizing radiation when absorbed by materials can change the atomic structure of the material by knocking electrons out of atoms.

Ionizing radiation existed in nature billions of years before life appeared. It was unknown to scientists until the end of the 19th century. X-rays were discovered by Roentgen in Germany in late

1895 and radiations from radioactivity (alpha, beta and gamma rays) were discovered early in 1896 **(Cameron, 1978).**

Gamma and X-rays are known as ionizing radiation, and they are high-energy, penetrating forms of electromagnetic radiation. They are identical but X-rays has longer wavelength and less energy than gamma rays. Moreover, X-rays are emitted by electrons, not by the nucleus. Ionizing radiation is released by atoms that have an excess of energy, mass, or both (unstable atoms). They travel at the speed of light and penetrate matter more easily; Metals such as lead are normally required to absorb their energy **(WHO 1997).**

Ionizing radiation damages human tissue in several ways. It interacts directly with targets such as RNA, DNA, and proteins, breaks their covalent bonds, and irreversibly destroys their structure. Ionizing radiation also bombards free water to remove electrons which quickly decay to highly information. Ionizing radiation causes severe cellular disruption that usually results in cell death. However, most cell types do not manifest evidence of damage until mitosis occurs, and several divisions may ensue before actual cell death **(WHO 1997).**

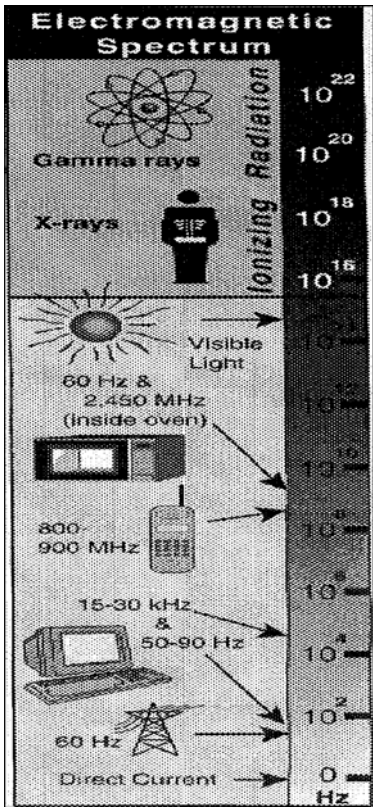

Figure (C) Electromagnetic spectrum showing frequencies from ionizing radiation to direct current. Selected technologies and the frequencies at which they operate are shown (Rapid, 1996).

B) Non ionizing radiation

Non ionizing radiation lacks the energy to facilitate the release of electrons from target tissues. It does not change the atomic structure of the human body. Examples of non ionizing radiation include ultraviolet, visible light, infrared light, microwaves and radiowaves.

Ultraviolet light (UV) is a form of radiation which is not visible to the human eye, UV radiation has shorter wavelengths (higher frequencies) compared to visible light but have longer wavelengths (lower frequencies) compared to X-rays. UV radiation is divided into three wavelength ranges: A, B and C.

Sunlight is the greatest source of UV radiation. Man-made ultraviolet sources include several types of UV lamps, arc welding, and mercury vapor lamps.

UV radiation is widely used in industrial processes and in medical and dental practices for a variety of purposes, such as killing bacteria, creating fluorescent effects, curing inks and resins, phototherapy and sun tanning.

Visible light runs from the familiar blue to green to yellow to orange to red. Red light is the least energetic of the colors of visible light and blue is the most energetic.

Infrared light lies between the visible and microwave portions of the electromagnetic spectrum. Infrared light has a range of wavelengths. Far infrared waves are thermal. The heat that from sunlight, a fire, a radiator or a warm sidewalk is infrared.

Radio waves have wavelengths as short as a few millimeters (tenths of inches) and as long as hundreds of kilometers (hundreds of miles). Microwaves, which are used for cooking and for communication, are short wavelength radio waves with wavelengths between a few and a few hundred millimeters (tenths of inches to tens of inches).

Various frequencies of radio waves are used for television and radio broadcasts, military communications, mobile phones, wireless computer networks, and numerous other communications applications.

Levels of non ionizing radiation emitted from VDTs as ultraviolet, visible and infra-red found to be below levels which are considered dangerous.

Exposure to radiations is known to affect the immune system which may leads to inflammation, cancer and dental diseases within the oral cavity. So, saliva can be used as a diagnostic tool in the assessment of the severity of illnesses caused by radiation exposures **(WHO 1997).**

COMPOSITION OF SALIVA

Since the early 1900s, saliva has proven to be noninvasive medium from which measure a wide range of hormones, pharmaceuticals and antibodies, saliva has many advantages in the use (easy access and non-invasive collection) have caused saliva to be a unique fluid as a diagnostic medium during recent years, which offers more privileges over serum, saliva is a vital body fluid, and is known to be critical for the preservation and maintenance of oral health. It is composed of a variety of organic and inorganic compounds allowing its varied functional properties which are derived from local vasculature of the salivary glands and also they reach the oral cavity via the flow of gingival fluid **(Kaufman and Lamster, 2002).**

The inorganic component is composed mostly of electrolytes such as sodium, potassium, magnesium, bicarbonates, phosphates, and nitrogenous products such as urea and ammonia. While, the organic component includes several classes of proteins such as immunoglobulins, enzymes, and mucins. Because the final saliva product is an aggregate of the saliva produced by several glands, each with different secretory characteristics, the composition of whole saliva at any particular time can be highly variable. This variability is further enhanced by the fact that secretory characteristics of each gland will change with the type of stimulus driving the saliva production. Furthermore, electrolyte composition of saliva will change depending on flow rates caused by changes in

the amount of inorganic compounds secreted or reabsorbed in the salivary ducts. In general, whole saliva is composed of approximately 99.5% water and has a specific gravity between 1.002 and 1.0012 and a PH that varies between 5.75 and 7.05.

The osmolarity of saliva is largely determined by the major ions: sodium, potassium, chloride, and bicarbonate. The PH is largely determined by the CO_2 content of saliva because bicarbonate is the principal salivary buffer system. **(Garrison et al., 1982)** assessed the role of reduced salivary flow and intra oral pH on gram-negative bacterial colonization of the or pharynx, this results suggest that reduced salivary flow and the concomitant reduction of intraoral pH may predispose patients to bacterial colonization with Klepsiella pneumoniae.

On the other hand Phosphate serves a minor role in buffering saliva. The electrolyte composition of saliva is relatively independent of plasma concentrations because electrolytes are transported into saliva via an active process, organic compounds passively diffuse into saliva, and therefore their concentrations in saliva reflect plasma concentrations.

1. Inorganic Component

The major salivary cations are chloride, bicarbonate, and phosphate. Salivary concentrations of chloride from the parotid gland and salivary gland are equivalent or lower than that of plasma. Salivary chloride concentrations are flow dependent, decreasing with decreasing flow rates. In the resting state, salivary bicarbonate concentrations can be as low as 5 meq/L, and with stimulation

bicarbonate concentrations may exceed that of plasma (27 meq/L). Moreover, salivary bicarbonate is derived from plasma as well as from metabolic activity in the gland. Salivary phosphate is also present at concentrations appreciably higher than that of serum and serves as one of the minor buffers about the amounts in pyrophosphate.

It should be added that **(Hosseini et al., 2006)** reported that there were no significant differences between the whole saliva values of male and female Iranian students with mean age 22 years. They evaluated inorganic phosphate, chloride, calcium, magnesium, glucose and protein concentration in saliva. Inorganic phosphate concentration was 1.52±0.63 and 1.58±0.63 mmol/l in males and females, respectively. Also, chloride concentration was 27.60±11.06 and 30.42±12.74 mmol/l in males and females, respectively. Moreover, calcium concentration of the whole saliva averaged 2.17±0.76 and 1.87±0.78 mmol/l in males and females, respectively. The mean whole saliva magnesium concentration was 1.27±0.45 and 1.37±0.44 mmol/l in males and females, respectively. The average glucose concentration was 0.75±0.44 and 0.73±0.47 mmol/l in males and females, respectively. While, total protein concentration in saliva was 6.69±2.89 and 7.26±3.78 mg/ml in males and females, respectively **(Agha Hosseini et al., 2006).**

On the other hand, minor inorganic components of saliva include iodine and fluoride which are present in different concentrations, the concentration of iodine in saliva is roughly 10 to 15 μg/mL and exists mainly in the inorganic form. While, salivary

fluoride content is approximately similar to that of plasma but is elevated slightly in individuals who drink fluoridated water or use fluoridated toothpaste. In these individuals, there is a prolonged release of fluoride in saliva from sparingly deposits on the teeth and soft tissues. These small elevations in salivary fluoride levels are believed to be important in preventing the formation of dental caries.

2. Organic Component

The major salivary glands are regarded as the principal sources of lingual lipase and salivary amylase. Also, salivary antimicrobial substances such as immunoglobulin A (IgA), lactoferrin, lysozyme, and lactoperoxidase.

Immunoglobulin A (IgA) is the predominant immunoglobulin in saliva, and also the predominant humoral factor in exocrine secretion and is normally abundant in the mucus coating of the gastrointestinal tract. Immunocytes produce 3 grams of salivary IgA daily. It is present at a concentration of approximately 20 mg/100 mL, and plays an important role in the local immune system of the salivary gland.

IgA accounts for approximately 15-20% of immunoglobulin, but it is the most abundant Immunoglobulin in secretions: saliva, tears, bronchial, intestinal and GI secretions.

Salivary IgA (sIgA) is found predominantly in the dimeric form in which two IgA macromolecules are covalently linked via a 'J' chain. Dimeric IgA is formed by plasma cells in the interstitium of the salivary gland and is transported across the acinar cell into the

acinar lumen via an active transport process. Two immunoglobulins, IgG and IgM, are also present in saliva, at much lower concentrations.

There are many factors also influence sIgA level including; anti-inflammatory drugs, antibiotics, parasympathetic stimulation, intestinal infections, intestinal bacteria and yeasts, ageing, high alcohol intake, maldigestion, malabsorption, gastroenteritis, chemotherapy and food poisoning. However, its role as a protective agent against dental plaque formation in humans is still controversial.

sIgA provides localized antibody protection on mucosal surfaces and function by preventing the micro-organism from adhering to such surfaces and penetrating their epithelial lining. It is also thought that sIgA can bind to microbial pathogens directly within epithelial cells and also bind to antigens in the mucosal lamina porpria and excrete them and decrease the access of these antigens to the systemic circulation.

The evidence of the role of sIgA in the periodontal disease is controversial. It has been suggested that sIgA is decreased in patients with increased intensity of gingival inflammation. However, immuno-deficient patients usually are not predisposed to periodontal pathology **(Berkovitz et al., 1982).** It is also hypothesized that the mechanism by which sIgA protects against periodontal disease is by preventing bacteria adherence to the mucosa rather than antigen destruction **(Bokor-Bratic, 2000)**. On the other hand, decreased sIgA levels in saliva appear to influence host resistance to mucosal

inflammation in some patients, and in particular those with an increased susceptibility and response to periodontal pathogens. This was confirmed by **(Hagewald et al., 2000)** as they found that sIgA was significantly lower in both early onset and aggressive periodontitis. It should be also mentioned that patients with bleeding gingival units after plaque accumulation had significantly higher sIgA **(Schenek et al., 1993).**

TRACE ELEMENTS

Trace elements are essential elements that present in minute amounts in saliva and its withdrawal could produce immunological as well as pathological abnormalities within the human body, which could be prevented by supplementation of these elements.

1. ZINC (Zn)

Zinc has been found to be an essential element in most species; it is essential for biological functions of all living matter. Zinc is required for the metabolic activities of over 70 metalloenzymes. The total amount of zinc in the human body is in the range of 1.36-2-32 g. The concentration of zinc in plasma is about (100 + 10) μg/dL **(Pekarek et al., 1972).** The concentrations of Zn in human mixed saliva vary greatly, ranging from 88 mg/ml to 136 mg/ml **(Freeland-Graves et al., 1981).** In addition, zinc is essential for the development and maintenance of the immune system **(Halsted et al., 1974)**. Nutritional problems causing Zn deficiency observed both in human and animal populations that have profound effects on host defense mechanisms **(Fraker et al., 1986).** Zinc exerts a

powerful and apparently a specific effect on the thymus, on T-lymphocytes and on cellular immunity on cell mediated responses **(Daredenne & Savino, 1987)** Zinc stabilizes macromolecules and biological membranes and influences the migration rate and phagocytic activity of macrophages; therefore, it might interfere with the dynamics of the inflammatory process **(Michaelsson et al., 1977).**

Zinc is essential for normal lymphocyte counts and for normal lymphocyte response **(Golden et al., 1978).** Moreover, **(Beisel et al., 1981)** demonstrated that the immature lymphocytes may be harmed more than the mature cells by the deficiency of zinc. Severe zinc deficiency may cause selective impairment of T-cell and B-cell immunity function. It should be also added that the response of lymphocytes to T-cell dependent and T-cell independent antigen were suppressed in zinc deficiency **(Fraker et al., 1978 and Winchurch et al., 1984)**. Zinc deficiency also alters lymphocyte and monocyte function in man and animals, causing lymphopenia, increased number of circulating T-suppressor cells and decreased circulating T-helper cells.

Restriction of the dietary zinc influence levels of the thymulin hormone which is biologically active on T-cells zinc supplementation to mildly zinc deficient subjects increases the serum thymulin activity **(Fraker et al., 1986).**

Thymulin is considered to be physiologically involved in T-cell differentiation and promotes T-cell function including allogenic cytotoxicity, suppresser function and interleukin-2 production

(Daredenne et al., 1982; Prasad et al., 1988). Thymulin requires the presence of zinc to express its biological activity. So, functional thymulin deficiency could contribute significantly to immune deficiency induced by the lack of zinc intake **(Prasad et al., 1988).**

Tanaka et al., (1978); Cunningham-Rundles et al., (1979); Fernandez et al., (1979); Chandra, (1980); and Daredenne et al., (1982) described a severe depression of serum immunoglobulins in patients who were found to have low serum zinc level. The patients also had moderate to severely depressed lymphocyte proliferation to mitogens and to antigens. The intestinal competition of zinc with copper, iron, lead, calcium and cadmium may accentuate nutritional deficiencies or toxicities from these environmental metals **(Abdel-Mageed and Oehme, 1990).**

Moreover**, (Duchateau et al., 1981)** concluded that zinc administration has immuno-regulatory and since zinc treatment which is nontoxic and not expensive, could be used in various conditions associated with immunodeficiency.

It should be mentioned that moderately large amounts of oral zinc supplement consumed by healthy subjects results in reduction of lymphocyte response to different T-cell and B-cell mitogens as well as T-dependent antibody responses **(Chandra, 1984).** So, if one has an over active immune function, zinc intake at intermediate levels will suppress the hyper activity to normal, whereas if there is a hypofunction of the host defenses, supplemental zinc will restore the activity to normal **(Solomons, 1982).**

2. Copper (Cu)

Cu is found in its elemental form and also as a component of many materials. The adult human body contains approximately 80 mg of copper **(Cartwright and Wintrobe, 1964).** Total blood Cu level varies in different species, it ranges from 1.1-1.5 mg/ml for the human and 0.2 – 0.35 μg/ml for domestic fowl **(Underwood, 1977).** In human saliva Cu is found in low concentrations with some differences according to the type of saliva taken and method of analysis. Moreover, **(Arwill et al., 1967)**, found a concentration of 0.28 ppm for fresh stimulated whole saliva, the concentration was quite low and certainly lower than those found in enamel. The enamel surface is capable of accumulating and retaining high concentrations of elements such as Cu **(Derenzis et al., 1969).** It should be pointed out that Cu has been studied for its toxicity and deficiency in man and animals, its role in dentistry has been neglected **(Underwood, 1977).**

The relationship between Cu and the immune response has been widely studied. It is shown that there is a strong relationship between Cu and the integrity of the immune response especially in relation to pathogenic challenges **(Prohaska & Lukasewycz, 1983).** Cu has a wide spread use for kitchen utensils, as thermal and electric conductors and in sanitation. On the other hand, Cu plays an important role in maturation of collagen and elastin and their level is very high in the young child and drop with age. Dietary intakes will markedly affect the levels of Cu found in organs. Not only does the dietary intake of Cu that found at different concentrations, but also because of interactions of the element with molybdenum, Zn, Cu,

iron and calcium. Zinc diminishes Cu absorption as they antagonize each other by increased production of metallothionine in mucosal cells that in turn binds to Cu preferentially **(Sarker, 1994).**

Cu affects both, nonspecific and specific immune system, it is found to be related to the nonspecific immune system through a close relation of copper to neutrophils function. In animals, copper with 3-mercapto-2hydroxy propylether of dextran was injected intravenously to normal and febrile rabbits and the following indices were determined; killing and phagocytic capability of peripheral blood neutrophilia migration of lymphocytes, number of B-cells, and number of cells producing IgM. It was found that, normal rabbits responded to such injected complex by the increase of killing capability of peripheral blood neutrophils, enhanced formation of rosettes against rabbit RBCs, increased amount of IgM-producing cells and inhibition of migration activity of peripheral blood lymphocytes. In febrile rabbits; as a result of the interaction with bacterial pyrogens, the injected complex potentates and prolongs the effect of killing ability and phagocytic activity of neutrophils, prolongs the mitogenic effect of B-lymphocytes and potentates the immunogenic effect evidenced by the increased number of IgM-producing cells **(Obminska, 1988).**

The effect of Cu on Alveolar bone resorption promotes the question of whether Cu has any relationship to periodontal diseases; a limited study by **(Miglani et al., 1969)** showed no difference in blood serum. On the other hand, it was noticed that the severity of copper deficiency is related to the degree of impaired immunity and

is dependent on the duration and time of restriction of copper in diet **(Prohasya & Lukasewycz, 1989).**

Dietary Cu deficiency leads to thymic atrophy and depressed thymocyte mitogenic activity **(Prohaska et al., 1983).** It was also found that, the production of interleukin-2 by T-cells is depressed by large doses of copper, suggesting the direct toxicity of copper on T-cell activation **(Kucharz & Sierakowski, 1988).** Moreover, Cu plays an important role in the maturation sequence of lymphoid tissues and the early deficiency of copper leads to impairment of the immune system **(Mulhern et al., 1987).**

Cu deficiency has been associated also with increased susceptibility to infection. Animals supplemented with dietary copper showed a significant reduction in pathological damage associated with the invading organisms **(Nadler et al., 1972).** Domestic animals with insufficient Cu intake showed decreased bactericidal activity **(Jones & Suttle, 1983),** together with an increased susceptibility to bacterial infections and decreased resistance to tumor Challenge **(Lukasewycz & Prohaska 1982).**

Serum levels of copper and zinc were evaluated in-patients with nasopharyngeal carcinoma before, during and after radiotherapy. Before radiotherapy serum copper level was significantly higher in nasopharyngeal carcinoma patients than in normal objects but the difference of serum zinc level was not significant. The ratio Cu/Zn also showed a significant difference between normal subjects and nasopharyngeal carcinoma patients preradiotherapy. During and after the period of radiotherapy, the

serum copper level decreased as compared with the level of preradiotherapy. The Cu/Zn ratio decreased after radiotherapy but not significantly **(Hsu et al., 1994).**

3. Iron (Fe)

The amount of iron in the human body is in the range 4.2-6.1g, **(Dreizen & Levy 1970)** in a study primarily concerned with comparing the effects of varying stimuli on the trace element composition of mixed saliva observed the Fe was the only element consistently identified in all saliva samples. The concentration of iron in saliva is 0.67-1.2 mg/L. Both the nonspecific and specific immune systems are regulated by iron level in the body **(Bryan & Leech, 1983).** Iron may bind directly to lymphocyte surface whether it is in resting state or after it has been activated. Such binding may occur via a molecule secreted by that cell rather than by receptors expressed by it **(Strom & Bangs, 1982).** After iron has achieved contact with a lymphocyte, at least two mechanisms could explain its effect on the proliferative response of that cell. First, it may affect certain intracellular enzymes or proteins involved in the response **(Munn et al., 1981).** Second, iron may alter the regulation or expression of certain receptors involved in lymphocyte division. That mechanism appears more likely as iron can regulate membrane receptors and proteins in bacteria as well as those of human lymphocytes **(Nishiya et al., 1979).**

Peripheral B-cell numbers from patients with serum iron levels more than 200 μg/dL tender to be lower than those from patients with lower levels of iron. This was particularly true for B-cells

bearing surface IgM and IgD. However serum iron level appeared not to influence the numbers of circulating cells bearing surface IgG and IgA **(Kapadia et al., 1980).**

T-lymphocytes are affected by iron overload especially in patients with chronic uremia with repeated blood transfusions and administration of oral or intravenous iron supplements leading to marked increase in serum ferritin concentration **(Ali et al., 1980).** These patients demonstrated marked inhibition of T-cell immune responsiveness reflected in vivo by prolonged skin allograft survival and reduced cutaneous reaction to antigens **(Opelz & Terasaki, 1980).**

Many studies were done to demonstrate the importance of iron in regulating the expression of T-lymphoid cell surface markers, in influencing the expansion of different T-cell subsets, and in affecting different immune cell functions **(De Sousa, 1989).**

(El-El Wany, 1988) studied the total iron in human saliva and serum in cases of chronic gingivitis, moderate and advanced periodontitis. He found that total iron concentrations in saliva of patients with chronic gingivitis, moderate and advanced periodontitis was increased compared to that of the control. Meanwhile no difference was present between the total iron concentration in serum of patients when compared to that of controls.

4. Magnesium (Mg)

Magnesium requirement for the average adult is about 300mg/day. The wide variation of Mg concentrations in saliva (0.1-0.7) mg/dl varies inversely with flow rate and also with individual variation.

Magnesium is one of the elements, which have a special attention because of its biological functions in immune system competence and host defensive mechanisms. Magnesium deficiency causes disturbances in immune system with multiple immunodeficiencies. Magnesium deficiency causes thymic gland hypertrophy and lymphomas may develop. It also causes leucocytosis and marked eosinophilia **(Beisel, 1982 and Iskandar, 1990).**

Magnesium has a great influence upon lymphocyte functions, as it is important for lymphocyte proliferation to different mitogens **(Beach, 1987).** B-lymphocytes are less susceptible to magnesium deprivation than T-lymphocytes which are profoundly influenced by lack of magnesium **(Flynn, 1984).** Increased concentrations of magnesium enhance lymphocyte mitogenesis **(Beach, 1987).**

Most stages of phagoctosis (chemotaxis, attachment and opsonization, ingestion, digestion and microbial killing) require magnesium ions **(Adel Salam et al., 1987)** and are inhibited by magnesium depletion **(Dobrina et al., 1989).**

(Estensen et al., 1976) concluded that magnesium is essential for most of the human neutrophil functions. They explained that magnesium ions move into or out of the cell in the direction of the concentration gradient. In the presence of very external

concentration of magnesium, any function of the neutrophil that could depend on influx of magnesium might be inhibited.

The magnesium required for lymphokines that induced inhibition of macrophage migration differed form that required for lymphokine-induced activation process **(Johnson et al., 1980).**

(Alcock & Shils, 1974) studied the effect of magnesium deficiency on the serum IgG level in rats. They found that the rats fed the magnesium deficient diet decreased levels of serum or plasma IgG. Administration of magnesium to the depleted animals resulted in an increase to normal of the serum magnesium and an increase in serum IgG to a level above that of controls 24 hours later, and it continued to rise markedly during the following 14 days. They suggested that magnesium had a direct role either in the synthesis, release, or metabolism of IgG.

They also suggested that the lymphocyte and plasma cell were especially sensitive magnesium depletion with regard to immunoglobulin synthesis. Moreover**, (Elin ,1975)** found that after 6 days of dietary magnesium deficiency in mice, there was a significant decrease in the concentrations of IgG2, IgA and IgM.

5. Fluoride

Fluoride plays an important role in cariostasis or caries prevention. The cariostatic effect is due to the direct influence on the mineral phase of dental enamel, but fluorides might also influence cariogenic microorganisms or other components in dental plaque **(Ripa et al., 1987; Kaufmann & Bartholmes, 1992).**

Fluorides prevent dental plaque to attach the teeth and depress its glycolytic activity as well as plaque acidogenesis as reflected by the increase in plaque pH **(Woolley & Rickles, 1971 and Schneider & Muhlemann, 1974)**.

Fluorides affect several bacterial enzymes leading to a change in the metabolic activity and the normal growth of bacteria **(Hamilton, 1977 and Loesche, 1977)**. Consequently, there was a decrease in gingival inflammation **(Leveret et al., 1984).**

A high level of fluoride in plaque may inhibit the growth of acidogenic and aciduric bacteria and mutans streptococci which are associated with the initiation of caries **(Hamada & Slade, 1980; Hamilton 1990; Tatevossian, 1990 and Van loveren, 1990).** It has been proposed that the inhibition of caries by fluoride could also be due to altered growth rates and a change in the metabolism of cariogenic microorganisms resulting in lower of acid production**. (Brown & Hewitt, 1974; Kroncke, & Kroncke 1974; Rosen, 1978; and Brown et al., 1990).**

6. Calcium

(Sewon et al., 1995) aimed to study whether salivary calcium is higher in treated periodontitis affected subjects or periodontitis free patients. The test group consisted of 20 (15 men, 5 women) periodontitis- affected subjects and the control group 15 subjects (10 men, 5women) free from periodontitis. Paraffin-stimulated whole saliva was collected to buffering capacity, numbers of mutans streptococci, lactobacilli and yeasts. The results showed a higher calcium concentration ($p<0.05$) in the periodontitis affected group

than in the periodontitis free group The periodontitis affected group had more intact teeth The present findings may indicate that elevated level of salivary Ca is characteristic of periodontitis affected patients both before and after periodontal treatment.

(Sewon et al., 1998) studied the correlations between high salivary calcium content and periodontitis, and between high salivary calcium level and the number of intact teeth in selected groups of subjects. A thorough oral examination including orthopantomo-grams was carried out for a total of 137 healthy subjects; 63 men (35.4+5.6 years) and 74 women (33.2+4.7 years). Paraffin-stimulated saliva was collected from the subjects and salivary flow (ml: min) buffering capacity. Calcium (mMo1.1) and microbial variables including lactobacilli, yeasts, mutans strepto-cocci, total streptococci, number of aerobes and anaerobes were determined. The calcium level of whole saliva had a median of 1.23 mMo1.1. subjects with calcium level below the median were categorized as low while those with higher values formed the high salivary calcium there were more men than women in the. High salivary calcium group ($p=0.025$) subjects in the high calcium group showed more bleeding on probing ($p=0.026$) had more intact teeth ($p=0.045$) and lower DMF-scores ($p=0.025$) than their counterparts. No other differences were found between the two groups. We found clear associations between the level of salivary calcium and factors reflecting gingival health on one hand, and dental health on the other in a randomly selected group of healthy subjects, and conclude that

salivary calcium may be important with regard to both dental and gingival health.

It should be also mentioned that adult male rats were exposed to 4 and 10 Gy of whole-body gamma radiation. Lethal radiation increased plasma calcium with subsequent decrease while plasma magnesium decreased in both groups, plasma iron in 4 Gy irradiated rats diminished. Both groups of animals exhibited significant diminution of plasma copper **(Sarkar, et al., 1982).**

BIOLOGICAL HAZARDS OF RADIATION

Radiation can produce its biological effects through interaction with matter, Cell contents are mostly water (H_2O) i.e. hydrogen and oxygen, followed by other elements of low atomic number i.e. carbon and nitrogen. Although the damaging feature of ionizing radiation is through the deposition of the absorbed energy to tissue contents **(Potten, 1985).**

I. Interaction of Radiation with Matter

The word interaction is applied to processes in which the energy and/or the direction of the radiation are altered. There are several mechanisms by which energy is transferred from radiations to biological materials. They could be illustrated through the interaction of the various types of radiations with atomic electrons and nuclei of the medium they transverse. Particulate radiations yield their energy by different processes depending on the particle charge, mass and energy. Electrons lose energy through collisions with atomic orbital electrons leading to ionization excitation followed by emission of electromagnetic radiation.

A high energy electron may also interact with the nucleus when passing close to it causing a bending in its path and so loses part of its energy as bremsstrahlung radiation.

On the other hand, electromagnetic radiations transfer their energy to a biological material through scattering and absorption. The energy of infrared and visible radiation is mainly absorbed by

the whole molecules and atoms while the energy of an ultraviolet photon, when being absorbed by an orbital electron, is sufficient to excite atom and so it becomes chemically reactive. X and γ rays are considered as ionizing radiation since their photon energy is great enough to release a planetary electron and set the atom in an ionized state which is highly reactive.

There are 3 main processes through which X and γ photons are attenuated (i.e. reduced in intensity due to absorption and scattering) and lose energy as they traverse a medium. They are schematically illustrated as shown in **(Cameron and Skofronick, 1978)** and could be outlined as follows:

1) Photo–electric effect

Which describes the case when a photon is absorbed by the atom and transfers all its energy to an orbital electron which is ejected out with a kinetic energy equals the difference between its binding energy and the photon energy. The emitted electron is termed "photo electron" and its vacancy is refilled by an electron jump from an outer shell giving rise to the emission of another photon which together with the photoelectron may interact with other atoms. Photoelectric absorption is dominant up to photon energy of 50 KeV.

2) Compton effect

Here the photon collides with a valence electron transferring only part of its energy to the recoiling electron known as "Compton electron". The photon is then scattered with a lower energy to undergo other interactions. This effect is dominant for photon

energies in the range 200 KeV – 2 MeV.

3) Pair production

In this process, a high energy photon passing to an atomic nucleus is affected by its strong nuclear field and suddenly disappears and its energy is partly transformed into an electron – position pair in accordance to Einstein mass – energy – energy relation ($E = mc^2$). This process is called "annihilation", and becomes significant at very high energies > 5 MeV.

II. Mechanism of biologic action for radiation

The mechanism of biologic action for such radiation could by explained through their direct or indirect effects as outlined by the following two theories.

1) Target theory (Direct effect)

The concept of target theory was first introduced by **(Dessaur, 1923)** In its simplest form, it states that a decrease in the surviving fraction of target molecules after irradiation is an exponential function of dose. This type of dose – response curve is called a 'single hit curve', because only one hit (ionization) is required for inactivation of a biological molecule. It should be also mentioned that in case of several hits, non exponential curves can take place. Such curve could be interpreted through a "multi-target model" in which the biological system contains a number of targets to be inactivated or through a "multi-hit model" in which a single target can sustain few hits for inactivation. An extension of the straight line

portion can indicate that number. Moreover, the effect of a given dose is independent on the dose rate, linear energy transfer "LET" and fractionation.

2) Theory of Indirect Effect

The inactivation of target molecules is caused by free radicals which produced by ionizing radiation.

The damage to cells by irradiation is caused by both ionization (direct effect) and free radicals (indirect effect). Since water is a major constituent of cells, it is necessary to understand the effect of irradiation on water.

So when X-rays interact with water two primary free radicals are formed:

$$\text{X ray} + H_2O \rightarrow H^+ \quad \text{(Hydrogen free radical reducing agent)}$$

$$+ OH^- \quad \text{(Hydroxyl free radical oxidizing agent)}$$

These free radicals are very reactive and can attack molecules like DNA, RNA and proteins. Most of the free radicals are very short lived, with a life less than 10^{-10} sec. So, free radicals come together they combine to form a chemical bond by sharing their unpaired electrons. In water, hydrogen and hydroxyl free radicals recombine to form hydrogen peroxide (H_2O_2) and Hydrogen atoms **(Prasad, 1974).**

$$OH + OH \rightarrow H_2O_2$$

$$H + H \rightarrow H_2$$

It is thus clear that while the target theory postulates that

sensitive structures, as chromosomes, are struck directly by ionizing radiation, while the theory of indirect action deals with a biologic unit undergoing radiation induced changes when a sensitive target is hit directly by energy transferred through free radicals formed in the irradiated material.

III. Sequences of radiation injury

The sequential development of radiation injury in biological systems is primarily initiated at the molecular level. The nucleic acids are considered the primary site of radiation injury to the cell, followed by the molecules of the cell membrane and other critical biomolecules of the cell system. Since biomolecules are the target for radiation energy absorption, this results into a population of excited and ionized physiochemical bonds of molecules. The number of affected molecules depends on the amount of radiation energy absorbed in a specific mass of biological media.

The ultimate outcome will also depend on the radiosensitivity of the cells and tissues of the biological system involved in the radiation exposure. The most important biological factors that determine cellular radiosensitivity are cell division, processes of cellular differentiation, proliferation, cellular organization and biochemical activity of the cell in particular during synthesis of critical molecules. Completely differentiated cells are considered relatively radioresistant **(Yarmonenko, 1988).**

The ultimate response of cells and tissues to radiation injury is

invariably dependent on the radiation dose and the ability of the cells to repair sublethal damage. High radiation doses usually result in mitotic arrest and high incidence of cell death, with little chance of regenerative cellular repopulation. In this situation, there will be arrest of tissue development and cellular replacement In case of exposure to high doses of radiation, the various cell types in body tissue will suffer radiation induced cell death in proliferating cells; or radiation induced physiological and functional disturbances in non-proliferating differentiated cells. At relatively lower radiation doses, some primordial cells may survive the radiation injury and proceed towards regeneration and reconstitution of the tissue cellular population. Lower doses of radiation fail to produce cell killing, but succeed in producing radiation induced mutations and other molecular alteration resulting in cellular abnormalities that become inherited in the genetic cell line of the cells composing the tissue and ultimately produce tissue and organ abnormalities **(El-Naggar, 2001).**

1) Radiobiological principle

Two essential radiobiological principles should be considered. The first is the Linear Energy Transfer (LET), which is defined as the average amount of energy imparted from the incident radiation to the biological system in a unit length of the linear track. The dimensions of the LET are given in terms of electron volts per micron of linear track. On the basis of such consideration, radiation may be classified as those of high LET such as heavy charged particle radiations; and those of low LET such as photon radiations.

The biological effects induced at the molecular level are distinctly different in both situations. Moreover, of the second concept is the Relative Biological Effectiveness (RBE) of the various types of ionizing radiations. The RBE is defined as the quotient the doses from a specific radiation as related to a standard radiation, to produce the same biological end point in both situations. This will provide a differential understanding of the ability of the different types of radiation to cause biological damage and will also give an insight of the differential radiosensitivity of the biological system in its response to the incident radiation. These two concepts are fundamental in the proper understanding of the radiation induced alterations in cells initiated at the molecular level **(El-Naggar, 2001).**

2) Deoxyribonucleic acid (DNA) affection

The effects of radiation on the cell in a biological system are essentially derived from the damage caused to the biomolecules constituting the cell. In case of exposure to low radiation doses, damage to the DNA present in the cell nucleus is of great concern. Directly or indirectly by the action of chemical radicals, radiation can induce changes in the base sequence and can therefore alter the genetic code script. The radiation induced DNA damage is expressed as DNA mutation occurring in genes of chromosomes which alters the genetic information that is transmitted from the cell to its progeny. The DNA molecule is known to possess an efficient potential for repair mechanisms, however, this repair is not always error free. Most damage is repaired, however, some damage remains

or is badly repaired. This initial DNA damage has consequences on the cell and its progeny **(El-Naggar, 2001).**

The process by which DNA mutations can be reduced by a small prior conditioning dose of radiation is called 'Adaptive Response'. It has been postulated on experimental evidence that this conditioning dose probably causes stimulation of the repair mechanisms in the cell. Such process of adaptive response has been demonstrated in human lymphocytes and in certain mammalian cells. Adaptation is likely to occur together with the processes of DNA mutation and its subsequent effects. The balance between the stimulated cellular repair and residual damage is not yet clear.

Although radiant energy can affect cytoplasmic enzymes, macromolecules and organelles, the most vulnerable target is nuclear DNA. The nucleus is the prime target of radiation injury. With sufficient exposure, the nucleus appears swollen and the chromatin is clumped. At higher levels, there is pyknosis and even fragmentation of the nucleus. The cytoplasmic changes include cell swelling, mitochondrial distortion and degeneration of the endoplasmic reticulum. Plasma membrane focal defects and breaks may appear and indeed the cell may be disrupted.

3) Clinical radiation effects

Radiation effects can be classified into Stochastic (Probabilistic Effects) and Non-stochastic (Deterministic Effects). This recent realistic classification depends on the concept of the threshold dose to produce an effective response. This classification was adopted by

the International Commission on Radiological Protection (ICRP) since 1977.

A) Delayed stochastic (probabilistic) effects

They have the features of no threshold; have latent period, probabilistic nature of all mechanisms involved and dose response relationship (increase probability with increase dose). The populations at risk are atomic energy workers, staff of medical radiation (diagnostic and therapeutic), mining workers and embryos of the above groups. These include hereditary, congenital and teratogenic genetic, cancer transformation, premature aging, cataract and infertility.

i) Hereditary effects are effects that are transmitted to the progeny of parents who have developed radiation injury to the gonads. These effects may be expressed in the first generation or later.

ii) Congenital malformations and teratogenic effects that may be produced in the developing embryo-fetus during intrauterine life, induced by exposure of the abdomino-pelvic region of the pregnant mother to radiation. The type and degree of malformation depends upon the magnitude of the radiation dose and more specifically on the stage of gestation at which radiation exposure took place. Teratogenesis is those effects expressed and permanently present in the organism. The origin of it must be genetic, congenital or induced **(Cotran et al., 1994).**

iii) Genetic effects are produced by radiation induced injury to

genetic material (DNA) in the cell. They are termed mutations, which are defined as any permanent change in the chemical, physical, functional or structural properties of the DNA molecule. Mutations are divided into gene mutation and chromosome aberrations.

vi) Cancer transformation may occur due to permanent change to the DNA molecule which is called initiation process. If clones of mutant cells are presented (due to inactivation of tumor suppressor genes) this stage is called promotion process. When the cell becomes committed to the malignant process, it is called the conversion stage.

v) Others: Premature Aging, Cataract and Infertility.

B) Acute Non-stochastic (Deterministic) effects.

These effects occur only after relatively high threshold dose of radiation, below which the particular effect does not occur. The occurrence and severity of effect produced is a function of the magnitude of dose and dose rate. The pathogenesis of induction and mechanisms of development are non-stochastic i.e. deterministic in nature. These effects appear within hours or days after exposure without a latent period.

Major examples of non-stochastic (deterministic) effects are all forms of acute radiation injury to tissues or organs. All forms of Acute Radiation Syndromes. Haemopoitic “Bone Marrow” syndrome, the threshold dose is about 2 Gy, manifested by pancytopenia, increase bone marrow proliferation and differentiation of stem cells. Gastro-intestinal syndrome, threshold dose is 4.5 Gy,

manifested by gastro-enteritis, which leads to dehydration. Cardio-vascular syndrome, the threshold dose is 6.5 Gy, manifested by disturbance in microflow, capillary fragility, petecial hemorrhages, myocardial ischaemia, hypotension and cardiac shock. Oro-respiratory syndrome, the threshold dose is 8 Gy, manifested by petechial hemorrhages, constriction of the trachea and bronchioles, pulmonary edema and respiratory distress. Central nervous system syndrome, the threshold dose is about 10 Gy, manifested by disturbance of the physiology and function of the cerebral cells leads to loss of reflexes, convulsions, coma, it has very bad prognosis. Associated syndromes include skin burns, depression of immune response and psychosomatic disturbances.

The studies performed in this thesis deal with radiation effects induced during embryonic development and fetal growth. These effects are very different to those induced by radiation on adult cellular populations, tissues and organ systems. The main reasons for this difference are the processes of cellular organization, proliferation, differentiation and growth. These processes assume basic patterns of differences when they occur during intrauterine life and when they occur in adult cellular population. However, in spite of these great differences, it is found logic to include a short synopsis that deal with radiation effects on adult tissues.

At sufficient dosage radiation can inhibit indefinitely the cells' capacity to divide. This inhibition of cell proliferation is the usual mechanism by which radiation kills cells (except at extremely high levels of exposure). Selective inhibition of cell proliferation leading

to cell killing during fetal development accounts for the somatic effects and teratogenicity of radiant energy.

Smaller doses of radiant energy may induce mutations and heritable or nonheritable alterations in metabolism that are compatible with cell survival and continued reproduction. When such injuries are heritable and involve germinal cells, overt or occult defects are transmitted to offspring. Radiation is a potent cause of mutation and oncogenic transformation.

The effect of radiation upon organs depends on the dose, type of tissue irradiated and time lapse since irradiation. Injury may become apparent sometimes within days to months, or only after some time lapse (latency), which may be as long as many years **(Cotran et al., 1994).**

i) Vascular changes

Vessels in the skin may show only dilatation, producing some erythema. Later or with higher doses, there is endothelial swelling and vacuolation or even destruction of endothelial cells, particularly in the microvasculature, with secondary thromboses or hemorrhages. At a later stage, intimal hyperplasia and collagenous hyalinization with thickening of the media develop. Such changing in arterioles and small arteries result in marked narrowing or even obliteration of the vascular lumina **(Cotran et al., 1994).**

ii) Hematopoietic and lymphoid systems

The hematopoietic and lymphoid systems are extremely

susceptible radiant injury. With high dose levels and large exposure fields sever lymphopenia may appear within hours, with shrinkage of the lymph nodes and spleen. Radiation directly destroys lymphocytes, both in the circulating blood and in tissues (nodes, spleen and thymus, gut) and causes cytological disorganization. Regeneration may occur within weeks to months. The circulating granulocyte count begins to fall toward the end of the first week, with possibly disappearance of these cells in the circulating blood during the second week. Recovery may require two to three months. Neutrophil count returns within 2-3 months. Platelets are similarly affected, with the nadir of the granulocytes. Erythrocytes are radioresistant, but anemia may appear after two to three weeks and be persistent for months because of marrow damage. The hematopoietic cells in the bone marrow are also quite sensitive to radiant energy, including the red cell precursors **(Finch, 1979).**

VISUAL DISPLAY TERMINAL

VDT (video display terminal or sometimes visual display terminal) is a term used for the computer display. A display is a computer output surface and projecting mechanism that shows text and often graphic images to the computer user, using a cathode ray tube (CRT), liquid crystal display (LCD), light-emitting diode, gas plasma, or other image projection technology. The display is usually considered to include the screen or projection surface and the device that produces the information on the screen. In some computers, the display is packaged in a separate unit called a monitor.

Major issues related to the VDT include the effect of prolonged visual interaction with display content in terms of medical health deterioration; this depends on proper viewing distances, the amount and effect of exposure on users to the radiation that emanates from VDTs. Moreover, the possible health effects of video display terminals (VDTs) were the main interest of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) **(Bergqvist, 1984).**

I. Origin of Visual Display Terminal (VDT) Radiation

1) Cathode Ray Tube (CRT), which forms the TV screen with its face, releases electrons which are accelerated towards the screen. Images on VDT screen are produced by this projected electron beam which moves horizontally and vertically across the screen. This horizontal and vertical 'scanning' is controlled by horizontal and

vertical deflection coils, such that each time the beam travels across the screen in response to the horizontal coil, it also moves slightly downward in response to the vertical deflection coil. On the other hand, conventional VDTs containing CRT use also magnetic fields to produce the image on the screen, and some emission of those magnetic fields is unavoidable. The spot of electrons which sweep the screen generates Pulsed Electro. Magnetic Radiation (PEMR) which, at close range, disturbs the balance of all living cells

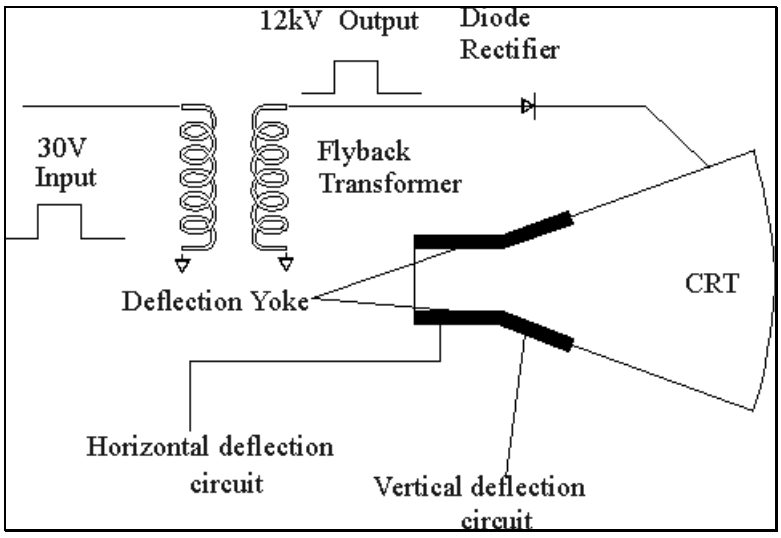

Figure (D) Cross Section of a Typical Video Display Terminal

2) Electromagnetic fields

Electromagnetic fields usually created around the electric wires within the VDT. Moreover, electromagnetic radiations could be described also as the periodic variation of electric and magnetic field at a given point. Man-made sources of electromagnetic fields that form a major part of industrialized life are electricity, microwaves and radiofrequency fields which are found at the relatively long wavelength and low frequency end of the electromagnetic spectrum

and their quanta are unable to break chemical bonds. Electric fields exist whenever a positive or negative electrical charge is present, they exert forces on other charges within the field. The strength of the electric field is measured in volts per meter (V/m). Any electrical wire that is charged will produce an associated electric field. This field exists even when there is no current flowing. The higher the voltage, the stronger the electric field at a given distance from the wire.

Electric fields are strongest close to a charge or charged conductor, and their strength rapidly diminishes with distance from it. Conductors such as metal shield them very effectively. Other materials, such as building materials and trees, provide some shielding capability. Therefore, the electric fields from power lines outside the house are reduced by walls, buildings, and trees. When power lines are buried in the ground, the electric fields at the surface are hardly detectable.

Magnetic fields arise from the motion of electric charges. The strength of the magnetic field is measured in amperes per meter (A/m); more commonly in electromagnetic field research, scientists specify a related quantity, the flux density (in microtesla, μT) instead. In contrast to electric fields, a magnetic field is only produced once a device is switched on and current flows.

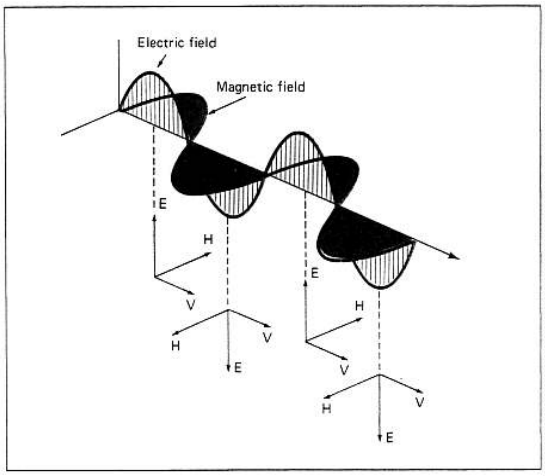

Figure (E) Electricity flowing through a wire or any electronic component propagates an electromagnetic wave with two vectors, the electric vector, *E*, and the magnetic vector, *H*. *V* is the direction of wave travel. These waves are generated by the components and printed circuits within a VDT and/or a microcomputer (Highland, 1998).

The higher the current, the greater the strength of the magnetic field, the strength of the magnetic field is measured in amperes per meter (A/m); Like electric fields, magnetic fields are strongest close to their origin and rapidly decrease at greater distances from the source. Magnetic fields are not blocked by common materials such as the walls of buildings.

Electric fields	Magnetic fields
• Electric fields arise from voltage. • Their strength is measured in Volts per metre. • An electric field can be present even when a device is switch off. • Field strength decreases with distance from the source. • Most building materials shield electric fields to some extent.	• Magnetic fields arise from current flows. • Their strength is measured in amperes per meter (A/m).. • Magnetic fields exist as soon as a device is switched on and current flows. • Field strength decreases with distance from the source. • Magnetic fields are not attenuated by most materials.

Table (A) Differences between Electric and Magnetic fields.

II. Types of VDT radiations

1) Very low frequency (VLF) fields originate from the current in the vertical deflection coil and arise from the output lead of the fly back transformer.

2) Extremely low frequency (ELF) fields which fall below the 300 Hz range. The time-varying electromagnetic fields produced by electrical appliances are an example of Both ELF electrical and magnetic fields are produced by the electric circuits responsible for the vertical motion of the electron beam on the VDT. More specifically, the magnetic field originates from the current in the vertical deflection coil, and the electric field arises from a modulation of the static charge on the screen. Our electricity power supply and all appliances using electricity are the main source of

ELF fields. Moreover, personal computers produce low EMF which radiate from all sides of the VDT.

3) Intermediate frequency (IF) fields with frequencies from 300 Hz to 10 MHz. Computer screens, television, mobile telephones and radio transmitters, radar anti-theft devices and security systems produce radiofrequency fields and they are considered the main source of IF fields. The maximum radiofrequency emission levels at 300 mm from the screens of either the monochrome or color VDTs.

4) Ultraviolet radiation (UV)

The UV irradiance from the VDT at maximum intensity is still substantially lower than that from normal fluorescent room lighting. The maximum measured UV emission from a VDT is 124 mW/m^2. It should be noted that this was obtained with the detector in contact or in close proximity to the screen. It was also found that the majority of the 200 types of VDTs tested had irradiances of less than 10 mW/m^2.

For the UV-A region, the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that an irradiance upon the unprotected skin or eye should not exceed 10 W/m^2 for exposure periods of greater than 1000 seconds over an 8 hour working day. For all VDTs measured the UV emission occurred at wavelengths longer than 350 nm. In fact for all VDTs more than half of the UV emission occurred in the range 390 to 400 nm. The average UV irradiance measured within VDTs by **(Elliot et al., 1986)** was 1.43 mW/m^2. These values range between

approximately three and five orders of magnitude below ACGIH recommended limits.

5) Ionizing radiation (X-Rays). No ionizing radiation above background was detected for any of the VDTs.

The National Health and Medical Research Council of Australia recommends for television viewers that the ionizing radiation exposure rate shall not exceed 0.5 mR/hr averaged over an area of 1000 mm^2 at a distance of 50 mm from any point on the external surface of the receiver. This recommendation can be equally applied to VDTs. All VDTs evaluated complied with this recommendation **(Elliot et al., 1986).**

III. Effects of VDT radiation on human health

1) General condition

The use of computer rarely causes; headaches, skin allergy, nausea, dizziness, difficulties in concentrating, fatigue, miscarriages, eye strain, other vision problems, and sleeplessness. Moreover, **(Santini et al., 2002)** reported that the use of both cellular phones and VDT significantly increased concentration difficulties. Digital cellular phone users also significantly more often complained of discomfort, warmth, and pricking of the ear during phone conversations as a function of calling duration per day and number of calls per day. They concluded that Electromagnetic fields emitted by digital cellular phones affect working memory in humans and this effect may be related to cerebral vessel dilatation, attributed to brain heating. It is well known also that microwaves increase the

temperature of material from inside to outside. Thus, the warmth sensation of the ear reported by digital cellular phone users during communication is the result, at the skin level, of mild cerebral hyperthermia. Thus, the warmth sensation of the ear might be a signal for users indicating that it is time to stop the call **(Santini et al., 2001).**

2) Psychosomatic

(Steffy and Jones, 1989) made a survey to determine whether VDT operators experience greater psychosomatic distress, job tension, job dissatisfaction, and strain than non operators or employees who operate VDTs infrequently. After controlling for demographic suggest that hours of VDT use has an impact on employee well-being, though role strain was more consistently related to outcome measures.

On the other hand, **(Olivetti et al., 1985)** evaluated the prevalence of psychosomatic symptoms in a group of VDT telephone operators and compared with a control group (people not working at VDTs) by using questionnaires. The results show that psychosomatic symptoms are much more frequent in VDT operators in comparison with the control group.

3) Pregnancy

(Bryant and Love, 1989) investigated the potential effects of VDT use on risk of spontaneous abortion in pregnancy. The overall exposure to VDT" s during the period of interest (three months proceeding the last menstrual period [LMP] to four months post-

LMP) did not indicate an increased risk for either control group comparison. Furthermore, when exposure data were re-classified to remove women with distant or single exposures, no significant odds ratios were found. While several socioeconomic and obstetric variables were significantly associated with VDT use. Moreover, **(Schnorr et al, 1991)** studied the relation between spontaneous abortion and the use of video display terminals (VDTs). A cohort of female telephone operators who used VDTs at work was compared with a cohort of operators who did not use VDTs. Abdominal exposure to extremely-low-frequency fields (45 to 60 Hz) was similar for both operators who used VDTs and those who did not. They found no excess risk of spontaneous abortion among women who used VDTs during the first trimester of pregnancy and no dose-response relation was apparent when they examined the women's hours of VDT use per week there continued to be no risk associated with the use of VDTs when they accounted for multiple pregnancies, conducted separate analyses of early abortion, late abortion, and all fetal losses, or limited our analyses to spontaneous abortions for which a physician was consulted. The use of VDTs and exposure to the accompanying electromagnetic fields were not associated with an increased risk of spontaneous abortion in this study.

On the other hand, **(Abenhaim et al 1988)** evaluated the effects of VDT Work on pregnancy outcome. They show that the use of VDTs poses no increased risk of congenital anomalies, stillbirth, or premature birth. Consensus evaluation of divergent epidemiological results concluded that VDT work is not a risk factor significantly

affecting spontaneous abortions. The risk of low birth weight could not be validly assessed.

On the other hand, **(Kurppa et al., 1985)** studied the relation between exposure to VDTs and birth defects, a study was done on mothers of 1475 children reported consecutively to the Finnish register with congenital malformations on the central nervous system, orofacial clefts, skeletal defects, or cardiovascular malformations and the forms of the same number of their paired referents were studied. They were compared between the pregnant mothers exposed to VDTs during the first trimester with those not exposed at all to detect any birth defect. The results did not indicate any teratogenic risk for operators of VDTs. Moreover, **(Brandt and Nielsen, 1990)** study the congenital malformations among children of women working with video display terminals in a case-base study among 214,108 commercial and clerical employees in Denmark. The results of this study did not support the hypothesis that the use of video display terminals during pregnancy is associated with an increased risk of congenital malformations.

(Nielsen and Brandt, 1990) investigated the risk of adverse pregnancy outcome among women working with a VDT. Data on VDT use, job stress, ergonomic factors, and life-style factors collected with questionnaires sent to 6212 women and 426 employers. There was no increased risk of medically verified spontaneous abortion among women with VDT use. The relative risk for women exposed to any degree of use was 0.94 (95%

confidence interval 0.77-1.14). Ergonomic work load and job stresses were not cofounders.

(Tikkanen et al., 1990) studied the possible effects of working with VDTs during pregnancy on the occurrence of cardiovascular malformations in the offspring in 500 cases and 1055 controls. Both the case and control mothers were interviewed by midwives using a structured questionnaire approximately three months after delivery. The mother's occupation, job description and employer the first trimester were noted, as were large number of other exposures to chemical and physical factors. In logistic regression analysis maternal exposure to VDTs for at least 20h a week during the first trimester of pregnancy showed a point estimate of odds ratio of 1.4 with 95% confidence limits of 0.5and 3.8, when adjusted for age and alcohol use. Maternal exposure to VDTs was not associated with indicators of fetal growth such as birth weight, placental weight or length of gestation.

(Windham et al., 1990) investigated the effects of video display terminals use during pregnancy and the risk of spontaneous abortion, low birth weight, or intrauterine growth retardation. They concluded that the risk for low birth weight (LBW) among the control group was not greatly elevated at either VDT use level, the risk for intrauterine growth retardation was somewhat elevated among women with greater VDT use.

Moreover, **(Juutilainen, 1991)** studied the effects of low-frequency magnetic fields on embryonic development and pregnancy. The results of experiments with mammals are

inconsistent. There is more evidence of effects on mice than on rats, and the data suggest that fetal loss might be increased rather than malformations. Most of the epidemiologic studies related to pregnancy and low-frequency fields have concerned operators of VDT. The results do not provide evidence for an association between adverse pregnancy outcome and use of a VDT.

4) Skin

(Liden and Wahlberg, 1985) examined 74 persons who complained of skin symptoms by occupational dermatologists. The objective was to see whether any type of rash could be suspected to depend on VDT work, subjects with seborrheic dermatitis, acne, and rosacea were overrepresented in the exposed group. Whether this occurrence was due to physical factors, psychological factors, or pure chance is still unclear. This study and observations from our clinical observation imply that a relationship might exist between VDT work and aggravation of seborrheic dermatitis, acne, and rosacea and probably Poikiloderma of Civatte. Moreover, **(Liden and Berg, 1991)** investigated whether skin problems are more common in VDU-exposed persons than in non- exposed controls, whether there are differences in objective and/or subjective symptoms and signs, and whether there is a" Specific" dermatosis associated with VDU work. A self-reported questionnaire was mailed to 3.877 individuals. The clinical diagnosis, based on objective signs and anamnestic data showed a somewhat attenuated association with exposure. The status diagnosis, based solely on objective signs, failed to show any association to VDU exposure.

Unilateral skin rashes occurred at the same frequency in the exposed and the non-exposed groups. It is concluded that there is nothing in this investigation, or in any other investigation, that would speak against the notion that VDU-related skin problems and the allergy to electricity is just another facet of the "20th century syndrome".

5) Eye

(Malfatti et al., 1985) evaluated the incidence of the "ocular fatigue syndrome" in a group of VDT telephone operators and compared with a control group. The results show that the "ocular fatigue syndrome" is much more frequent in VDT operators in comparison with the control group. Moreover, **(Balisario et al., 1988)** evaluated the ocular symptoms on a VDT operators group, by using questionnaires and an ophthalmological screening. The results show that some ocular fatigue symptoms are much more frequent in VDT operators in comparison with the control group. VDT operators working more than 4- hours/ day at VDT are the most affected.

(Gobba et al., 1988) studied the lighting conditions, luminance, contrast, and design of the workplace in VDT work stations operated by a group of female VDT data-acquisition clerks. The results confirmed that VDT data-acquisition work can lead to temporary myopia (myopization) in a remarkable percentage of operators, a significant correlation between eye discomfort, ocular asthenopia, and myopization was also found. Illumination levels, luminance, and contrast seem to be of paramount importance regarding visual symptoms: neither asthenopia nor myopization was

observed when all of these conditions were adequate. If the ergonomic design of the workplace and the viewing distance are adequate, there are also usually fewer musculoskeletal symptoms. The results suggest that changes in the ocular refraction status before and at the end of the work-shift, as determined by an automatic refractometer, provide a good objective index of VDT-induced "ocular fatigue", which in this study proved to be significantly related to workplace conditions. Moreover, **(Luberto et al., 1989)** studied temporary myopia and subjective symptoms in video display terminal. Subjective VDT-related symptoms of asthenopia were assessed by means of a questionnaire. AII operators were examined by an ophthalmologist. Visual acuity was measured using vision tables with optotypes. In order to achieve an objective assessment of VDT-induced visual fatigue, refractive power was measured at the beginning and at the end of the shift, using an infra-red autorefractometer. Changes in refractive power were then related to VDT work and asthenopia symptoms. The results suggest that ametropic subjects are likely to be more susceptible to visual fatigue than emmetropic subjects, since there was a tendency for the prevalence of asthenopia to increase in the former group. It can be concluded that end-of-shift myopization, as measured by an automatic refractometer, may be used as a reliable objective measurement of VDT-related visual fatigue. Moreover, **(Yeow and Taylor, 1989)** compared VDT group and non VDT work group and studied the effect of VDT on the visual functions. They paid particular attention to their effects on the refractive error of different refractive groups and for different age populations. Other visual

functions measured were visual acuity (VA), accommodation, and convergence. Results show that VDT work does not have a significantly greater effect on visual function than non-VDT work.

On the other hand, **(Nyman et al., 1985)** examined the VDT operators and control before and at the end of work sessions for changes in refraction, accommodation, convergence capacity, and binocular vision such as heterophoria and fusion range. No differences could be established between the VDT operators and the control. It should be also added that **(Thaler and Steinkogler, 1987)** made ophthalmological screening of 152 employees working at VDTs. In 62% of the people tested spectacles were prescribed for correction of vision at working range. Two years later a follow-up examination was performed. The correction had to be revised for 23% of the people working at VDTs. It is recommended that ophthalmological screening should not be restricted to people working at VDTs. All employees whose work involves close-range vision require regular ophthalmological check-ups.

It should be also mentioned that **(Wiggins and Daum, 1991)** evaluated the effects of small amounts of uncorrected astigmatism on the visual comfort of VDT users. The analysis of the data indicated greater reported eyestrain for the test lens pair. These results suggest careful consideration be given to the correction of small amounts of astigmatic errors for VDT users. In microwave ovens this fact is employed to warm up food. The levels of radiofrequency fields to which people are normally exposed are very much lower than those needed to produce significant heating. The

heating effect of radio waves forms the underlying basis for current guidelines. Scientists are also investigating the possibility that effects below the threshold level for body heating occur as a result of long-term exposure. To date, no adverse health effects from low level, long-term exposure to radiofrequency or power frequency fields have been confirmed, but scientists are actively continuing to research this area.

No ocular injury due to exposure to RF radiation at frequencies less than 500 MHz has been reported in the literature. As there is no emission detected at frequencies above 500 MHz in this or the other surveys cited, it can be concluded that there is no ocular hazard from the RF emissions from VDTs. The main responses of the eye to excessive amounts of UVR are photokeratitis, conjunctivitis and lenticular cataracts. As photokeratitis and conjunctivitis are induced mainly by radiation of wavelengths less than 320 nm, 26 they are unlikely to be produced by VDTs, which emit no UVR below 350 nm. The effects of UVR with wavelengths greater than 350 nm on the human eye, in particular the lens, where most of the absorption at these wavelengths takes place, is less well documented. The available evidence suggests that extremely large closes of UVR of wavelengths greater than 350 nm are required to induce cataract formation, perhaps of the order of 0.5 to 1.0 MJ/m2. Exposures received from VDTs are at least 3-4 orders of magnitude below this **(Elliot et al., 1986).**

6) Musculoskeletal

(Arndt, 1983) studied the stresses on the musculoskeletal system, in order to develop design guidelines for VDT workstations. Evaluations of VDT workstations reveal that many of the health problems experienced. Many tasks lead to prolonged static positioning of the back, neck, arms and legs; producing rapid fatigue and increasing the risk of chronic problems and the effect of repetitive motion patterns which could lead to disorders in the muscles, tendons, nerves and joints. However, the effects of job pressures must not be overlooked as a potential contributing factor in postural complaints.

Moreover**, (Fahrbach and Chapman, 1990)** studied the relation between VDT work duration and musculoskeletal discomfort. Effects on Musculoskeletal discomfort, work position, and job stress factors were compared in government office workers grouped according to whether they used video display terminals more or less than 4 hours per day. The results of this study suggest that limits on VDT use to less than 4 hours per day do not necessarily protect against health problems.

It should be pointed out that **(Horikawa, 2001)** studied the effect of VDT height on the trapezius muscle hardness: quantitative evaluation by a newly developed muscle hardness meter. When using a desktop personal computer (PC), no change was observed in muscle hardness even after a 30-min task if a subject was in the reference posture with a declination angle formed by the Reid's line directed toward the upper edge of the PC screen and the horizontal plane within 5-10 degrees. However, an increase in muscle hardness

was observed after a 30-min task in a posture of looking down at the screen (angle of declination: 15-20 degrees). When the same tasks were performed with a notebook PC, muscle hardness increased after 15 min. Fifteen minutes of relaxation exercise reduced the muscle hardness caused by VDT work.

RADIATION AND ORAL HEALTH

The effects of radiations on oral mucosa and teeth were studied and they could be summarized as follows;

1. Soft and Hard Tissues

(Zahran, 2000) made a study on the effects of microwave radar radiations in oral health. It was found that there is a relative increase of gingival index associated with relative elevation of DMF score (decay, missed, filled tooth) this was due to degeneration in gingival and periodontal tissues which is the main structure surrounding the teeth.

2. Immunoglobulin A

(Hagag, 1985) studied the effect of radiation on mixed salivary secretory immunoglobulin A in patients under radiotherapy. The result show that radiation exposure causes increase in mixed salivary IgA in patients under radiotherapy, salivary IgA reaches its maximum peak after the second week of exposure to therapeutic radiation and declines after that till the fifth week of radiotherapy, gradual decrease in mixed salivary IgA level is noted after radiation end but never reaches the normal level of the control subjects even after one year, the increase of IgA level was associated with depression of salivary flow rate.

3. Melatonin

Melatonin is a neurohormone that regulates sleep cycles, sex hormones, and reproduction. It is produced by the pineal gland, a small pea-shaped gland connected to the optic nerve and located in the middle of the brain near the hypocampus. The pineal gland is light sensitive and in lower life forms is just below the skin surface. The chameleon's ability to change its body pigmentation to mimic that of its surroundings is attributed to the pineal gland. In eastern cultures the pineal gland has been associated with the third eye. Melatonin follows several natural cycles. It is higher at night than during the day and is associated with restful sleep. It is higher in young people, particularly infants who spend a lot of time sleeping, as opposed to the elderly who have difficulty sleeping. It is higher in winter than in summer and it has been linked with changes in serotonin levels and seasonal affective disorder (SAD), a form of depression that is accompanied by prolonged periods of fatigue. Melatonin has been used to treat sleep disturbances associated with jet lag. The evidence linking changes in the melatonin cycle to EMF exposure is growing. We now know that the pineal gland can sense changes in electromagnetic frequencies other than those associated with visible light including static and power frequencies fields **(Liburdy et al., 1993)** as well as solar flares **(Hansen et al., 1987).** Timing of exposure is critical for melatonin production. If EMF exposure occurs in the evening it can interfere with night-time concentrations of melatonin and affect sleep but if it occurs earlier in

the day it has no effect on melatonin production **(Reiter et al., 1995).**

Melatonin also controls the concentrations of sex hormones. High levels of melatonin are associated with lower levels of estrogen. Some types of breast cancer are estrogen-sensitive which means their growth is promoted by estrogen. High levels of melatonin (which suppresses estrogen levels) may have a protective effect on this form of cancer. Conversely, if normal night-time peaks of melatonin are reduced and estrogen levels remain high, this form of breast cancer is likely to be more aggressive. Studies of women sleeping under electric blankets had lower night-time melatonin levels **(Wilson et al., 1990).** This study shows that melatonin regulation in influenced by power line frequency at intensities commonly found in the home. Since melatonin controls reproductive cycles it may also explain some of the miscarriages experienced by women who either sleep in a high EMF environment (electric blankets, waterbeds, or ceiling-cable heating systems) or work with video display terminals that generate power frequency and higher frequency fields **(Wertheimer and Leeper, 1986, 1989; Goldhaber et al., 1988).** Melatonin has also been heralded as a natural anti-cancer chemical **(Reiter et al., 1995).** Its antioxidant properties may help control the growth of other forms of cancer. Various forms of cancer have been linked with EMF exposure. If endogenous melatonin concentrations are reduced, the natural ability of the body to fight cancerous cells may be compromised, resulting in a more aggressive spread of the cancer.

Melatonin is synthesized from serotonin, a neurotransmitter associated with depression **(Reiter et al., 1995)**. Imbalances in the serotonin/melatonin cycle may account for depressive symptoms experienced by people living near power lines or working in high electromagnetic environments. Melatonin is linked with some of the key responses to electromagnetic fields, namely breast cancer as well as other forms of cancer, miscarriages, and depression, and for this reason is one of the more likely candidates for explaining the mechanism responsible for some of the bioeffects of electromagnetic fields.

(Shigekazu et al., 2002) studied the effects of VDT tasks with a bright display at night on melatonin, core temperature, heart rate, and sleepiness. The effects of performing video display terminal (VDT) tasks with a bright display (BD) at night on nocturnal salivary melatonin concentration, rectal temperature, heart rate, and sleepiness were examined. The exciting VDT task with both BD and DD significantly suppressed the nocturnal increase in sleepiness. The BD significantly suppressed the nocturnal decrease in rectal temperature during both exciting and boring VDT tasks. The nocturnal salivary melatonin concentration was significantly suppressed by the combination of the exciting task and BD. The results suggest that performing an exciting VDT task with a BD suppresses the nocturnal changes in melatonin concentration and other physiological indicators of human biological clocks.

(Stark et al., 1997) investigated the influence of electromagnetic fields in the short-wave range (3-30 MHz) radio

transmitter on salivary melatonin concentration in dairy cattle. The hypothesis to be tested was whether EMF exposure would lower salivary melatonin concentrations, and whether removal of the EMF source would be followed by higher concentration levels. For this pilot study, a controlled intervention trial was designed. Two commercial dairy herds at two farms were compared, one located at a distance of 500m (exposed), the other at a distance of 4,000m (unexposed) from the transmitter. At each farm, five cows were monitored with respect to their salivary melatonin concentrations over a period of ten consecutive days. Saliva samples were collected at two-hour intervals during the dark phase of the night. As an additional intervention, the short-wave transmitter was Switched off during three of the ten days (off phase).The samples were analyzed using a radioimmunoassay. The average nightly field strength readings were 21-fold greater on the exposed farm (1.59 mA/m) than on control farm (0.076 mA/m). The mean values of the two initial nights did not show a statistically significant difference between exposed and unexposed cows. Therefore, a chronic melatonin reduction effect seemed unlikely. However, on the first night of re-exposure after the transmitter had been off for three days, the difference in salivary melatonin concentration between the two farms (3.89pg/ml, CI:2.04, 7.41) was statistically significant, indicating a two-to seven-fold increase of melatonin concentration. Thus, a delayed acute effect of EMF on melatonin concentration cannot completely be excluded. However, results should be interpreted with caution and further trials are required in order confirm the results.

Moreover, **(Wright and Lack, 2001)** compared different wavelengths of light for melatonin suppression and phase shifting of the salivary melatonin rhythm. The wavelengths compared were 660nm (red), 595nm (amber), 525nm (green), 497nm (blue/green), and 470nm (blue). They were administered with light-emitting diodes equated for irradiance of 130muW/cm2. Fifteen volunteers participated in all five wavelength conditions and a no light control condition, with each condition conducted over two consecutive evenings. Half-hourly saliva samples were collected from 19:00 to 02:00 on night and until 01:00 on night 2. Light was administered for the experimental conditions on the first night only from midnight to 02:00. Percentage melatonin suppression night l and dim light melatonin onset (DLMO) for each night were calculated. The shorter wavelengths of 470, 497, and 525nm showed the greatest melatonin suppression, 65% to 81%. The shorter wavelengths also showed the greatest DLMO delay on night 2, ranging form 27 to 36 min. the results were consistent with the involvement of a scotopic mechanism in the regulation of circadian phase.

(Griefahn et al., 2002) studied the effects of electromagnetic radiation (bright light, extremely low-frequency magnetic fields, infrared radiation) on the circadian rhythm of melatonin synthesis, rectal temperature, and heart rate. Seven healthy men (16-22 yrs) completed 4 permuted sessions. The control session consisted of a 24-hour bed rest at > 30lux, 18 degrees C, and > 50 dBA. In the experimental sessions, either light (1500 lux), magnetic field (16.7 Hz, 0.2 mT), or infrared radiation (65 degrees C) was applied from

5pm to l am. Salivary melatonin level was determined hourly, rectal temperature and heart rate were continuously recorded. Melatonin synthesis was completely suppressed by light but resumed thereafter. The nadirs of rectal temperature and heart rate were delayed. The magnetic field had no effect. Infrared radiation elevated rectal temperature and heart rate. Only bright light affected the circadian rhythms of melatonin synthesis, rectal temperature, and heart rate, however, differently thus causing a dissociation, which might enhance the adverse effects of shift work in the long run.

Moreover, **(Altpeter et al., 2006)** studied the effect of short-wave (6-22 MHz) magnetic fields on sleep quality and melatonin cycle in humans: the schwarzenburg shut-down study. This paper describes the results of a unique "natural experiment" of the operation and cessation of a broadcast transmitter with its short-wave electromagnetic fields (6-22 MHz) on sleep quality and melatonin cycle in a general human population sample. In 1998, 54 volunteers (21 men, 33 women) were followed for l week each before and after shut-down of the short-wave radio transmitter at schwarzenburg (Switzerland). Salivary was sampled five times a day and total daily excretion and acrophase were estimated using complex cosinor analysis. Sleep quality was recorded daily using a visual analogue scale. Before shut down, self-rated sleep quality was reduced by 3.9 units (95% CI: 1.7-6.0) per mA/m increase in magnetic field exposure. The corresponding decrease in melatonin excretion was 10% (95% CI: -32 to 20%). After shutdown, sleep quality improved by 1.7 units (95% CI: 0.1-34) per mA/m decrease in magnetic field exposure. Melatonin excretion increased by 15%

(95% CI: -3 to 36%) compared to baseline values suggesting a rebound effect. Stratified analyses showed an exposure effect on melatonin in poor sleepers (26% increase; 95% CI: 8-47%) but not in good sleepers. Change in sleep quality and melatonin excretion was related to the extent of magnetic field reduction after the transmitter's shut down in poor but not good sleepers.

4. Oral Keratinocytes

The effect of low frequency electromagnetic fields (ELF) on biochemical properties of human oral Keratinocytes was studied by **(Manni et al, 2004).** They found that 50 Hz electromagnetic fields may modify cell morphology and interfere in differentiation and cellular adhesion of normal Keratinocytes.

5. Bone healing

(Buzza et al., 2003) studied the effects of electromagnetic field on bone healing around commercially pure titanium surface: Histologic and mechanical study in rabbits. The purpose of this pilot study was to evaluate the histologic and mechanical healing process in dental implants under the action of pulsed electromagnetic field (PEMF). Forty-eight commercially pure implant fixtures were implanted in tibiae metaphysis of 12 New Zealand white rabbits divided into experimental (PEMF) and control groups. A PEMF with pulse width of 85 microseconds and a pulse frequency of 20 Mc was applied for 30 minutes per day. The animals were killed 21 and 42 days after implantation. The mechanical tests were performed in all animals and bone biopsies were prepared for decalcified sections analysis. Mechanical tests did not show

significant differences between the groups (P> 0.05); however, statistically significant differences were observed over time (P < 0. 0001). Similar histologic features were achieved for both groups. These results suggest that PEMF stimulation does not improve the bone-healing process around commercially pure dental implants.

(Diniz et al., 2002) investigated whether the effects of pulsed electromagnetic field (PEMF) stimulation on the osteoblast proliferation and differentiation are mediated by the increase in the nitric oxide (NO, nitrogen monoxide) synthesis. They concluded that the PEMF stimulatory effects on the osteoblasts proliferation and differentiation were mediated by the increase in the NO synthesis.

Moreover, **(Diniz et al., 2002)** assessed the effects of pulsed electromagnetic field (PEMF, 15 Hz pulse burst, 7 Mt peak) stimulation on bone tissue-like formation on osteoblasts (MC3T3-El cell line) in different stages of maturation were assessed to determine whether the PEMF stimulatory effect on bone tissue-like formation was associated with the increase in the number of cells and/or with the enhancement of the cellular differentiation. The cellular proliferation (DNA content), differentiation (alkaline phosphatase activity), and bone tissue-like formation (area of mineralized matrix) were determined at different time points. PEMF treatment of osteoblasts in the active proliferation stage accelerated cellular proliferation, enhanced cellular differentiation, and increased bone tissue-like formation. In conclusion, PEMF had a stimulatory effect on the osteoblasts in the early stages of culture, which increased bone tissue-like formation. This stimulatory effect

was most likely associated with enhancement of the cellular differentiation, but not with the increase in the number of cells.

6. Dental Material

(Hubalkova et al., 2002) evaluated the reaction of selected dental materials in the magnetic field of a magnetic resonance imaging device to determine a possible health risk. The following dental materials were tested in vitro during magnetic resonance imaging: 15 dental alloys, four dental implants, one surgical splint and two wires for fixation of maxillofacial fractures. Possible artifacts (corresponding with magnetic properties), heating and force effects were tested. Results concerning movement and heating were in agreement with the literature. The artifacts seen were significant: for the surgical splint, a spherical with a diameter of 55 mm; for the wires, up to 22 mm; and for the dental blade implant, an artifact of 28 x 20 mm. The results of our tests of selected dental appliances indicate that their presence in the human organism is safe for patients undergoing magnetic resonance imaging procedures. The presence of artifacts can substantially influence the magnetic resonance imaging results.

7. Xerostomia

(Backstrom et al., 1995), investigated the effects of radiotherapy- induced xerostomia on energy and nutrient intake in individuals treated for malignancies in the head and neck region.

Irradiated patients with dry mouth symptoms had significantly lower mean intake of vitamin A, beta-carotene, vitamin E, vitamin B6, folacine, iron and zinc than those in the control group. The intake of vitamins A and C exceeded or reached the normal levels. However the average intake of fibre, iron, bet-carotene, vitamin E, zinc, selenium, and iron did not reach the recommended levels, in neither the experimental nor the control groups.

8. Cortisol Level

(Bakke et al., 2004) assessed the salivary cortisol level, salivary flow rate, and masticatory muscle activity in response to acute mental stress: A comparison between aged and young women. They aimed to assess the age-related variations in these variables in response to minor acute and naturalistic stressors in terms of computer task. Methods: 13 aged (60-70 years old) women with frequent practice and long experience with computer use. The computer tasks were randomized and comprised a mentally demanding, modified Stroop color-word test (CWT) and a less demanding reference test, both with duration of 20 min and with equal physical demand. Visual analogue scales for assessment of mental stress and perceived task difficulty and performance, measurements of saliva flow rate and cortisol concentration (unstimulated whole saliva), as well as surface electromyography of the temporalis and masseter muscles were used for assessment, and spearman correlation analysis and ANOVA with repeated measures were used for statistical evaluation. They concluded that the study showed marked differences in the response to mental demands

compared with young women. The mental stress, reflected by increase of salivary cortisol concentrations (indicating the stress level), saliva flow rate, visual analogue scale ratings, and activity level of the jaw elevator muscles, was more pronounced in the aged women in response to the computer tasks.

Subjects and Methods

Subjects and Methods

Subjects

Cross sectional study was carried out on one hundred healthy subjects volunteered to participate in the present study; they are living in Cairo and were selected according to our inclusion criteria as follow:

- Age range (22-40y)
- Apparently healthy and not suffering from any systemic diseases as evaluated by the Cornell medical index **(Kerr and Millard, 1965)** and by the modified Cornell medical index **(Brightman, 1994).**
- No history of motor system disorders that could affect their salivary flow or their jaw elevator activity.
- None of them undergone surgery of the salivary glands or receiving any medication known to affect salivary gland function.
- All of them had at least 24 teeth or fixed prosthesis in full dental arches with posterior occlusal support and no orofacial pain.

Subjects were divided into two groups.

Group I (Exposed group)

Includes fifty participants whose work necessitates exposure to visual display terminals (full occupational time) i.e. minimum eight hours/day, minimum five days/week, for two years or more.

- The subjects were using color display screen of (1,024×768 pixels) ranging from 14-22 inch, it was placed in front of the subject with its top aligned with the subject's eyes and the screen-eye distance adjusted individually (average = 45 cm in front of the subject).

They were selected from the following institutions:

- Scientific research academy (national information network)
- Smart village.
- The cabinet information and decision support center.
- Atomic energy authority (center of designing circuits and systems).
- Link.net Company.

Group II (Control group)

Includes fifty participants their age matched with group I but they are working in a field does not necessitate exposure to visual display terminals i.e. they does not use computer at all even in their houses. All of them were apparently healthy, not suffering from any systemic disease.

All subjects in both groups were informed about the goal and the procedure of the study and gave their written consent to participate in the study.

Subjects of this study were classified into two main studies.

1- Cross sectional study (exposed and non exposed group).
2- Longitudinal study (before and after exposure in the exposed group).

Methods of these examinations

Both groups were subjected to the following investigations.

1-Oral and dental examination:

Including dental and gingival examinations i.e. teeth or hard tissues and soft tissues examinations. The decayed-Missing-Filled Index (DMF) used as method for dental assessment of dental caries and gingival index (GI) used as method for assessing the severity and quantity of gingival inflammation. The examinations were conducted with the aid of an artificial light source, disposable mouth mirrors, exploring probe, periodontal probe and a shipsyring.

The following indices were used in the study:

Gingival index:

The gingival index (GI) was proposed by **(Loe and Sillness, 1963)** as a method for assessing the severity and quantity of gingival inflammation in individual patients or among subjects in large population groups. Only gingival tissues are assessed with the gingival index. According to this method, each of the four gingival areas of the tooth (facial, mesial, distal, and lingual) i.e. severity of gingivitis at four smooth surfaces of each tooth is assessed separately for inflammation and given a score from 0 to 3.

The criteria for quantifying the severity and degree of gingival inflammation are as follows:

0 Normal gingiva

1 Mild inflammation: slight change in color and slight edema, and glazing. No bleeding on probing.

2 Moderate inflammation: redness, edema, and glazing. Bleeding on probing.

3 Severe inflammation: marked redness and edema. Ulceration, Tendency toward spontaneous bleeding.

Bleeding is assessed by running a periodontal probe along the soft tissue wall of the gingival crevice. The scores for the four areas of the tooth can be totaled and divided by four to give a tooth score. By adding the tooth score together and dividing by the number of the teeth examined, an individual GI score can be obtained. The gingival areas of all teeth or selected teeth can be assessed. A GI score of 0.1 to 1.0 indicates mild inflammation, 1.1 to 2.0 indicates moderate inflammation, and 2.1 to 3.0 indicates severe inflammation.

The Decayed-Missed-Filled Index (DMF Index)

This index was introduced by (**Klein et al., 1938)** for dental assessment of dental caries. Instruments used: mouth mirror and explorer or a CPI probe **(WHO 1997).** The DMFT index is an irreversible index, which measures the total lifetime caries experience.

D describes decayed teeth

M describes missing teeth due to caries

F describes restored teeth due to caries

All the teeth in oral cavity are examined, the teeth not included are:

1. Third molars
2. Unerupted teeth/ congenitally missing teeth/ supernumerary teeth
3. Teeth extracted or lost for reasons other than caries
4. Teeth restored for reasons other than for caries like trauma.

Calculation of DMFT Index: All the decayed, missing and filled components are added separately to get the DMF score for that patient. Values for permanent and deciduous teeth should not be added, they should be kept separate.

2-Saliva analysis:

Saliva analysis was performed for both groups. The following salivary components were examined in both groups: pH, trace elements (anions and cations) and secretary immunoglobulin A.

- The mean pH values were compared between the exposed and non exposed groups.
- The mean values of the anions (Sulphate, Phosphate, Fluoride) were compared between the exposed and non exposed groups.
- The mean values of cations (calcium, zinc, copper, iron, magnesium, sodium, potassium, ammonia) were compared between the exposed and non exposed groups.

- The mean values of salivary immunoglobulin A were compared between the exposed and non exposed groups.

The following components were examined before and after exposure in the exposed group: pH, anions (fluoride), cations (iron and calcium), salivary immunoglobulin A.

- The mean values of Fluoride were compared between before and after exposure in the exposed groups.
- The mean values of Calcium and iron were compared between before and after exposure in the exposed groups.
- The mean values of salivary immunoglobulin A were compared before and after exposure in the exposed groups.

Collection of saliva samples:

Subjects had been asked not to eat 2 hours prior to the examination. Unstimulated whole saliva (5ml) was collected from all subjects, and participants were instructed to wash their mouth to remove any food debris.

The participants were asked to bend their heads forward to allow accumulation of saliva (by gravity) into the floor of the mouth for 3 minutes. Then the cotton pellet was removed by using a disposable tweezer and squeezed in dry plastic tube, 5 ml of saliva were collected and divided into two tubes, the first for trace elements analysis and the second for sIgA analysis, finally the samples were collected on ice over five minute period and transferred by using ice box until stored and freezed in the lab at (-10 °c) till analysis.

Estimation of salivary elements

i) pH

pH level of salivary samples was measured by using pH meter * (Cyberscan 500).

ii) Trace elements (Inorganic constituents): Anions e.g. sulphate, phosphate, fluoride and cations e.g. calcium, zinc, copper, iron, magnesium, sodium, potassium, ammonia.

Saliva samples from all subjects were collected and sent to the Central laboratory for elemental and isotopic analysis, Nuclear Research Center, Atomic Energy Authority. Trace elements are detected by using **ion chromatography.**

Samples were diluted (10 times dilution) by using micropipette **(Autoclavable Nichipet 5000 DG) with deionized double distilled water (Conductivity is 18 μ ohm /cm) by using 4 options instruments (10 μ ohm /cm) followed by maxima instrument (18 μ ohm /cm). That is in order to have an accurate results i.e. avoiding contamination of the collected salivary samples by any impurities could be found in normal water. Then these samples were prepared for measurements of anions and cations by using *** ion chromatography. Moreover, a standard solution of different concentrations of the ions needed to construct the calibration curves for each ion.

*Eutech: cybemetics

**Nichiryo

***Binouf Chromatography,Inc. Rosebay court. Fairfax, VA 22033 Fax: +1703966346 USA

***Binouf Chromatography, Pic. Sydney St.. Chelsea London. Sw3 6NJ Resister in England & wales No. 2994175 UK.

iii) Protein (Organic constituents) e.g. **secretory Immunoglobulin A (IgA).** sIgA has been measured by using enzyme-linked immunosorbent assays (ELISA).

PREPARATION AND STORAGE OF REAGENTS

 The **ELISA** wash buffer concentrate should be diluted with aqua dest. 1:10 before use (add 900 ml aqua bidest to 100 ml concentrate). Crystals could occur due to high salt concentration. The crystals have to be resuspended before dilution of the buffer solutions using a water bath (37°C).

SPECIMEN COLLECTION AND PREPARATOON

To avoid variation we recommend collecting the saliva sample always at the same time of the day.

30 min before collection no food or liquid should be consumed. The samples are centrifuged at 3000 rpm 10 min. Take the supernatant and dilute 1:2000 in wash buffer (add 10 µ ý in 1 ml and dilute this solution once more 50 µ ý in 1ml – 100 µ ý of this working solution is used).

Test procedure

Wash the precoated micro titer plate 5x with 250 µ ý ELISA wash buffer. Carry out the tests in duplicate.

1. Add 100 µ ý calibrators, control and patient samples (saliva diluted, see above).
2. Incubate for 1 hour, shaking on a horizontal mixer, at room temperature.
3. Aspirate and wash the wells 5x with 250 µ ý ELISA wash buffer.
4. Add 100 µ ý peroxidase-labelled anti-slgA antibody.
5. Incubate for 1 hour, shaking on a horizontal mixer, at room temperature.
6. Decant the content of the plate and wash the wells 5x with 250 µ ý wash buffer.
7. Add 100 µ ý TMB substrate solutions.
8. Incubate for 5-10 minutes at room temperature.
9. Add 50 µ ý stop solution and mix shortly.
10. Determine absorption with an ELISA reader at 450 nm against 620 nm as reference. If no reference wavelength is available only at 450 nm. If the highest standard exceeds the measurement range of the photometer, absorption must be measured immediately at 405 nm against 620 nm as reference.

For the calculation of saliva values results from the microplate reader has to be multiplied with 2.000.

3-Body temperature:

Body temperature was examined for both groups before and after working shift hours. This is done by using digital thermometer**.**

The mean values of body temperature were compared between the exposed and the non exposed groups.

The mean values of body temperature were compared between before and after exposure in the exposed group.

Statistical Analysis

Statistical analysis was carried out using SAS program **(SAS, 1988).** Student t test (Procedure t test of SAS) was run to compare the difference between exposed and non exposed groups. Paired t test (procedure Means of SAS) was run to test the difference between before and after exposure to electromagnetic waves.

Results

Results

The sample included one hundred subjects participated in this study, with an age ranging from 22-40 years.

Fifty individuals whose work necessitates exposure to electromagnetic waves emitted from visual display terminals representing the first group (group I).

Meanwhile the other group consists of fifty individuals whose work does not necessitate exposure to electromagnetic waves emitted from visual display terminals representing the second group (group II).

Dental indices results

Table (1) represents comparison between the mean values of gingival index and decayed, missed, filled index in the exposed and non exposed groups.

Table (1): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on dental parameters of exposed and non exposed groups

	Exposed		Non exposed		
Parameter	Mean	S.D.	Mean	S.D.	p
GI	1.446	0.777	1.570	0.768	0.341 NS
DMF index	17.844	0.700	17.804	0.589	0.648 NS

S.D. = Standard deviation.

P = Probability level between exposed and non-exposed groups.

NS = Insignificant ($p>0.05$).

GI = Gingival index.

DMF = Decayed, Missed, Filled.

Changes in gingival index

Table (1) and figure (1a) illustrate the mean values of GI of the exposed and non exposed groups.

The mean value of gingival index was (1.446 ± 0.777) in the exposed group while it was (1.570 ± 6.768) in the non exposed group i.e. lower in the exposed group.

Using t test, this difference in the mean values of gingival index between exposed and non exposed group was found to be statistically insignificant (P>0.05).

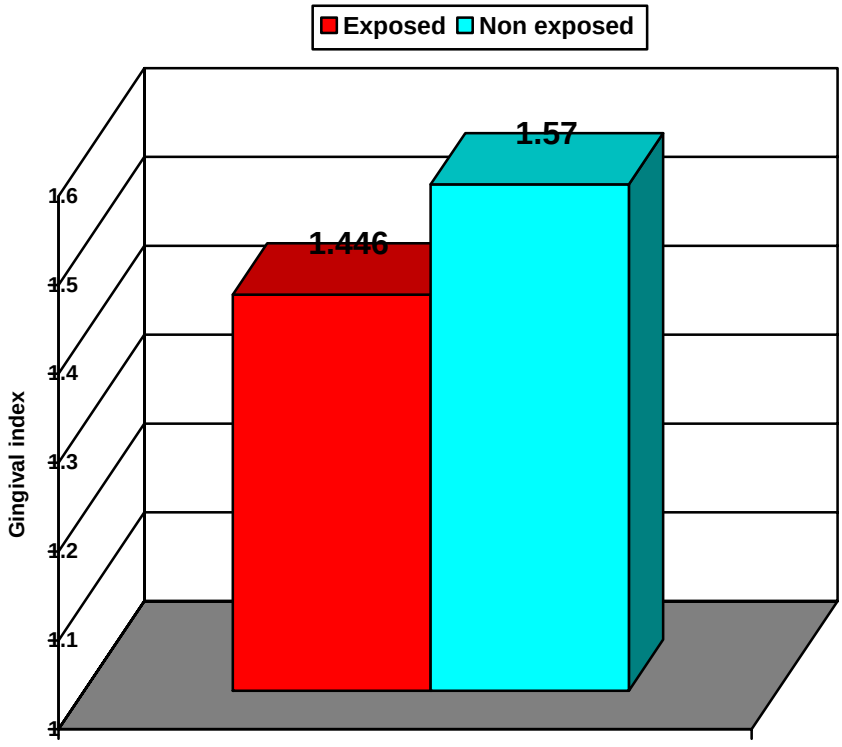

Figure (1a): Mean gingival index in exposed and non exposed groups.

Changes in DMF index

Table (1) and figure (1b) illustrate the mean values of DMF index in the exposed and non exposed group

The mean value of DMF index was (17.844 ± 0.700) in the exposed group while it was (17.804 ± 0.589) in the non exposed group i.e. higher in the exposed group.

Using t test, this difference in the mean values of DMF index between exposed and non exposed group was found to be statistically insignificant (P>0.05).

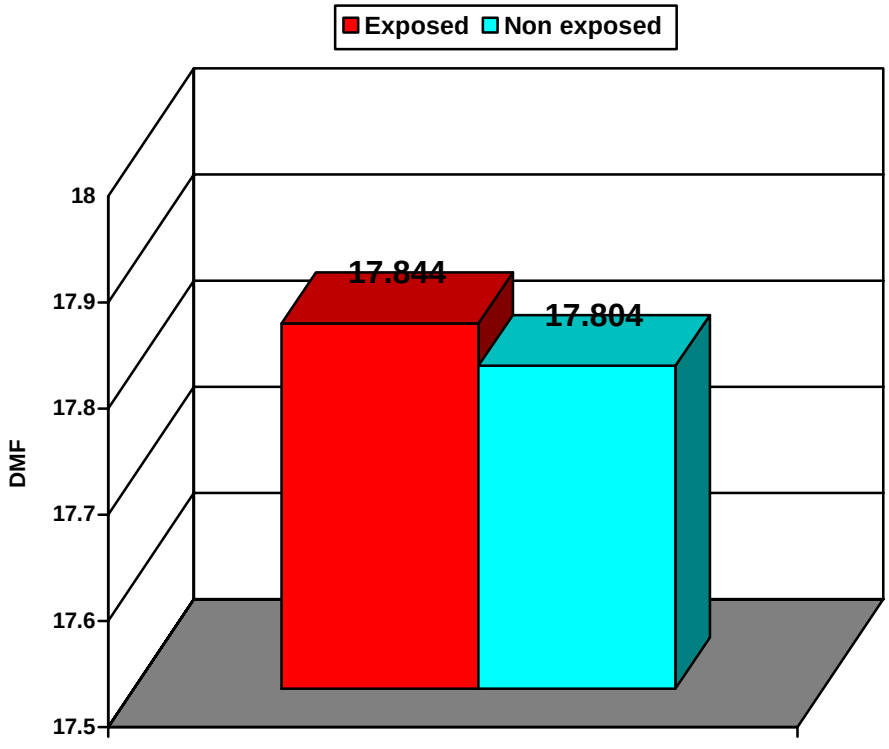

Figure (1b): Mean DMF in exposed and non exposed groups.

pH studying result

Table (2) represents comparison between salivary pH in the exposed and non exposed groups.

Table (2): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary pH

	Exposed		Non exposed		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
pH	**7.4594**	**0.95257**	**7.4134**	**0.84934**	**0.799 NS**

S.D. **= Standard deviation.**

P **= Probability level between exposed and non-exposed groups.**

NS **= Insignificant (p>0.05).**

Table (2) and figure (2) illustrate the mean values of salivary pH in the exposed and non exposed group, the mean value of pH was (7.4594 ± 0.95257) in the exposed group while it was (7.4134 ± 0.84934) in the non exposed group i.e. higher in the exposed group.

Using t test, this difference in the mean values of pH between exposed and non exposed groups was found to be statistically insignificant (P>0.05).

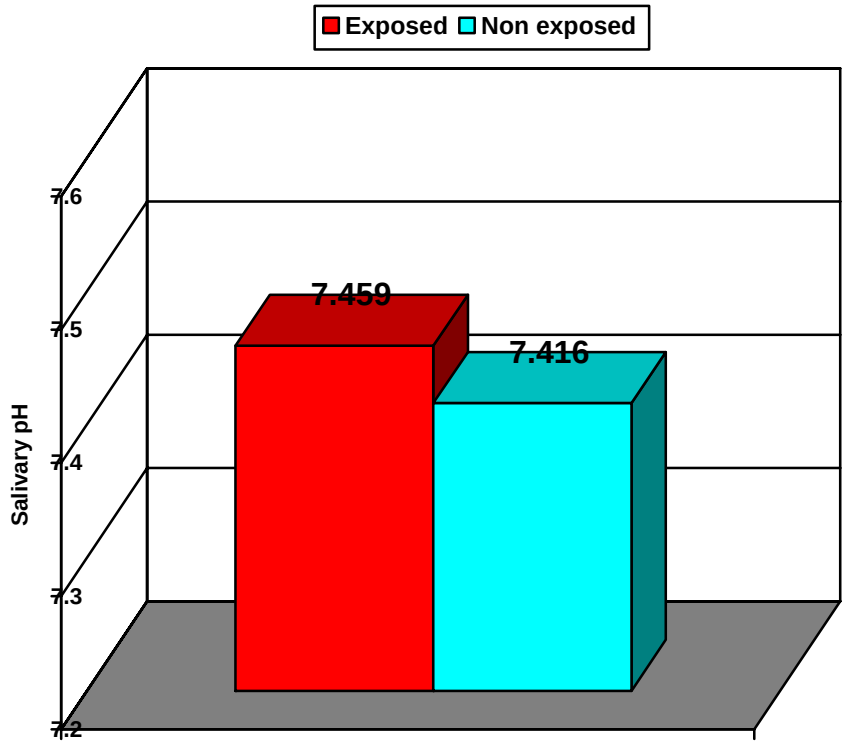

Figure (2): Mean salivary pH in exposed and non exposed groups.

Tables (3) represent comparison between salivary pH before and after exposure to electromagnetic waves emitted from visual display terminals.

Table (3): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary pH before and after exposure

	Before exposure		After exposure		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
pH	**7.463**	**0.930**	**7.456**	**0.932**	**0.969 NS**

S.D. = Standard deviation.

P = Probability level between before and after exposure to electromagnetic waves.

NS = Insignificant (p>0.05).

Table (3) and figure (3) illustrate the mean values of pH before and after exposure to electromagnetic waves, the mean values of was (7.463 ± 0.930) before exposure while it was (7.456 ± 0.932) after exposure i.e. decreased after exposure.

Using paired t test, this decrease in the mean values of pH after exposure was found to be statistically insignificant (P>0.05).

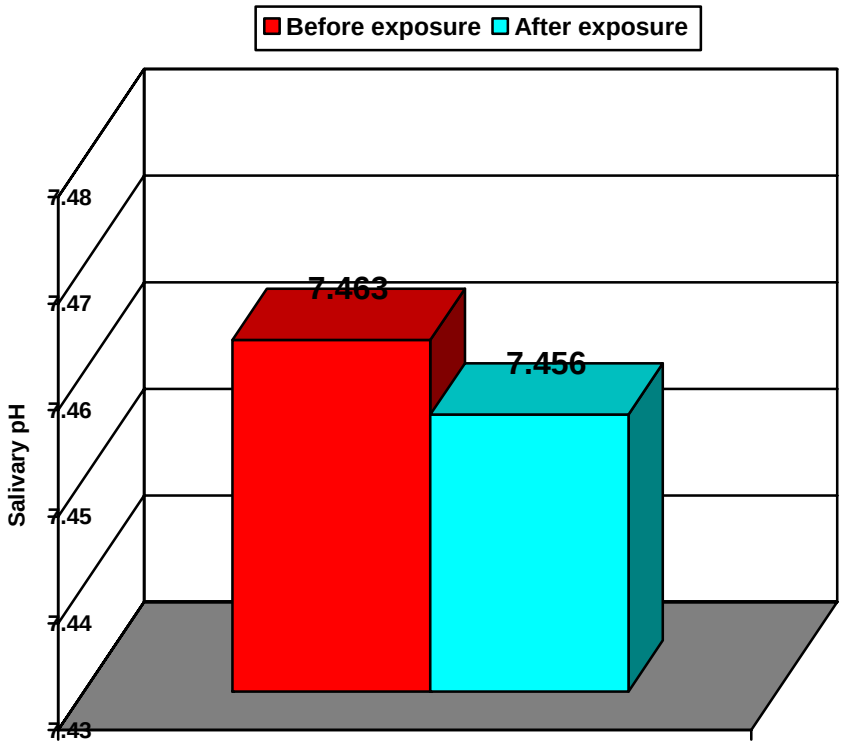

Figure (3): Mean salivary pH before and after exposure

Anions studying results

Tables (4) and figure (4) represent comparison between the mean values of the anions (So_4^{2-}, Po_4^{3-}, F^-) in the exposed and the non exposed groups.

Table (4): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary anions

	Exposed		Non exposed		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
SO_4^{-2}	**14.216**	**6.583**	**15.279**	**5.280**	**0.375 NS**
PO_4^{-3}	**61.187**	**44.444**	**69.453**	**43.928**	**0.352 NS**
F^-	**79.083**	**37.948**	**82.912**	**50.254**	**0.668 NS**

S.D. = Standard deviation.

P = Probability level between exposed and non-exposed groups.

NS = Insignificant (p>0.05).

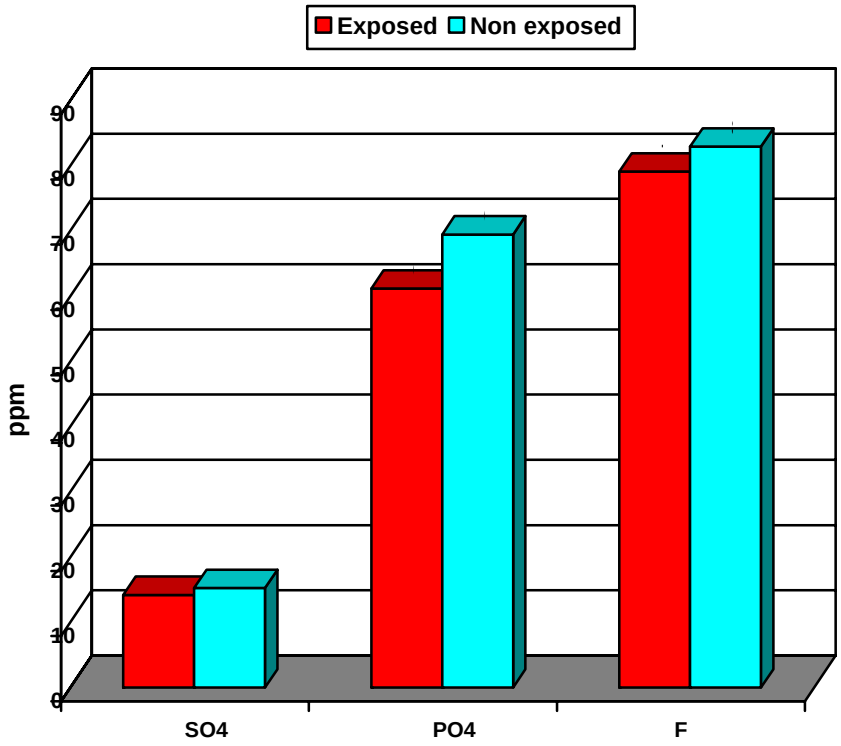

Figure (4): Mean salivary anions in exposed and non exposed groups

Table (4) and figure (4a) illustrate the mean values of sulfate So_4^{2-} in exposed and non exposed groups, the mean value of So_4^{2-} was (14.216 ± 6.583) in the exposed group while it was (15.279 ± 5.280) in the non exposed group i.e. lower in the exposed group.

Using t test, this difference in the mean values of So_4^{2-} between exposed and non exposed groups was found to be statistically insignificant (P>0.05).

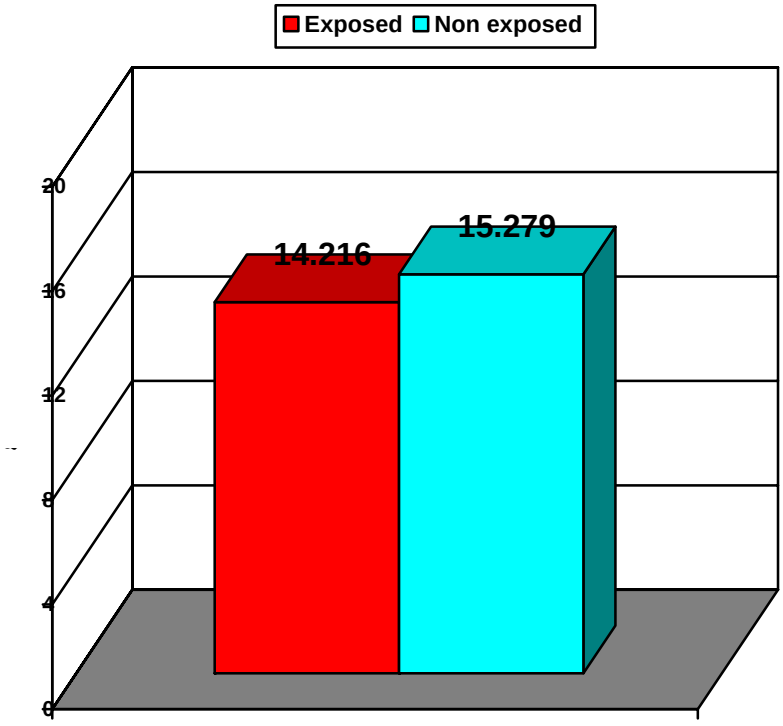

Figure (4a): Mean salivary SO_4^{-2} in exposed and non exposed groups

Table (4) and figure (4b) illustrate the mean values of phosphate Po_4^{3-} in exposed and non exposed groups, the mean value of Po_4^{3-} was (61.187 ± 44.444) in the exposed group while it was (69.453 ± 43.928) in the non exposed group i.e. lower in the exposed group.

Using t test, this difference in the mean values of phosphate between both groups was found to be statistically insignificant (P>0.05).

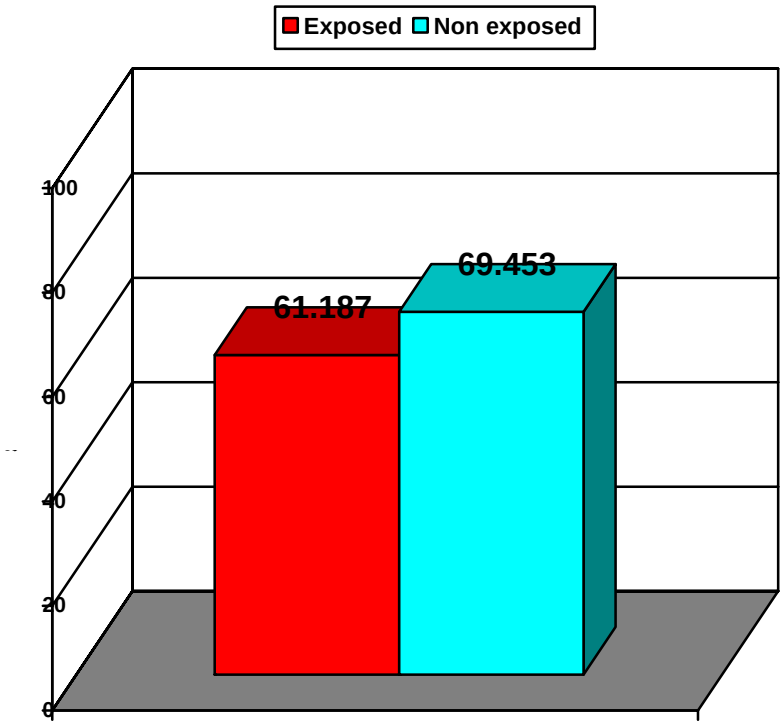

Figure (4b): Mean salivary PO_4^{-3} in exposed and non exposed groups

Table (4) and figure (4c) illustrate the mean values of fluoride F^- in exposed and non exposed groups, the mean value of F^- was (79.083 ± 37.948) in the exposed group while it was (82.912 ± 50.254) in the non exposed group i.e. lower in the exposed group.

Using t test, this difference in the mean values of fluoride between both groups was found to be statistically insignificant (P>0.05).

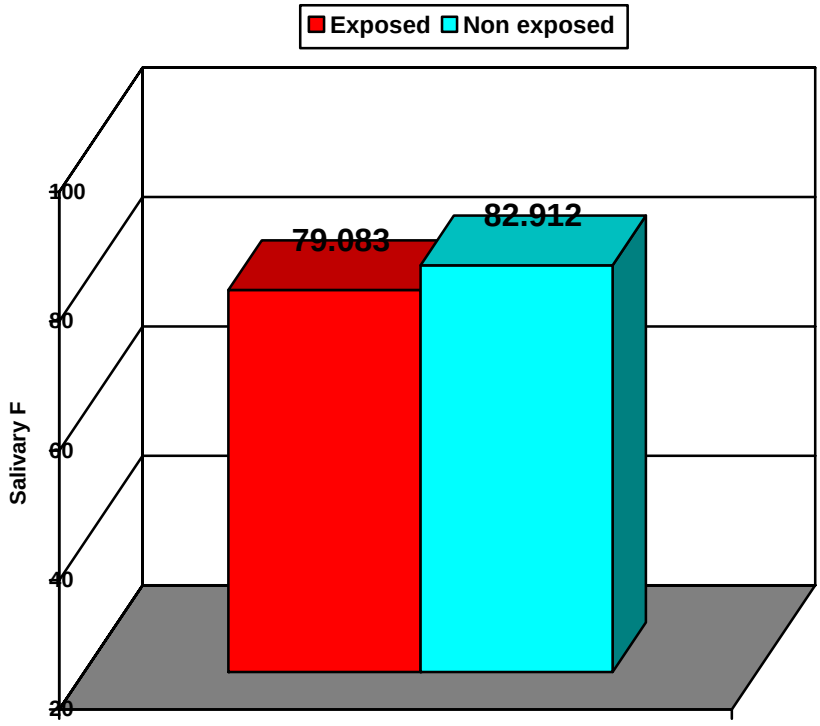

Figure (4c): Mean salivary F^- in exposed and non exposed groups

Table (5) represents comparison between fluoride before and after exposure to electromagnetic waves emitted from visual display terminals.

Table (5): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary F^- before and after exposure

	Before exposure		After exposure		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
Fluoride	**79.95**	**37.171**	**79.958**	**37.164**	**0.141 NS**

S.D. = Standard deviation.

P = Probability level between before and after exposure to electromagnetic waves.

NS = Insignificant (p>0.05).

Table (5) and figure (5) illustrate the mean values of fluoride F^- before and after exposure, the mean value of F^- was (79.95 ± 37.171) before exposure while it was (79.958 ± 37.164) after exposure i.e. increased after exposure.

Using paired t test, this increase in the mean values of F^- after exposure was found to be statistically insignificant (P>0.05).

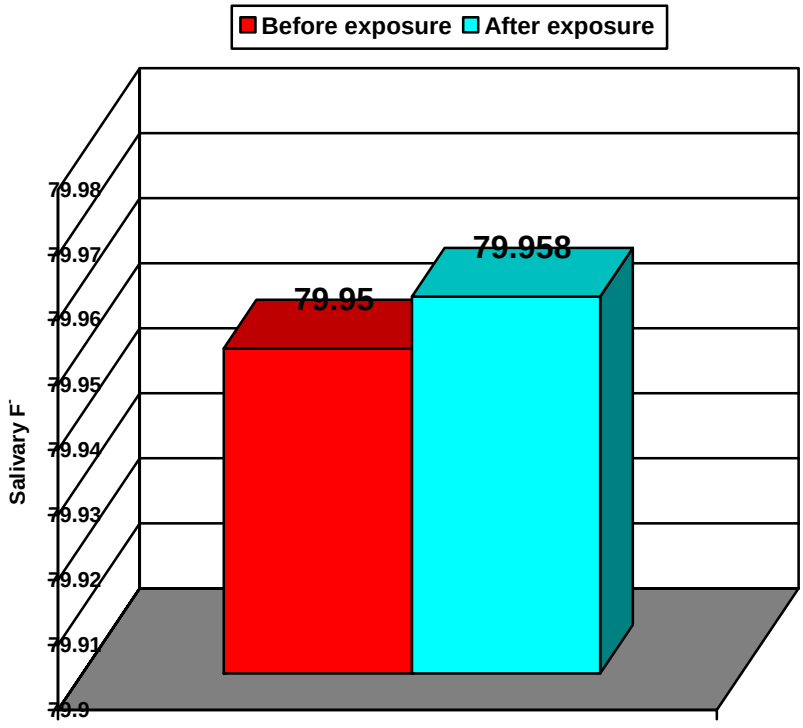

Figure (5): Mean salivary F^- before and after exposure

Cations studying results

Table (6) and figures (6-1) and (6-2) represent comparison between the mean values of the salivary cations (Zn^{2+} , Cu^{2+} , Fe^{3+} , Ca^{2+} , Mg^{2+} , K^{2+} , NH_4^+ , Na^+) in the exposed and non exposed groups.

Table (6): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary cations

	Exposed		Non exposed		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
Zn^{+2}	**0.496**	**0.198**	**0.507**	**0.260**	**0.802 NS**
Cu^{+2}	**0.110**	**0.068**	**0.128**	**0.052**	**0.147 NS**
Fe^{+3}	**0.934**	**0.614**	**0.911**	**0.375**	**0.817 NS**
Ca^{+2}	**40.675**	**22.834**	**44.302**	**6.428**	**0.282 NS**
Mg^{+2}	**4.427**	**1.604**	**3.900**	**1.682**	**0.112 NS**
K^+	**227.988**	**89.713**	**239.800**	**70.348**	**0.466 NS**
NH_4^+	**77.624**	**34.790**	**80.314**	**28.195**	**0.672 NS**
Na^+	**24.266**	**7.179**	**24.410**	**5.862**	**0.913 NS**

S.D. **= Standard deviation.**

P **= Probability level between exposed and non-exposed groups.**

NS **= Insignificant (p>0.05).**

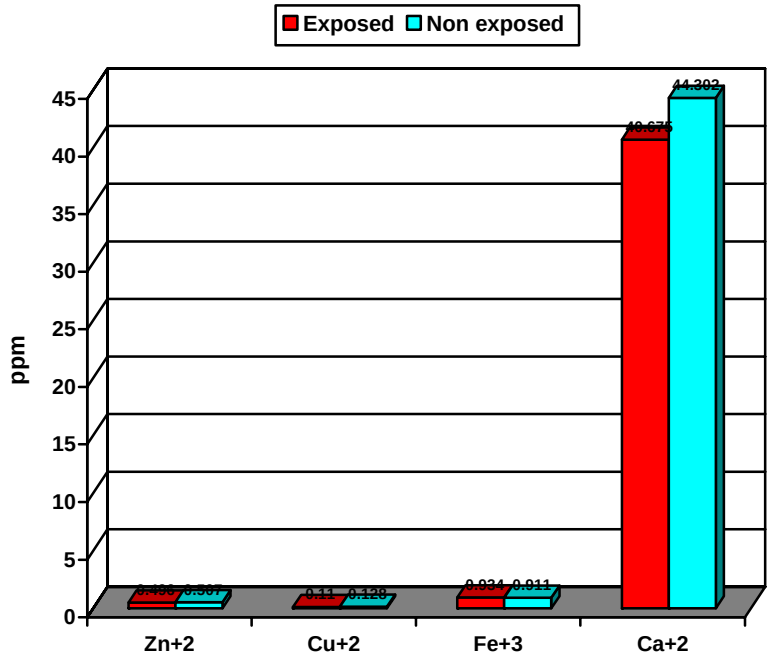

Figure (6-1): Mean salivary cations in exposed and non exposed groups

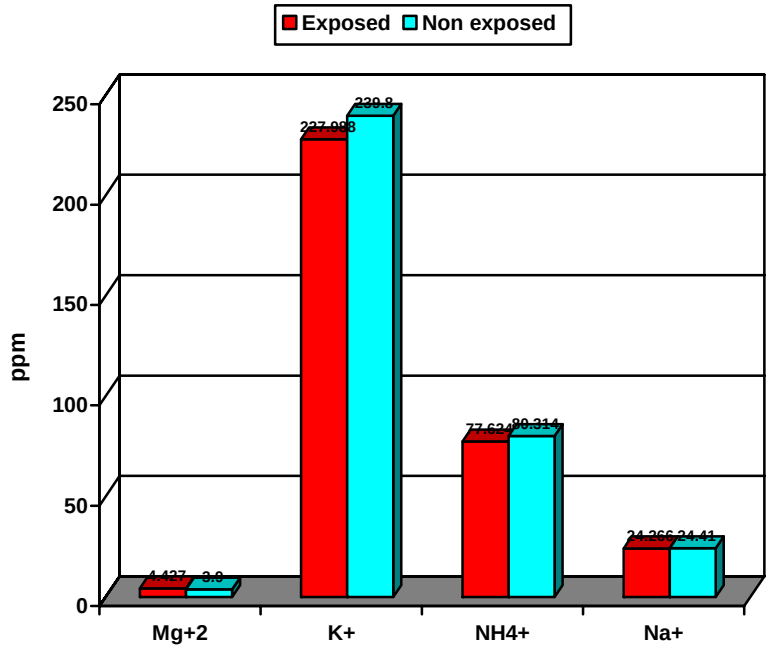

Figure (6-2): Mean salivary cations in exposed and non exposed groups

Table (6) and figure (6a) illustrate the mean values of zinc (Zn^{2+}) in exposed and non exposed groups, the mean value of Zn^{2+} was (0.496 ± 0.198) in the exposed group while it was (0.507 ± 0.260) in the non exposed group i.e. lower in the exposed group.

This difference in the mean values of zinc between both groups was found to be statistically insignificant (P>0.05)

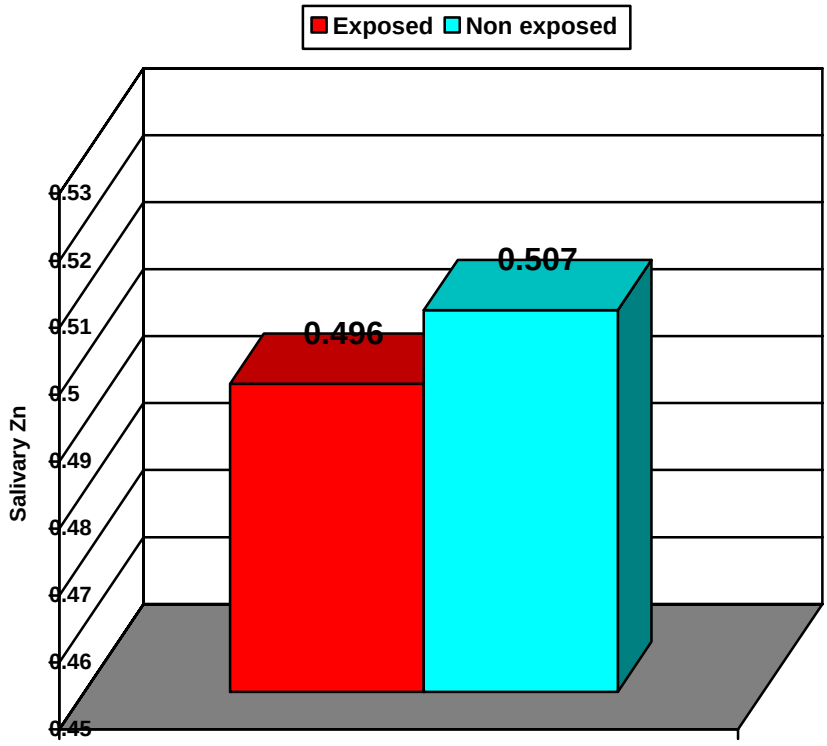

Figure (6a): Mean salivary Zn^{+2} in exposed and non exposed groups.

Table (6) and figure (6b) illustrate the mean values of copper (Cu^{2+}) in exposed and non exposed groups, the mean value of Cu^{2+} was (0.110 ± 0.068) in the exposed group while it was (0.128 ± 0.052) in the non exposed group i.e. lower in the exposed group.

This difference in the mean values of Cu^{2+} between both groups was found to be statistically insignificant (P>0.05).

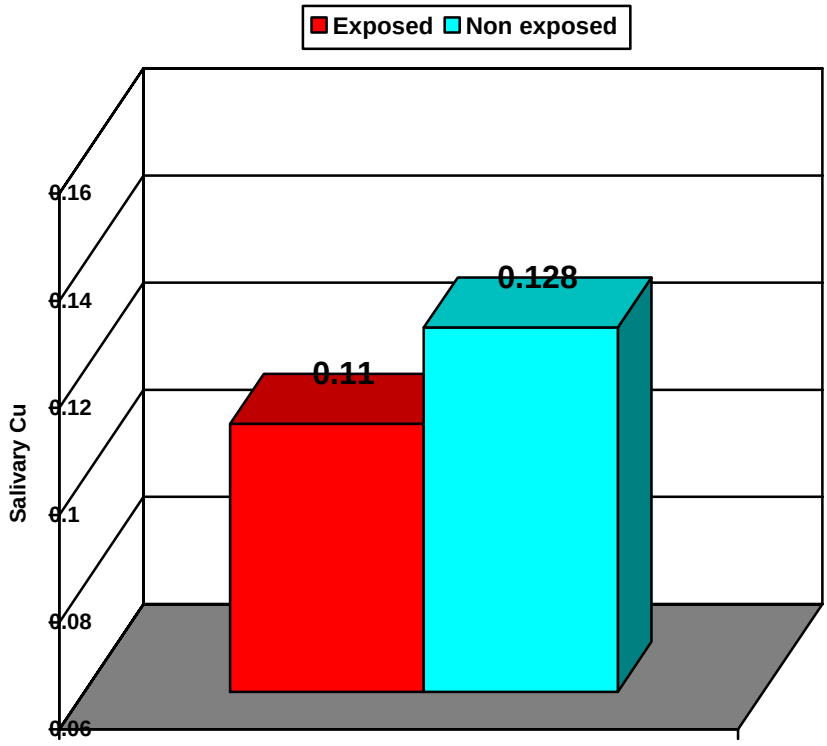

Figure (6b): Mean salivary Cu^{+2} in exposed and non exposed groups

Table (6) and figure (6c) illustrate the mean values of ferrous (Fe^{3+}) in exposed and non exposed groups, the mean value of Fe^{3+} was (0.934 ± 0.614) in the exposed group while it was (0.911 ± 0.375) in the non exposed group i.e. higher in the exposed group.

This difference in the mean values of Fe^{3+} between both groups was found to be statistically insignificant (P>0.05).

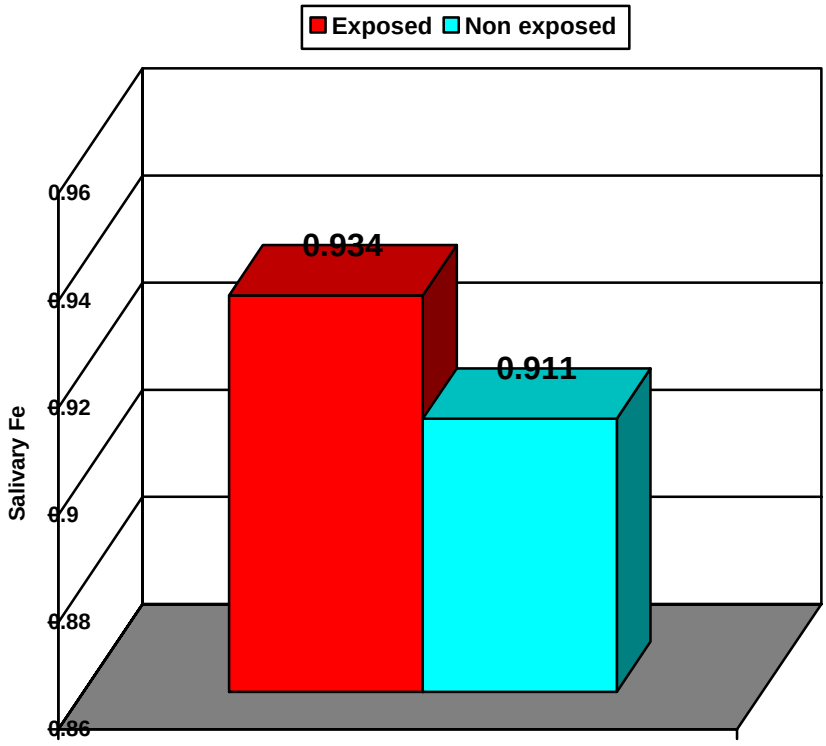

Figure (6c): Mean salivary Fe^{+3} in exposed and non exposed groups

Table (6) and figure (6d) illustrate the mean values of calcium (Ca^{2+}) in exposed and non exposed groups, the mean value of Ca^{2+} was (40.675 ± 22.834) in the exposed group while it was (44.302 ± 6.428) in the non exposed group i.e. lower in the exposed group.

This difference in the mean values of Ca^{2+} between both groups was found to be statistically insignificant (P>0.05).

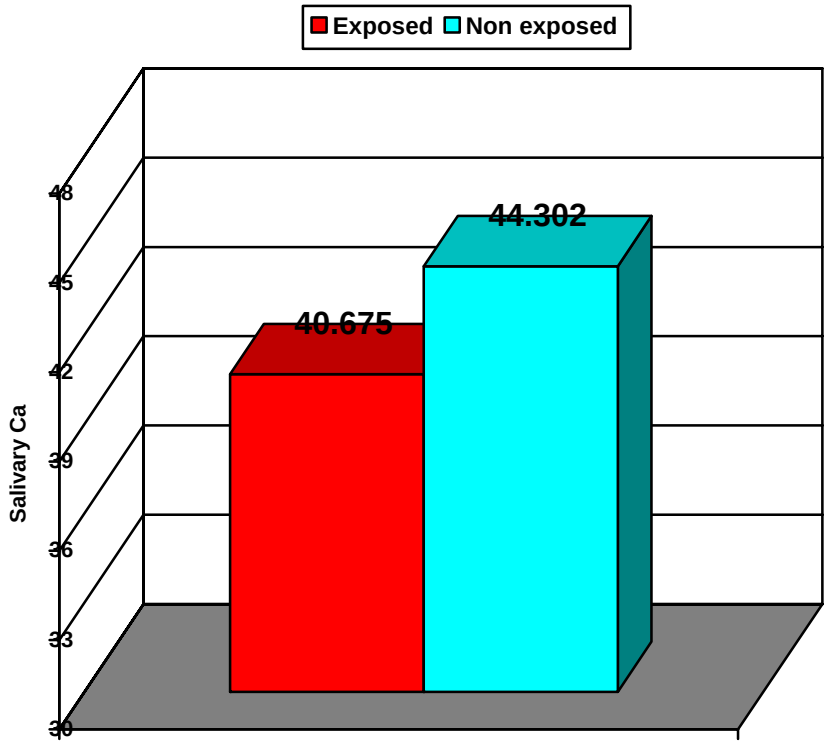

Figure (6d): Mean salivary Ca^{+2} in exposed and non exposed groups

Table (6) and figure (6e) illustrate the mean values of magnesium (Mg^{2+}) in exposed and non exposed groups, the mean value of Mg^{2+} was (4.427 ± 1.604) in the exposed group while it was (3.900 ± 1.682) in the non exposed group i.e. higher in the exposed group.

This difference in the mean values of Mg^{2+} between both groups was found to be statistically insignificant (P>0.05).

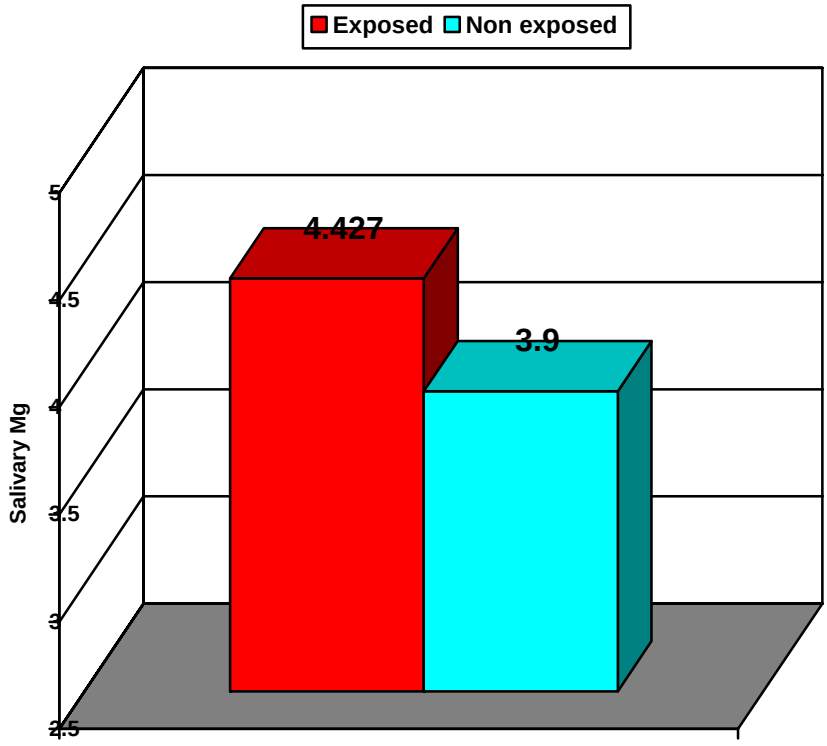

Figure (6e): Mean salivary Mg^{+2} in exposed and non exposed groups

Table (6) and figure (6f) illustrate the mean values of Potassium K^{2+} was (227.988 ± 89.713) in the exposed group while it was (239.800 ± 70.348) in the non exposed group i.e. lower in the exposed group.

By using t test, this difference in the mean values of K^{2+} between both groups was found to be statistically insignificant (P>0.05).

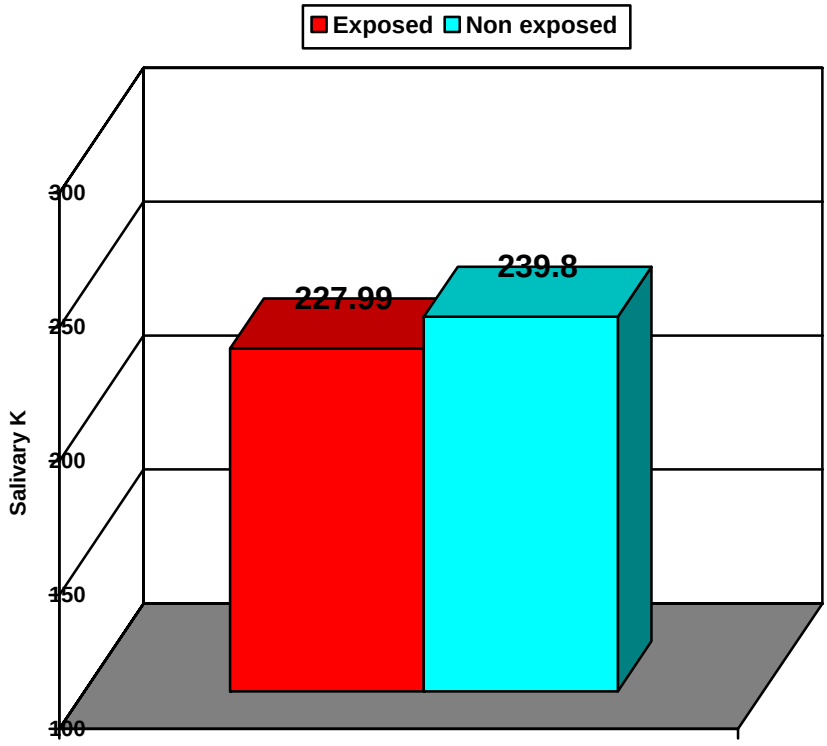

Figure (6f): Mean salivary K^{+} in exposed and non exposed groups

Table (6) and figure (6g) illustrate the mean values of Ammonia NH_4^+ in exposed and non exposed groups, the mean value of NH_4^+ was (77.624 ± 34.790) in the exposed group while it was (80.314 ± 28.195) in the non exposed group i.e. lower in the exposed group.

By using t test, this difference in the mean values of ammonia between both groups was found to be statistically insignificant (P>0.05).

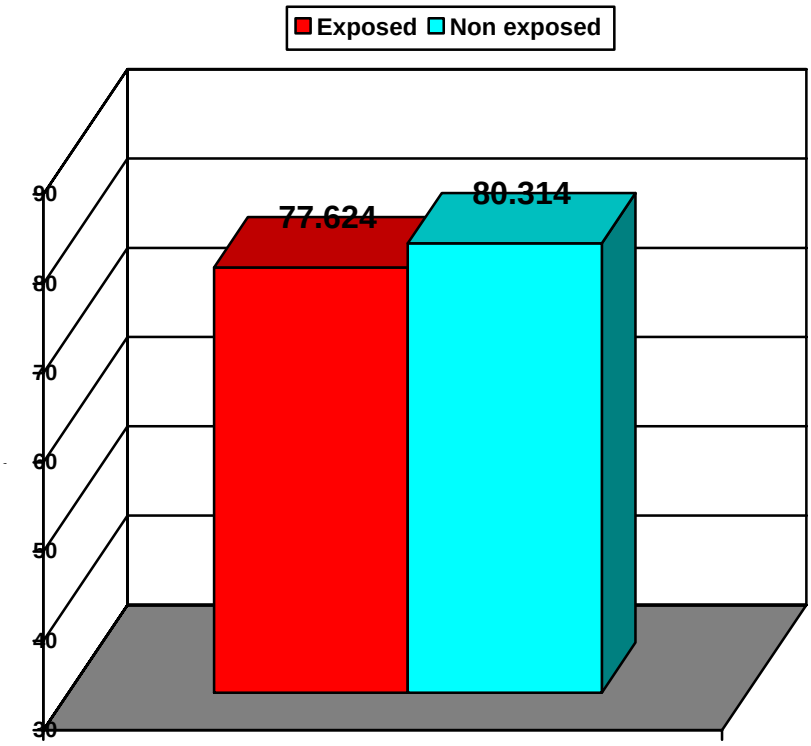

Figure (6g): Mean salivary NH_4^+ in exposed and non exposed groups

Table (6) and figure (6h) illustrate the mean values of sodium Na^+ in exposed and non exposed groups, the mean value of Na^+ was (24.266 ± 7.179) in the exposed group while it was (24.410 ± 5.862) in the non exposed group i.e. lower in the exposed group.

By using t test, this difference in the mean values of sodium between both groups was found to be statistically insignificant (P>0.05).

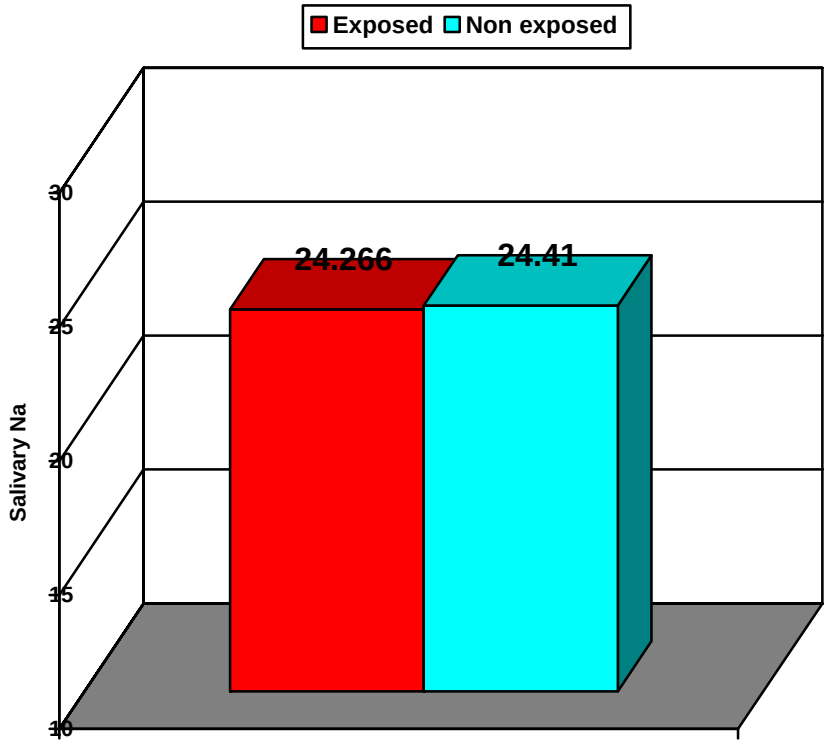

Figure (6h): Mean salivary Na^+ in exposed and non exposed groups.

Table (7) represents the effect of exposure to electromagnetic waves on salivary iron Fe^{3+}.

Table (7): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary Fe^{+3} before and after exposure

	Before exposure		After exposure		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
Iron	**1.1432**	**0.793**	**1.143**	**0.796**	**0.969 NS**

S.D. = Standard deviation.

P = Probability level between before and after exposure to electromagnetic waves.

NS = Insignificant (p>0.05).

Table (7) and figure (7) illustrate the mean values of iron Fe^{3+} before and after exposure to electromagnetic waves emitted from V.D.T.

The value of Fe^{3+} was (1.1432 ± 0.793) before exposure while it was (1.143 ± 0.796) after exposure i.e. decreased after exposure.

By using paired t test, this decrease in the mean values of iron after exposure was found to be statistically insignificant (P>0.05).

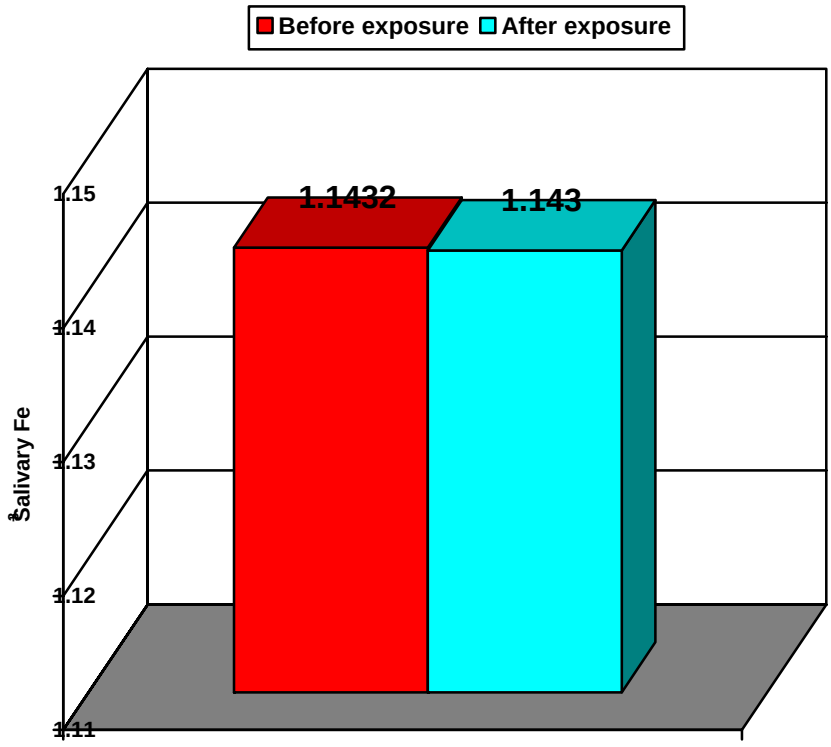

Figure (7): Mean salivary Fe^{+3} before and after exposure

Table (8) represents the effect of exposure to electromagnetic waves on salivary calcium Ca^{2+}.

Table (8): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary Ca^{+2} before and after exposure

	Before exposure		After exposure		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
Calcium	**44.483**	**20.549**	**44.415**	**20.530**	**0.287 NS**

S.D. = Standard deviation.

P = Probability level between before and after exposure to electromagnetic waves.

NS = Insignificant (p>0.05).

Table (8) and figure (8) illustrate the mean values of calcium Ca^{2+} before and after exposure to electromagnetic waves emitted from V.D.T.

The mean value of Ca^{2+} was (44.483 ± 20.549) before exposure while it was (44.415 ± 20.530) after exposure i.e. decreased after exposure.

By using paired t test, this decrease in the mean values of Ca^{2+} after exposure was found to be statistically insignificant (P>0.05).

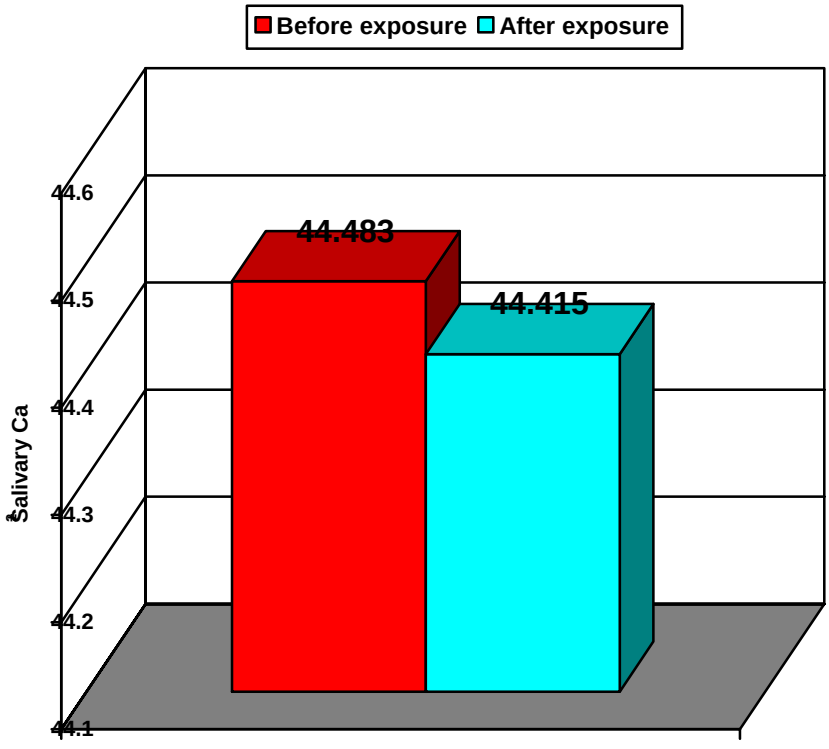

Figure (8): Mean salivary Ca^{+2} before and after exposure.

Protein (sIgA) studying results.

Table (9) represents comparison between the mean values of salivary immunoglobulin A in exposed and non exposed groups.

Table (9): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary IgA in exposed and non exposed groups

	Exposed		Non exposed		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
sIgA	**291.800**	**80.780**	**303.600**	**64.788**	**0.502 NS**

S.D. = Standard deviation.

P = Probability level between exposed and non-exposed groups.

NS = Insignificant (p>0.05).

Table (9) and figure (9) illustrate the mean values of salivary immunoglobulin A in exposed and non exposed groups, the mean value of sIgA was (291.800 ± 80.780) in the exposed group while it was (303.600 ±64.788) in the non exposed group i.e. lower in the exposed group.

By using t test, this difference in the mean values of sIgA between both groups was found to be statistically insignificant (P>0.05).

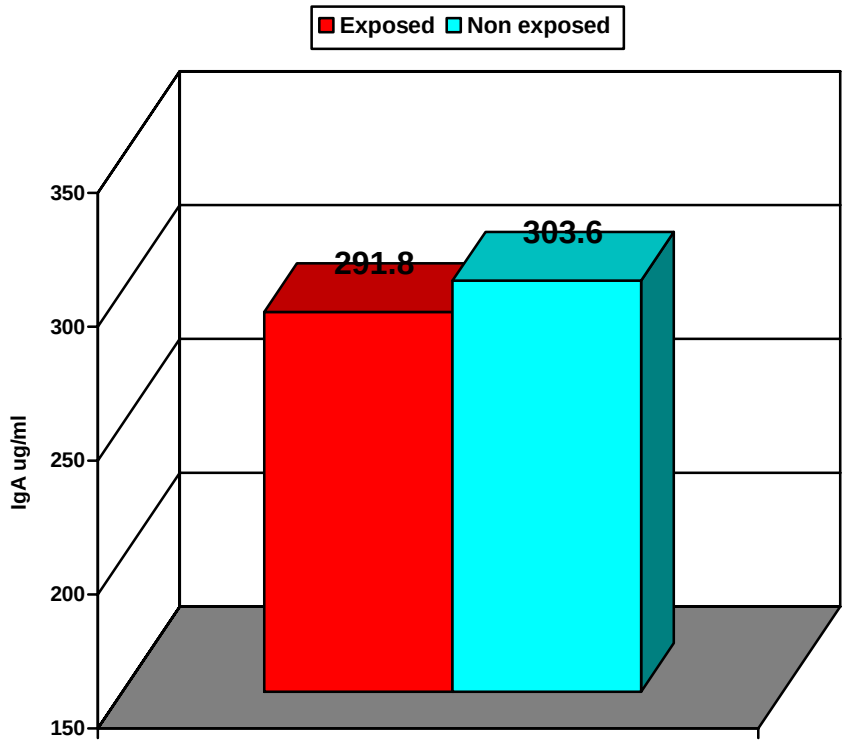

Figure (9): Mean sIgA in exposed and non exposed groups

Table (10) represents the effect of exposure to electromagnetic waves on salivary immunoglobulin A.

Table (10): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on salivary IgA before and after exposure

	Before exposure		After exposure		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
sIgA	**291.800**	**80.780**	**291.880**	**80.189**	**0.858 NS**

S.D. = Standard deviation.

P = Probability level between before and after exposure to electromagnetic waves.

NS = Insignificant (p>0.05).

Table (10) and figure (10) illustrate the mean values of sIgA before and after exposure to electromagnetic waves emitted from V.D.T.

The mean values of sIgA was (291.800 ± 80.780) before exposure while it was (291.880 ± 80.189) after exposure i.e. increased after exposure.

By using paired t test, this increase in the mean value of sIgA after exposure was found to be statistically insignificant (P>0.05).

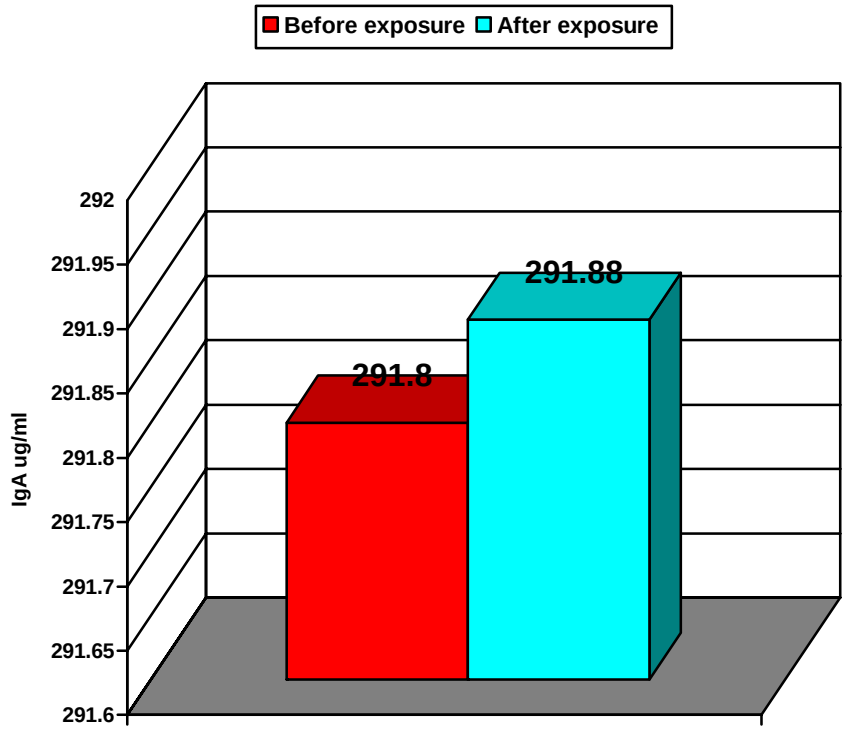

Figure (10): Mean sIgA before and after exposure

Body temperature studying results

Table (11) represents the effects of exposure to electromagnetic waves on body temperature and comparison between the mean values of body temperature in exposed and non exposed groups.

Table (11): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on body temperature of exposed and non exposed groups

	Exposed		Non exposed		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
Body temperature	**37.024**	**0.283**	**36.902**	**0.219**	**0.02***

S.D. = Standard deviation.

P = Probability level between exposed and non-exposed groups.

*** = Significant at p≤0.05**

Table (11) and figure (11) illustrate the mean values of body temperature in the exposed groups.

The mean value of body temperature was (37.024 ± 0.283) in the exposed group while it was (36.902 ± 0.219) in the non exposed group i.e. higher. in the exposed group.

Using t test, the difference in the mean values of body temperature between exposed and non exposed group was found to be statistically significant (P<0.05).

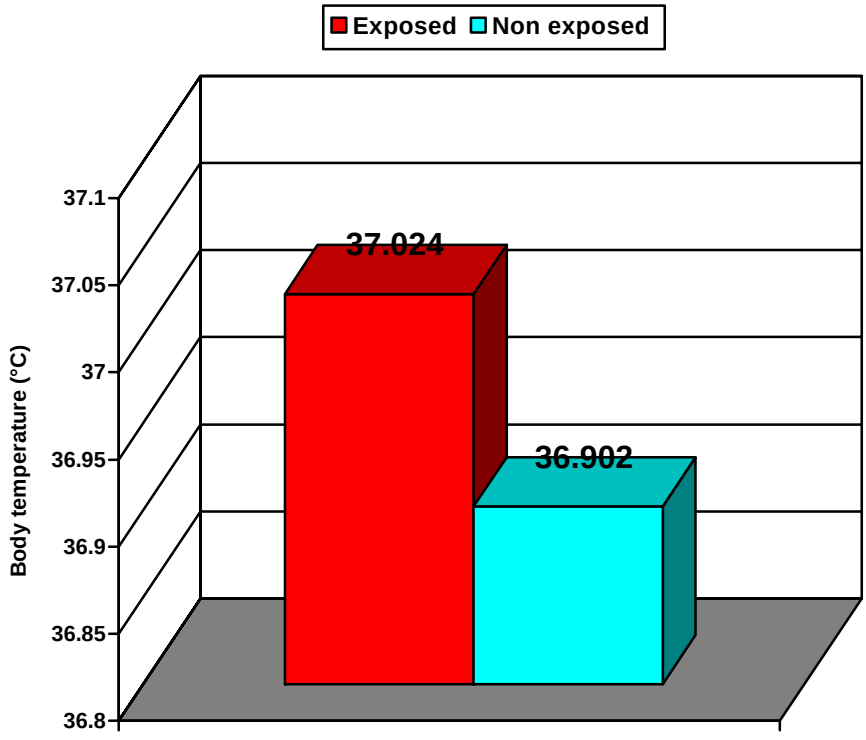

Figure (11): Mean body temperature in exposed and non exposed groups

Table (12) represents comparison between the mean values of body temperature before and after exposure to electromagnetic waves emitted from visual display terminals.

Table (12): Descriptive statistics and test of significant for the effect of exposure to electromagnetic waves on body temperature before and after exposure

	Before exposure		After exposure		
Parameter	**Mean**	**S.D.**	**Mean**	**S.D.**	**p**
Body temperature	**37.024**	**0.283**	**37.074**	**0.031**	**0.02***

S.D. = Standard deviation.

P = Probability level between before and after exposure to electromagnetic waves.

*** = Significant at $p \leq 0.05$**

Table (12) and figure (12) illustrate the mean values of body temperature before and after exposure, the mean value of body temperature was (37.024 ± 0.283) before exposure while it was (37.074 ± 0.031) after exposure i.e. increased after exposure.

Using paired t test, this increase in the mean values of body temperature after exposure to electromagnetic waves emitted from visual display terminals was found to be statistically significant ($P<0.05$).

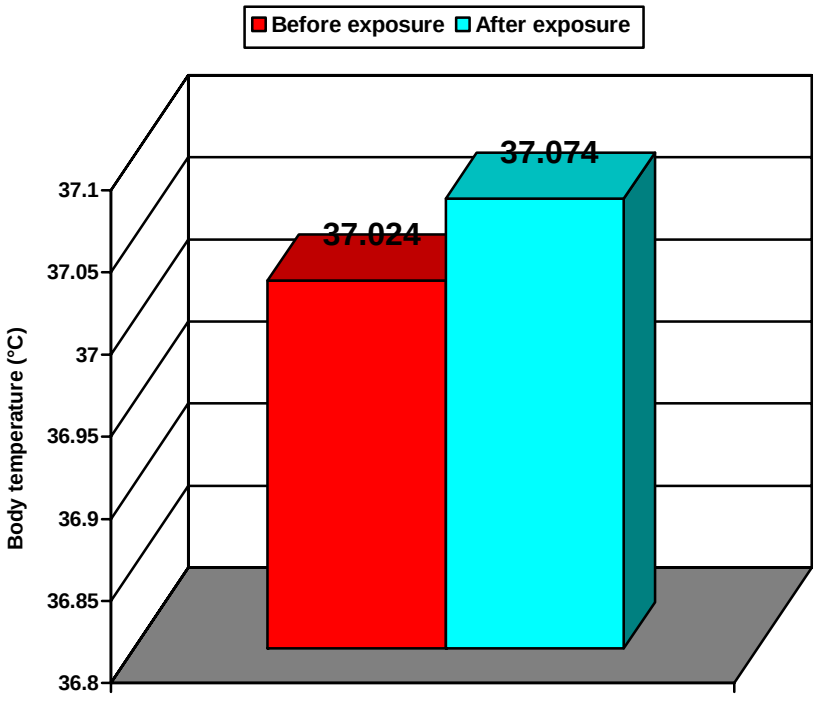

Figure (12): Mean body temperature before and after exposure

Discussion

Discussion

There is an increasing incidence of radiation hazards nowadays, as mankind is continuously exposed to various sources of radiation. Consequently, there is an increasing interest in evaluation of different radiation effects on the environment, one aspect which is of great impact on human health is the effect of non ionizing radiation emitted from visual display terminals on oral health status as it is widely utilized nowadays among people on large scales.

As part of this evaluation, this study was planned to investigate the effect of this kind of radiation on the oral health status either on the soft or hard tissues structure of the oral cavity or on some of the trace elements or proteins necessary for normal homeostasis.

In order to achieve this aim, the study was conducted on people working in the field of visual display terminals and they were chosen from different work places.

Concerning their age, it was chosen from 22 to 40 as this age group includes large number of computer users either on personal or professional level as the labor market prefers those young people who are fresh graduates updated with new computer sciences and are capable of sitting in front of visual display terminals 8 hours daily. In addition, this age group includes those who are well experienced in computer.

Regarding the duration of exposure to VDT it was chosen to be minimum eight hours daily as it is the average time of the working

shift hours for those who are working at the field of computer in front of visual display terminals

They were grouped as (1) and (2). Group (1) includes 50 employees working at the non ionizing radiation field with the possibility of close contact with electromagnetic waves radiated from visual display terminals. Group (2) includes employees or workers working away from any sources of VDTs radiation.

All chosen individuals were not suffering from any apparent health problems or any apparent diseases that could affect their oral conditions.

Gingival index (GI) and decayed, missed, filled index (D.M.F) index were taken for both groups, gingival index for assessing the severity and quantity of gingival inflammation among subjects in both groups, D.M.F index for dental assessment of dental caries among subjects in both groups.

Our results shows that there was difference in the mean values of gingival index and decayed, missed, filled index between the exposed and non exposed group, this difference was found to be statistically insignificant (P> 0.05), while **(Zahran, 2000)** found a relative increase of gingival index associated with relative elevation of DMF score in workers of microwave radar stations, this differences in the results of both studies could be explained as the radiation emitted from microwaves radar stations have higher energy and shorter wave length than radiation emitted from visual display terminals.

Saliva samples were taken from all subjects in both groups and also before and after exposure in the exposed group. The choice of saliva analysis was based on its importance as a diagnostic fluid and its role in the defensive mechanism of the body against certain pathological conditions **(Draus and Kono, 1965),** it maintains normal balance of the oral flora, protecting mucosa from overgrowth of potentially pathogenic organisms, saliva offers distinctive advantages over serum because it can be collected non invasively. Whole saliva, however, is most frequently used for diagnosis of systematic diseases, since it is readily collected and contains serum constituents. These constituents are derived from the local vasculature of the salivary glands and also reach the oral cavity via the flow of gingival fluid **(Kaufman et al., 2002)**.

Collection of salivary samples was performed using a small cotton pellet, as it was difficult to use a syringe. The cotton pellet was small in order not to stimulate the oral mucosa, but to collect the un-stimulated whole saliva.

pH analysis was done by using cyber scan, and also trace element was done by using ion chromatography.

The choice of pH analysis was based on its relation to the defense mechanism of the oral cavity and bacterial resistance, this is studied by **(Garrison, 1982)** who suggested in their results that reduced salivary flow and the concomitant reduction of intraoral pH may predispose patients to bacterial colonization with klepsiella pneumonia.

In this results, although there were differences in the mean value of salivary pH level either between exposed and non exposed group or between before and after exposure in the exposed group, these differences were found to be statistically insignificant (P>0.05), however **(Brown et al., 1975)** and **(Macfarlan et al., 1974)** showed that patients with reduced salivary flow secondary to S'jogren syndrome or to radiation induced sialadenitis have increased colonization with gram negative bacteria, while it is known that pathologically reduced salivary flow is associated with a concomitant decrease in the pH of stimulated parotid saliva **(Englander et al., 1959).**

Concerning the analysis of saliva trace elements either cations or anions, the trace elements were chosen to be analyzed as changing their levels in saliva affect the oral health status or the general conditions of the oral cavity or through indirect effect by affecting the general condition of the body e.g. the immune system of the body and consequently affecting the oral condition.

Zinc analysis was chosen as zinc plays an important role in the development and maintenance of the immune system **(Halsted et al., 1974)** and also in normal lymphocyte response **(Golden et al., 1978)**, in addition zinc supplement regulates and controls the activity of the immune function and it always restores the activity to normal.

So changing in the zinc level in saliva will affect indirectly the conditions of the oral cavity by its effect on the immune system of the human body.

On the other hand, copper was chosen to be analyzed as there is a strong relationship between Cu and the integrity of the immune response especially in relation to pathogenic challenges **(Prohaska & Lukasewycz, 1983),** and also Cu deficiency associated with increased susceptibility to infection **(Nadler et al., 1972),** domestic animals with insufficient Cu intake showed decreased bactericidal activity (**Jones, Suttle, 1983**) together with an increased susceptibility to bacterial infections and decreased resistance to tumor challenge **(Lukasewycz & Prohaska, 1982).**

So changing in the copper level in saliva will affect either the immune system of the human body or the susceptibility to infection or bacterial activity on resistance to tumor and so all the above might affect the oral cavity status.

Regarding iron analysis in saliva, iron level in the body regulates both the nonspecific and specific immune systems **(Bryan & Leech, 1983).** So it will affect indirectly the condition of the oral cavity.

On the other hand, total iron concentration in saliva of patients with chronic gingivitis, moderate and advanced periodontitis was increased compared to that of the control **(El-El Wany, 1988),** and this means that changing in the iron level in saliva affects the gingival conditions of the oral cavity.

Concerning magnesium analysis, magnesium deficiency causes disturbances in the immune system with multiple immunodeficiencies, magnesium deficiency causes thymic gland hypertrophy and lymphomas may develop, it also causes

leucocytosis and eosinophilia **(Beisel, 1982 and Iskandar, 1990)**, also **(Alcock and Shills, 1974)** suggested that magnesium had a direct role either in the synthesis, release or metabolism of IgG, morever **(Elin, 1975)** found that after six days of dietary magnesium deficiency in mice , there was a significant decrease in the concentrations of IgG, IgA and IgM, so changes in magnesium level will affect on the immune system or defense mechanism of the human body.

Concerning fluoride analysis, fluoride plays the major role in regulating the conditions of the oral cavity as it plays an important role in cariostasis or caries prevention due to its direct influence on the mineral phase of dental enamel and also influence cariogenic microorganisms or other components in dental plaque **(Ripa et al., 1987, Kaufmann & Bartholmes, 1992).** On the other hand, fluoride affects several bacterial enzymes loading to a change in the metabolic activity and normal growth of bacteria **(Hamilton, 1977 and Loesche, 1977).** Consequently, there was a decrease in gingival inflammation **(Leverett, 1984)**

Moreover, a high level of fluoride in plaque may inhibit the growth of acidogenic and aciduric bacteria and mutans streptococci which are associated with the inhibition of caries **(Hamada &Slade, 1980; Hamilton, 1990; Tatevossian, 1990 and Van Loveren, 1990).**

Fluoride prevents dental plaque to attach the teeth and depress its glycolytic activity as well as plaque acidogenesis as reflected by the increase in plaque pH **(Woolley and Rickles, 1971, Schneider**

and Muhlemann, 1974). So changing in fluoride level in saliva will affect directly on the conditions of the oral cavity and the oral health status.

Regarding the calcium analysis, calcium has its direct effect on the oral health status as **(Sewen et al., 1995)** found that higher calcium concentration was more in the periodontitis affected patients more than in periodontitis free patients while the peiodontitis affected patients had more intact teeth, this will indicate that elevated level of salivary Ca is characteristic of periodontitis affected patients i.e. lowering of gingival and periodontal conditions (soft tissue condition) and improving of the hard tissue conditions.

(Sewen et al., 1998) found that the high salivary calcium group showed more bleeding in probing and more intact teeth at lower DMF scores than their counterparts, they found clear association between the level of salivary calcium and factors reflecting gingival health on one hand and dental health on the other, so changing in Ca level in saliva affects directly on the oral health status.

Concerning the trace elements analysis results, although there were differences in the mean values of all anions and cations levels between the exposed and non exposed group and

also for fluoride, iron and calcium between before and after exposure in the exposed group, these differences were found to be statistically insignificant ($P>0.05$), however **(Hsu et al., 1994)** found a significant difference in the ratio of copper/ zinc between normal subjects and nasopharyngeal carcinoma patients preradiotherapy, during and after the period of radiotherapy, the serum copper level

decreased as compared with the level of preradiotherapy. The cu/zn ratio decreased after radiotherapy but not significantly. This change might be due to the type of ionizing radiation used in the treatment of carcinoma, while in this study the type of non ionizing radiation used can not induce significant changes in the levels of trace elements.

The choice of salivary secretary immunoglobulin A in particular was based on its direct relation to the field of dentistry especially in caries immunity as well as periodontal immunity **(Lehner et al., 1975).** Furthermore, the biological effects of radiation on salivary secretary IgA can help us to understand the biological changes and harmful effect that may occur in the mouth due to radiation exposure (**Tomasi et al., 1965; Lehner et al., 1967; Fisher et al., 1968; Mandel and Khurana, 1969; Mandel et al., 1973; Brown et al., 1975; Brown et al., 1976; Loning and Burkhardt, 1979; Kochetkova et al., 1981; Katz, 1983; Abdel Maguid, 1983; Yehia, 1985).** Evaluating the sIgA status of such individuals, therefore, may be of value as decreased levels of sIgA in saliva appear to influence host resistance to mucosal inflammation in some patients, and in particular those with an increased susceptibility and response to periodontal pathogens **(Hagewald et al., 2000)** report a statistically significantly lower concentration and secretion rate of total sIgA in aggressive periodontitis in resting and stimulated saliva. Further study regarding Generalized Early Onset Periodontitis (GEOP) found significantly lower concentration and secretion rate of total sIgA in

GEOP group, **(Schenk et al.,1993)** also reported significantly higher sIgA levels in samples taken from participants with low mean numbers of bleeding gingival units after plaque accumulation.

Concerning study results, although there was difference in the mean values of sIgA between exposed and non exposed group, this difference was found to be statistically insignificant (P>0.05) , on the other hand sIgA increased after exposure in the exposed group, although this increase it was found also to be statistically insignificant (P>0.05).However **(Hagag, 1985)** studied the effect of radiation on mixed sIgA in patients under radiotherapy, the results shows that radiation exposure causes increase in mixed salivary IgA in patients under radiotherapy.

This could be explained as the type of radiation and its energy, intensity and dose play very important role on the effect on saliva components or on the changes of its level.

Concerning the choice of body temperature measurements, it was chosen as previous researches concluded that electromagnetic waves emitted from digital cellular phones causing warmth, and pricking of the ear during phone conversations and affecting the working memory in humans and this effect may be related to cerebral vessel dilatation, attributed to brain heating **(Santini et al., 2002)** and also it is well known that microwaves increases the temperature of the material from inside to outside.

In our results, there was difference in the mean value of body temperature between exposed and non exposed group, it was higher in the exposed group, this difference was found to be statistically

significant (P<0.05) and also there was increase in the mean values of body temperature after exposure to VDTs in the exposed group, this increase was found also to be statistically significant (P<0.05), this is in accordance with **(Santini et al., 2002)** who found the same result after exposure to electromagnetic waves emitted from digital cellular phone and this confirm our result.

The effect of radiation emitted from VDTs on the human health had been studied during the last 25 years, all these previous studies have found that there is no direct harmful effect of VDTs on human health but they had indirect effect through the long duration of exposure, workplace conditions, prolonged static incorrect position in front of the screen, nature of stressful job, psychological strain and tension.

All of the above might lead to job dissatisfaction which has an impact on employee well being, this could be manifested by headache, nausea, dizziness, difficulties in concentration, fatigue, eye strain, ocular fatigue and sleeplessness.

Our study could be considered one of the few leading researches dealing with effect of VDTs on oral health status, most of our findings concerning the effects on the oral cavity were found to be undetectable effect, this was in accordance with many other previous researches which was concerned with the effects of VDTs on many different organs of the human body as previously mentioned.

This undetectable effect might be due to the weak type of non ionizing electromagnetic radiation emitted from VDTs with low

intensity, moreover the sample size was insufficient epidemiologically and the number of subjects were limited due to the administrative restrictions by the work managers in accessing their work places to examine their employees afraid of spreading fear among them in case the study proved the harmful effects. On the other hand, we made many investigations and test analysis for each subject to compensate for this limited sample size.

It should be pointed out that this radiation not emitted only from the screen but also from the other components of the monitor and they are scattered through many directions, so it is not focused on the oral cavity of the user, in addition to using of modern standards of protection including the liquid crystalline displays which decrease the amount of radiation emitted from that displays and so decreasing the harmful effect of VDTs on the human health.

Summary and Conclusions

Summary and Conclusions

Nowadays, there is an increasing incidence of radiation hazards, as humankind is continuously exposed to various sources of radiation. Consequently, and from the environmental point of view, there is an increasing interest in the evaluation of its various effects on the environment. One aspect, which is of great impact on human health, is the oral health status.

To identify the health hazards of electromagnetic radiation emitted from visual display terminals, in particular the oro-dental hazards, two groups are participating in this work, each consists of fifty persons.

The exposed group is composed of employees and operators, working in the field of computer or visual display terminals with average time durable in the job about 8 hours daily and for several years. The other group is a control group chosen far from visual display terminals either at work or home.

- Both groups were checked generally and oro-dentally. Besides, they were given a questionnaire to recognize the medical and oro-dental history, taking in consideration the base line for general health (excluding diabetic, and liver diseased persons).
- Both groups were subjected to certain investigation including body temperature examination, oral examination (gingival index and decayed, missed and filled index) and saliva analysis (pH, trace elements, salivary immunoglobulin A).

- All the above investigations were compared between both groups and some of them were compared between before and after exposure in the exposed group.
- The results of this study could be summarized as follows:
    - There were differences in the mean value of either gingival index score or D.M.F score between both groups, this difference was found to be statistically insignificant (P>0.05).
    - There were differences in the mean value of pH level in saliva between both groups and also between before and after exposure in the exposed group, this difference was found to be statistically insignificant (P>0.05).
    - There were difference in the mean values of salivary anions (sulphate, phosphate, fluoride) in saliva between both groups, this difference was found to be statistically insignificant (P>0.05).
    - There were difference in the mean values of salivary cations (zinc, copper, iron, calcium, magnesium, potassium, ammonia, sodium) in saliva between both groups, this difference was found to be statistically insignificant (P>0.05).
    - There were differences in the mean values of salivary immunoglobulin A between both groups, this difference was found to be statistically insignificant (P>0.05).

- There were differences in the mean values of fluoride, iron and calcium between before and after exposure in the exposed group, this difference was found to be statistically insignificant ($P>0.05$).
- There was differences in the mean values of body temperature between both groups, was higher in the exposed group, this difference was found to be statistically significant ($P<0.05$).
- There was increase in the mean value of body temperature after exposure to VDTs in the exposed group, this increase was found to be statistically significant ($P<0.05$).

Conclusions

Within the limits of this study, it is concluded that:

- Radiation emitted from visual display terminals does not affect either the gingival index nor the decayed, missed, filled index of the oral cavity.
- Radiation emitted from visual display terminals does not affect the pH level of saliva.
- Radiation emitted from visual display terminals does not affect trace elements values of saliva (Anions and Cations).
- Radiation emitted from visual display terminals does not affect the salivary immunoglobulin A level of saliva.

So, radiation emitted from visual display terminals does not affect the soft or hard tissue structure of the oral cavity or even affect the salivary components i.e. does not affect the oral health status.

On the other hand, radiations emitted from visual display terminals have noticeable effect on the temperature of the human body.

Recommendations

Recommendations

- Further studies should be done on large scales of population and further longitudinal study for all participants of this study should be done every two years to follow up the changes in the oral health status that could occure after long periods of exposure to radiation emmited from visual display terminals.

- Special attention should be paid to avoid continuos longstanding exposure to VDTs without any break intervals as the exposure to VDTs could have a possible harmful effects.

- Workers should avoid exposure from the back of VDTs which is not protected enough like the screen, this might need rearrangment of apparatuses and workers in their work places.

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