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Harmful Effects of Ionizing Radiation

Ravinder Guleria¹, Brijender Bhushan^{2*}, Ankit Guleria³, Ajay Bhushan⁴, Pawitar Dulari⁵

¹Department of Physics, Pandit Sant Ram Government Degree College, Baijnath (H.P.) India-176125

²Department of Zoology, Pandit Sant Ram Government Degree College, Baijnath (H.P.) India-176125

³B. Tech (CSE), National Institute of Technology, Hamirpur (H.P.) India-177005

⁴M. Tech (I.T.) Galgotias College of Engineering & Technology Greater Noida, (U.P.)-201306

⁵Department of Physics, Government PG College, Una (H.P.) India-174303

*Corresponding Author

Abstract: Human population throughout the world is surrounded by an invisible continuously increasing web of radiation, originating from both natural and non-natural sources. Radiation is of two types: ionizing and non-ionizing depending upon their energy. The exposure to radiation has increased many folds in the recent years with the invention and launch of many electromagnetic devices.

Exposure to ionizing radiations has been found to cause severe abnormalities in human beings such as DNA damage, cancer, infertility, electro-hypersensitivity, etc. which however is of different intensity depending upon the age group of human beings, with children and fetus being the maximum sufferers because of immature immune system and also various other cells in their body are still at the stage of division and differentiation. Present study has been aimed to investigate a generalized preliminary idea of various health related complications caused by ionizing radiations to human beings with special emphasis to fetus and children.

Keywords: Radiation, diseases, human population, fetus, children.

I. INTRODUCTION

Existence of electromagnetic radiation is as old as the Universe itself. Most of the radiation we receive is normally present in the environment. Some of the radiations e.g. light and heat are crucial for the survival of human beings and other organisms of this planet. The radiation all around us originates from natural and non-natural sources^{1, 2}. Depending upon the source, radiation is broadly divided into natural and non-natural radiation.

Natural radiations generally originate from the solar system, outer universe, radioactive materials present in earth's crust etc., whereas non-natural radiation is from man-made devices such as those used in the medical diagnosis and treatment, telecommunication etc.

However, both the sources of radiation, natural as well as man-made contribute nearly equally to the total radiation pool. Presently there has been a great concern throughout the world towards the adverse effects of the radiation on human beings and other organisms.

Among the human beings, children and fetus are especially prone to radiation. Major sources of radiation exposure to this population group include diagnosis instruments used in hospitals, communication systems, dryers, etc^{3, 4}.

This paper has been aimed to study the adverse effects of electromagnetic radiation on human health, especially mother, fetus and children.

A. Ionizing Radiation

Ionizing radiation is high frequency/low wavelength energy. Ionizing radiation carries sufficient energy to break the molecular bonds and displace or remove electrons from the atoms. These results in the formation of two charged particles (ions) which have the capability to cause severe damage to living cells of plants, animals and humans. The ionizing radiation is very useful and has a variety of applications in life.

For example, we use ionizing radiation in smoke detectors and to treat cancer or sterilize medical equipment. Similarly, X-rays are typically used to provide static images of body parts (such as teeth and bones), and are also used in industry to find defects in welds. But, ionizing radiations can be potentially harmful if not used correctly as these also include Alpha Particles, Beta Particles, Gamma Rays and X-Rays and Neutrons: which are emitted from naturally occurring radioactive materials (such as uranium, thorium, and radium) and other man-made radioactive elements and thus, need to be handled with utmost care⁽¹⁻⁸⁾.

II. EFFECTS OF IONIZING RADIATION

The biological effects of ionizing radiation are the combined result of direct absorption of energy at molecular level and the indirect oxidative damage produced by the reactive oxygen species. Ionizing radiation can damage the tissue, as it can break the bonds of the DNA molecules in the nucleus of a living cell. This damaged DNA can have a variety of consequences leading from the cell's death up to malignancy. The diseases like cancer which are most readily induced by radiation, is complex, and this risk increases with age. Exposure to radiation in childhood increases risk of leukemia, brain, and breast and thyroid cancer. Fetal exposure to radiation has been associated with severe mental retardation. There are also severe effects of radiations on the developing brain. Thus, radiological examinations should totally be avoided during early stages of life especially during the first three years. It is recommended to pregnant women to avoid exposure to radiation as much as possible. The diseases associated with radiation are as follows ⁽¹⁻¹¹⁾:

A. Leukemia

There is a strong evidence linking leukemia to ionizing radiation. This evidence is based upon studies conducted at Los Alamos National Laboratory, studies of nuclear workers at other sites, and others exposed to ionizing radiation. In addition, studies of survivors of atomic bomb explosions (Life Span Study / LSS) have also shown results of increased leukemia and associated mortality. Furthermore, leukemia occurs earlier than other solid cancers on frequent exposure to radiation. An alarming fact is that the risk of leukemia is higher for childhood exposures. Most studies on radiation therapy at high doses have confirmed an increase in the risk of leukemia. Notwithstanding the methodological limitations of some of the studies, the observed correlation between childhood leukemia and *in utero* exposure to diagnostic X-rays was interpreted as providing the etiological role of ionizing radiation.

B. Breast Cancer

The risk of breast cancer from radiation is easily evident in those women who have undergone radiation therapy in their infancy or early age. Breast cancer risk was associated with radiation exposure in the LSS cohort and among several medically exposed groups. The risk of breast cancer due to radiation has been found to increase linearly and also has more effect on young aged women similar to leukemia. In a surprising study, it was found that breast cancer was more prone in women less than 10 years of age at the time of atomic explosion – a time when there has been negligible growth of breast tissue. Thus, we can conclude that women who developed breast cancer at an early stage might have been susceptible to radiation genetically. A very similar pattern of breast cancers was found in women exposed to radiation due to other factors such as fluoroscopy. Age at exposure strongly influenced the risk of radiation-induced breast cancer with young women being at highest risk. It is thus advised to shield breasts during any therapy involving radiation.

C. Thyroid Cancer

Based on the data from the National cancer Institute's Surveillance, Epidemiology and End Results (SEER) dataset, thyroid cancer has nearly doubled in the U.S. during the last decade and almost tripled since the early 1970's. One major reason for this is ionizing radiation. External exposure to X-rays and γ -rays as well as internal exposure to radioiodine's through ingestion pose a major threat for to humans by contributing towards thyroid cancer. Thyroid gland has been found to be highly vulnerable to radiation especially in children. In the LSS cohort, a significant association was found between radiation dose and risk of thyroid cancer for those exposed before 19 years of age. Again, children are the most sensitive towards ionizing radiation in development of cancer and the risk of cancer decreases with age. The excess risk of development of cancer has been observed for many years after exposure and is the highest after 15-30 years. Many children were diagnosed with thyroid cancer after the Chernobyl incident. Thus, we conclude that ionizing radiations are a big threat to our thyroid gland particularly in children.

D. Brain Cancer

Brain cancer can also be a result of ionizing radiation though the chances are very less compared to the previous diseases. There is a very little probability of a harmful brain tumor occurring due to radiotherapy. According to Japanese researchers, there are no proofs of brain tumors due to radiations though an increase in malignant brain tumors has been observed after radiotherapy in many cases. The proof is yet again the strongest for people below 20 years of age. An alarming fact is that some studies have shown risk of brain tumor in cases of prolonged talks on cell phones with phone in close contact with ears. Hence, this should be avoided.

E. Mechanistic Approaches

When the living organisms are exposed to ionizing radiation, they could be affected either directly or indirectly or by both effects. It has been found that when a cell or tissue is exposed to radiation, several changes occur, e.g. damage to the normal architecture of cell membrane through lipid peroxidation, DNA damage as well as free radical formation.

F. Direct Damage

In direct interaction, a cell's macromolecules (proteins or DNA) are hit by ionizing radiation, which affects the cell as a whole, either killing the cell or mutating the DNA. A cell's DNA is severely affected on being directly struck by radiations. It is suggested that if only one strand of DNA is broken by ionizing radiation, repair could occur within minutes. However, when both strands of DNA are broken at about the same position, correction would be much less likely to occur but if there are a large number of ionizations in a small area (more than one single break in the DNA strand), the local cell repair mechanisms become overwhelmed. In such cases the breaks in DNA may go unrepaired, leading to cell mutations. Unrepaired DNA damage is known to lead to genetic mutations, apoptosis, cellular senescence, carcinogenesis and death.

G. Indirect Damage

Ionizing radiation may also affect indirectly, via the formation of free radicals (highly reactive atoms or molecules with a single unpaired electron). These radicals may either inactivate cellular mechanisms or interact with the genetic material (DNA). The oxidative reactions due to ionizing radiations cause physical changes in proteins, lipids, and carbohydrates, thus leading to impairment and loss of functionality of DNA. Indirect interaction is a result of radiations interacting with cellular water rather than the macromolecules of the cell. The resulting reaction is hydrolysis of water which gives a hydrogen molecule and a hydroxyl radical as the products which may also lead to cell death in many cases.

H. Chemical Consequences of Ionizing Radiation

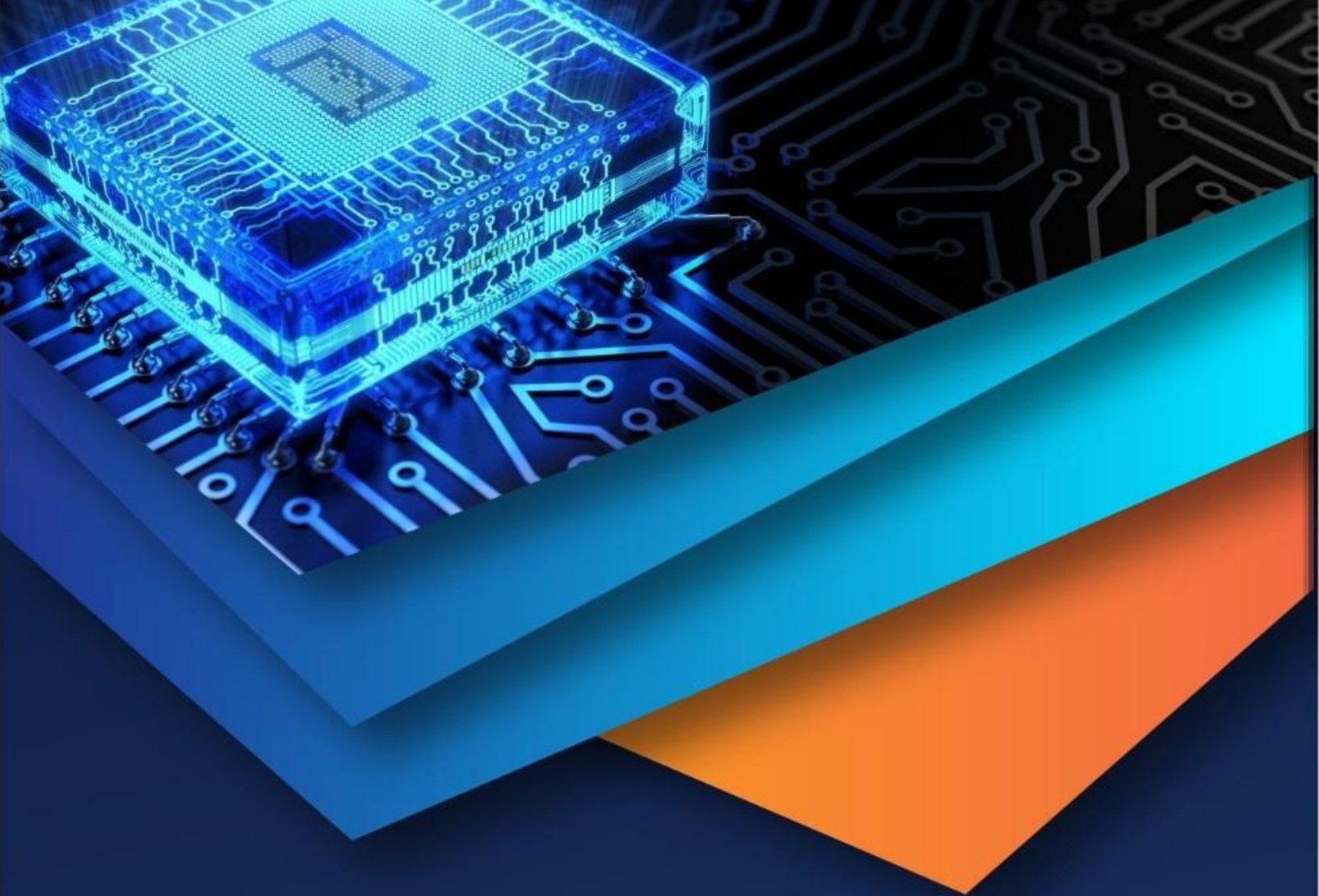
Since water is an integral component of the human body either during fetal life or in adult stage, it thus on exposure of radiation produces very reactive species such as electrons, monoatomic hydrogen atoms, hydroxyl free radical, hydrogen peroxide, etc., of short life span. These reactive species bind here and there within the cell and bring about various alterations in the normal cell functioning and structure, which ultimately results in the form of a disease.

I. Safety Measures: Using and Propagating

Keeping all the facts discussed above, it is evident that common exposure to radiations to the general population includes excessive use of domestic and commercial product and places emitting ionizing radiations, unnecessary exposure to radiations at hospitals, etc. Thus, it is necessary that we must use these applications well within limits and reduce the chances of exposure to this radiation, so that can save our self and coming generations from the harmful effects.

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