Radiation and radioisotope based tools and technologies are increasingly contributing to progress in the quality of human health, applications in agriculture and developments in industries and have provided powerful methods in research. Therefore, extensive radiobiological research is needed in generating new basic knowledge and understanding, in setting standards for safety, for establishing protocols for regulation and in providing guidance for effective protection of public health. It seems the professional responsibility of radiobiologist to understand, evaluate and control radiation exposures for ensuring the welfare of society.

Radiation has existed everywhere in the environment since the earth’s formation in rocks, soil, water and plants. It is a weak carcinogen but undue exposure could certainly increase health risks. The body has defense mechanisms against damage induced by radiation as well as by chemical and other carcinogens. These can be stimulated by low levels of exposure or over by very high level. Much larger doses are used to kill harmful bacteria in food and to sterilize bandage and other medical equipment. Radiation has become a valuable tool in our modern world.
Term “Radiation” is elastic unfortunately it has come to mean “something terrible” in ordinary conversation. Literally radiation means “anything emitted from a localized source”. How radiations originate is explained in following lines, atoms of a given element with different atomic number and mass are called isotopes. In general neutron to proton ratio in the nucleus will determine whether an isotope of a given element is stable enough to exist in nature. The unstable isotopes are commonly known as radioisotopes. These radioisotopes emit particle and/or electromagnetic radiations as a result of changes in the composition of the atomic nucleus. These processes are called radioactive decay.

The particles or radiations emitted by radioisotopes can be classified in a number of ways. It is useful to classify these radiations according to their biological effects. The more energy the particles of a radiation transmit to living organism, the more they can affect them. We classify radiation as penetrating and non penetrating.

Penetrating radiations means radiation that pass through our skin like X rays, gamma rays, radio waves etc.

Non penetrating radiations - radiation that do not pass through our skin these include alpha rays, beta rays neutrons etc.

More penetrating is the radiation, more harmful it is for living organism For eg among alpha, beta and gamma rays the order of their penetration is - Alpha <beta<gamma
That’s why among these three radiations gamma radiations are most harmful for living beings.

**Effect of radiations**

Biological effects begin with the ionization of the atoms the mechanism by which radiation causes damage to human tissue or any other material is by ionization of atoms in the material. Ionization absorbed by a tissue has enough energy to remove electrons from the atoms that make up molecules of the tissue. When the electron that was shared by the two atoms to form a molecular bond is dislodged by ionizing radiations. The bond is broken and thus the molecules falls apart. This is the basic model for understanding radiation damage. Potential biological effects depend on how much and how fast radiation dose is received.

Radiation doses can be grouped as:

1. Acute dose: It is defined as a large dose delivered during a short period of time. If large enough, it may result in effects which are observable within a period of hours or weeks.

2. Chronic dose: It is a relatively small amount of radiation received over a long period of time. The body has time to repair damage because a smaller percentage of the cells need repair at any given time. The body also has time to replace dead or non functioning cells with new and healthy cells.
Effect of radiations can be grouped as:

**Stochastic effects** - Those effects which increase with increase in the doses of radiation. For eg probability of cancer increases with increasing dose of radiation. This type of risk model is called stochastic.

**Nonstochastic effects** - those effects for which there is a dose threshold. Such effects are acute or late response.

Possible effects of radiations on cells:

Cells are undamaged by the dose - Ionization may form chemically active substances which in some cases alter the structure of the cells. These alterations may be the same as those changes that occur naturally in the cell and may have no negative effect. Cells are damaged, repair the damage and operate normally.

Some ionizing events produce substances not normally found in the cell. These can lead to a breakdown of the self structure. Cells can repair the damage if it is limited.

Cells are damaged, repair the damage and operate normally. If a damaged cell needs to perform a function before it has had time to repair itself, it will either be unable to perform the repair function or perform the function incorrectly or incompletely. These damaged cells may be unable to reproduce themselves or may reproduce at an uncontrolled rate. Such cells can be the underlying causes of cancer.
Radiations

Important Macromolecules

Other cell

Physical

Stage $< 10^{-13}$ Sec.

Ionized Macromolecules

Ionized Molecules

Chemical

Stage $< 10^{-6}$ Sec.

Macromolecular Radicals

Free Radicals

Direct Action

Indirect Action

Macromolecular Changes

Repair

No Repair

Metabolic

Stage $10^{-3} - 10^{-6}$ Sec.

Undamaged

Damaged Macromolecules

Macromolecules

Normal cell

Mutant Chromosomal Cell Damage

Dead Cell
Cells die as a result of damage:

If a cell is extensively damaged by radiations such that its reproduction is affected, the cell may die. Radiation damage to cells may depend on how sensitive the cells are to radiation. All cells are not equally sensitive to radiation damage. In general the cells which divide rapidly/or relatively non-specialized tend to show effects at lower doses of radiation than those which are less rapidly dividing and more specialized. Cells which produce blood are most sensitive and are biological indicator of radiation exposure. Lawrence (1965) has given the events taking place in living tissues after exposure to ionizing radiations which is given in the flow chart.

The body of humans (and other mammals) in composed of a variety of different organs and tissues. It has been observed that different tissues within animals can differ greatly in their response to radiation. Some show significant damage after low doses of radiation; others can receive massive doses without apparent injury. This fact was first recognized by the two French radiobiologist, Bergonie and Tribondeau. Based on their animals studies, they formulated the "law of Bergonie and Tribondeau" which states that cells are radiosensitive If (1) they have a high mitotic rate, (2) They have a long mitotic future, and (3) they are of a primitive type. The kidney is a moderately sensitive, which occurs 6 months to 9 year after the completion of radiation therapy.
Proper knowledge of the response of the kidney to ionizing radiation appears as problems of great clinical and biological importance. But perhaps in no field of radiation biology are opinions as greatly divergent as in considering the kidney to be radio resistant. A numbers of clinical and pathological observations were published dealing with the effects of irradiation on various organs and tissue including the kidney (Baeman and Linser, 1904; Buschke and Schmidt, 1905 and Warthin, 1907). On the basis of clinical experience, some authors consider the kidney as very radio-resistant to x-irradiation (Hartman et al., 1927)

A large number of literatures are now available indicating serious injury of the kidney in human patients exposed to extensive x-rays treatment and radiation induced kidney disease. Blake (1965) stated that "the kineys are resistant anatomically but probably most radiosensitive physiologically, from the stand point of serious or fatal damage.

A number of earlier investigations (Gabriel, 1926; Domagk, 1927; Lacassagne 1946 and Threlfall et al.; 1966) have indicated tubular damage was an early and prominent histological feature of radiation response in the kidney, but little attention was given to the changes in the other renal components.

Heavy metals are metallic elements which have a high atomic weight and a density much greater than water. There are more than twenty heavy metals, but four are of particular concern to human health
Lead (Pb), Cadmium (Cd), Mercury (Hg) and inorganic Arsenic (As). According to the U.S Agency for Toxic Substances and Disease Registry, these four heavy metals are four of the top six hazards present in toxic waste sites. They are highly toxic and can cause damaging effects even at very low concentrations.

Mercury poisoning (also known as hydrargyria or mercurialism) is a type of metal poisoning and a medical condition caused by exposure to mercury or its compounds. Mercury (chemical symbol Hg) is a heavy metal occurring in several forms. All of these, except elemental liquid mercury (for which intravenous injection of a certain volume) produce toxicity or death with less than a gram. The damage done by elemental mercury is caused by blocking blood vessels. Mercury's zero oxidation state Hg\(^0\) exists as vapor or as liquid metal, its mercurous state Hg\(^+\) exists as inorganic salts, and its mercuric state Hg\(^{2+}\) may form either inorganic salts or organomercury compounds; the three groups vary in effects. Toxic effects include damage to the brain, kidneys and lungs (Clifton, 2007).

Mercury is naturally occurring in the biosphere, but is also released into the environment by human activity, such as mining, combustion of fossil fuels and other industrial release. It is highly toxic to both eukaryotic and prokaryotic cells. Its effects depend on the route of exposure and the nature of the mercury compounds (Lee et al., 1997). The primary target organ of mercury toxicity is the kidney (renal proximal tubule). The main sites of deposition after inhalation of Hg...
vapour are the kidneys, the liver and the brain (Cherian et al., 1988). Toxic effects of mercury depend on its chemical form.

Mercury poisoning can result in several diseases, including acrodynia (pink disease) (Bjorklund, 1995), Hunter-Russell syndrome (Tokoumi et al., 1977) and Minamata disease (Davidson et al., 2004). Symptoms typically include sensory impairment (vision, hearing and speech), disturbed sensation and a lack of coordination. The type and degree of symptoms exhibited depend upon the individual toxin, the dose, and the method and duration of exposure.

Literature data suggest mercury damages DNA. Betti et al. (1993) reported DNA fragmentation in human and rat cells assessed by micro gel electrophoresis after in vitro and in vivo treatment with methyl mercury chloride (MMC) and dimethyl mercury. Mercury induces DNA single-strand breaks at low concentrations in mammalian cells (Rossmann, 1995).

Mercury is unique among the heavy metals in that it can exist in several physical and chemical forms, including elemental mercury, which is a liquid at room temperature. All forms of mercury have toxic effects in a number of organs, especially in the kidneys. Within the kidney, the pars recta of the proximal tubule are the most vulnerable segment of the nephron to the toxic effects of mercury. The biological and toxicological activity of mercurous and mercuric ions in the kidney can be defined largely by the molecular interactions that occur at
critical nucleophilic sites in and around target cells. Because of the high bonding affinity between mercury and sulfur, there is particular interest in the interactions that occur between mercuric ions and the thiol group(s) of proteins, peptides and amino acids. Molecular interactions with sulfhydryl groups in molecules of albumin, metallothionein, glutathione, and cysteine have been implicated in mechanisms involved in the proximal tubular uptake, accumulation, transport, and toxicity of mercuric ions. In addition, the susceptibility of target cells in the kidneys to the injurious effects of mercury is modified by a number of intracellular and extracellular factors relating to several thiol-containing molecules. These very factors are the theoretical basis for most of the currently employed therapeutic strategies. This review provides an update on the current body of knowledge regarding the molecular interactions that occur between mercury and various thiol-containing molecules with respect to the mechanisms involved in the renal cellular uptake, accumulation, elimination, and toxicity of mercury (Zalpus, 2000).

Grover et al. (2011) reported a dose-dependent increase in comet tail length in Wistar rat leucocytes after oral treatment with HgCl$_2$. Being more harmful than inorganic mercury compounds; organic mercury compounds cause damage at even lower concentrations. Testing mercury compounds for their ability to induce sister chromatid exchanges (SCEs), Lee et al. (1997) demonstrated that phenylmercury acetate at concentrations of 1-30 μmol L$^{-1}$ caused a significant elevation
of SCEs in cultured human lymphocytes in a concentration dependant manner. Although to a lesser extent, positive findings were also obtained for MMC at a concentration of 20 μmol L⁻¹, while mercury chloride did not produce positive results when used in the above concentrations. All tree compounds caused a significant increase in endoreduplicated mitoses, which could be due to the inhibition of spindle tubule assembly. The rate of elimination of mercury after a single oral or intra peritoneal administration of HgCl₂ to male or female mice has recently been demonstrated to be inversely related to the dose size Nielsen et al. (1991). The present study demonstrates dose-related induction of renal tubular damage, followed by regeneration, after oral administration of HgCl₂ to female mice. Dose-related increased fractional urinary mercury excretion (expressed as percent of dose) was also demonstrated. At increasing dose of HgCl₂, the renal activity of selenium-dependent glutathione peroxidase decreased, and was only 50% of the activity in untreated controls after administration of 200 μmol HgCl₂/kg. At higher doses, the renal concentration of glutathione was significantly reduced as well. The degree of tissue damage was inversely related to the fractional deposition of mercury in the kidneys. This study indicates that the reduction in fractional whole-body retention of mercury with increasing dose size previously demonstrated is due to increased urinary mercury excretion during transient renal damage followed by regeneration, as extensive leakage took place before extensive regeneration was noted.
Possible spindle toxicity and clastogenic activity of methyl mercury was reported by Amorim et al. (2000) in their study of cytogenetic damages in a population living in methyl mercury contaminated Amazon Basin.

Betti et al. (1993) also showed that MMC induced chromosome aberrations and aneuploidy in second metaphases, suggesting that MMC produced chromosome segregation errors.

RADIOPROTECTION

A clear understanding of radiation effect has played an important role in the development of radiation protection standards by the International Commission On Radiological Protection (ICRP) low level radiation (few in Gy) such as occupational exposures cannot induce any tissue reactions, however, they may be associated with some finite risk of carcinogenesis or genetic effects. Most of the scientific information on the risk of radiation is derived from the follow up of bomb survivors of Hiroshima and Nagasaki. A longer follow up of the survivors up to 1998 has provided more the cancer risk based on the reliable information on incidence rates rather than the mortality data used in earlier analysis.

Radiation produces highly reactive and dangerous molecular species called free radicals, in cells and tissues Radio protectors are agents that can prevent the formation of free radicals or destroy the free radicals already formed Many compounds with antioxidants activities
are proved to be effective radio protectors. Antioxidants are known to protect the living system from the deleterious effect of ionizing radiations.

Ganesh C. Jagetia (2006) studied the radio protective potential of plants and herbs against the effects of ionizing radiation, the results obtained from in vitro and in vivo studies indicate that several botanicals such as *Gingko biloba*, *Cantella asiatica*, *Ocimum sanctum*, *Hippophae rhamnoides*, *Panax ginseng*, *Amaranthus paniculates*, *Mentha piperita*, *Zingiber officinale*, *Ageratum conzoides*, *Aphanamixis polystachya* protect against radiation induced lethality, lipid peroxidation and DNA damage.

A large number of medicinal and aromatic plants are present in nature. Which are used in various ayurvedic formulations and they are very effective in radioprotection and at the same time nontoxic, inexpensive and easily available.

*Moringa*

*Moringa oleifera* is the most widely cultivated species of the genus *Moringa*, which is the only genus in the family Moringaceae. English common names include: moringa, drumstick tree (from the appearance of the long, slender, triangular seed-pods), horseradish tree (from the taste of the roots, which resembles horseradish), ben oil tree, or benzoil tree (from the oil which is derived from the seeds). It is a fast-growing, drought-resistant tree, native to the southern foothills of
the Himalayas in northwestern India, and widely cultivated in tropical and subtropical areas where its young seed pods and leaves are used as vegetables. It can also be used for water purification and hand washing, and is sometimes used in herbal medicine.

*Moringa oleifera* is a tree brought from the mind of God to the hands of man. It was recognized by the National Institutes of Health as the Botanical of the Year for 2007, and praised again in 2011 and 2012. It is valued worldwide for its ability to treat over 300 diseases. It has the ability to retain high concentrations of electrolyte minerals, allowing it to stay internally hydrated in the driest of conditions. Africans have honored it with names that translate to: “Never Die,” and “The Only Thing that Grows in the Dry Season,” and “Mother’s Milk.” I think it’s safe to say that this plant has saved more lives in 3rd world countries than any other. This amazing tree is capable of delivering what the body needs and these enzymatically active amino acid sequences may simply not exist in the food chain anywhere else, and that is just the tip of the nutritional iceberg when it comes to *Moringa oleifera*.

Sharma *et al.* (2012) studied the renoprotective effect of *Moringa oleifera* pods in 7,12 dimethylbenz[a] antracene- exposed mice. They investigated the potential of hydroethanolic extract of Moringa oleifera (MOHE) against 7, 12-dimethylbenz [a] anthracene (DMBA)-induced toxicity in male Swiss albino mice. Experimental mice were respectively pre-treated with 200 and 400 mg/kg of MOHE, and 0.5%
and 1% of butylated hydroxyanisole (BHA) for two weeks prior to the administration of 15 mg/kg of DMBA, respectively. Levels of xenobiotic metabolizing enzymes such as cytochrome (Cyt) P450 and Cyt b5, activities of reduced glutathione (GSH) and glutathione-S-transferase (GST) and renal aspartate amino transaminase (AST), alanine amino transaminase (ALT) and alkaline phosphatase (ALP), and content of protein and total cholesterol were measured to determine the nephrotoxicity caused by DMBA and to elucidate the ameliorating role of *M. oleifera*. Single oral administration of 15 mg/kg of DMBA resulted in significant increases in Cyt P450 and Cyt b5 (P<0.01). The toxic effect of DMBA was justified by the significant decreases in the activities of GSH and GST in renal tissues (P<0.05). The levels of renal AST, ALT and ALP and protein content which are indicative of renocellular damage were also found decreased along with significant increase in total cholesterol content in DMBA-treated mice (P<0.01). The DMBA-induced alterations in the tissues were significantly reversed after pre-treatment with 200 and 400 mg/kg of MOHE orally for 14 d (P<0.01). It was concluded that the the effects of MOHE in enhancing the levels of antioxidants and enhancing the levels of biochemical assays in DMBA-induced carcinogenesis are by reducing the formation of free radicals. The study rationalized the ethnomedicinal use of *M. oleifera* for the protection against nephrotoxicity induced by chemical carcinogens.
Moringa oleifera (Sajna in India) is considered to be a very popular vegetable among the Indian and African continent. Among its different parts, the leaf holds the best nutritional and medicinal properties. The present study was aimed to evaluate the protective action of Moringa oleifera leaf extract (MoLE) against oxidative stress induced DNA damage. To that end, the hydroxyl radical mediated DNA damage by Fenton reaction and hydrogen peroxide (H$_2$O$_2$) mediated DNA damage by comet assay were employed. Further, lipid per oxidation (LPO) was assayed to find whether MoLE can prevent the subsequent membrane damage. The extract prevented hydroxyl radical induced DNA damage as well as H$_2$O$_2$ mediated comet formation as determined by fluorescence microscopy. In addition, MoLE inhibits the LPO level by about 30% at 100 μg/ml concentrations. MoLE also inhibits the Topoisomerase I activity which is one of enzymes responsible for DNA metabolism. MoLE shows high polyphenol content (50 mg polyphenols/g dry leaf), strong reducing power, high metal chelating capacity and DPPH (2, 2-diphenyl-2-picryl hydrazyl) radical scavenging activity. All these parameters can immediately be correlated to its DNA protection efficacy. The present study, first time to our knowledge indicates that MoLE possesses significant DNA protective activity and hence suggested for the potential human consumption against oxidative DNA damage and cell damage (Sikder et al., 2013).
A lot of work has been done on the effects of radiation and mercury individually on the kidney of Swiss albino mice. But literature on combined effect of both the agents and their protection by herbal drugs is scanty and fragmentary. Therefore present study was planned to evaluate protective efficacy of *Moringa* against radiation and mercuric chloride induced histological and biochemical (total proteins, glycogen, cholesterol, acid & alkaline phosphatase activities, DNA and RNA) changes in the kidney of Swiss albino mice.