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Assessing the Dose Effect of Ionizing Radiation on Living Organism

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Abstract: Ionizing radiation is produced as a result of decay a given radionuclide. The standard measure of dosimeter is quantified according to the exposure of radiation. This method of quantification dose not incorporates the total amount of ionizing radiation that is associated with each damage the tissue. All human being are exposed to ionizing radiation with natural cosmic rays coming from outer space and x-ray treatment in hospital. Exposures also vary as a result of human activities and practices. The sources of radiation exposures to the human were estimated based on the dose effect the organ. Gamma rays were detected principal mechanism used to sodium iodide activated with thallium NaI(Tl) detection system.

Keywords: Ionizing radiation, Dose, Radiation, Exposure and radioactivity.

1 Introduction

Radiation is a form of energy, such as light or heat. Radiation is characterized according to the frequencies of these wavelengths. Infrared waves, microwaves, and radio waves occur at the lowest frequencies. Ionizing radiation occurs at the highest frequencies. The process of transforming a neutral atom or molecule into an electrically charged component is known as ionization. Ions are either positively charged or negatively charged, depending upon the number of protons and electrons present in the atom (Robert Angelo Borrelli 1999).

The natural sources of ionizing gamma radiation in the environment can be classified into terrestrial and Cosmo genic radiation sources. Terrestrial radioactivity comes from the ground and Cosmo genic radioactivity comes from the interaction of atmospheric gases with cosmic rays. Among these natural ionizing radiation sources, cosmic radiation contributes only to the external exposure of humans, whereas cosmic radiation induced radionuclides (for example ^{14}C) and terrestrial radionuclide's contributed to both external and internal exposures. External exposure of these radionuclides is mostly due to their emitted γ-rays and internal exposure is due to their deposition in the human body and their emitted α- and also β- and γ-radiation. Terrestrial radionuclides depend mainly on geographical and geological conditions. Depending on the composition of rocks, the level of radioactivity varies. Rocks formed from volcanic activities like granite and pumice contain radioactive elements (Kiplangat Elijah 2016).

Different related units are used for measuring radioactivity, absorbed dose, exposure and dose equivalent. Curie (Ci) and Becquerel (Bq) are the units for the measurements of radioactivity which refers to the concentration of emitted particles by a sample. Coulomb/kilogram (C/kg) and Roentgen (R) are the units for exposure which is defined as the amount of radiation traveling through the air. Gray (Gy) and radiation absorbed dose (rad) measures the concentration of absorbed (deposited) radiation by a material or person. Sievert (Sv) and Roentgen equivalent man (rem) are units to measures dose equivalent also known as effective dose which is defined as the amount of absorbed radiation and its medical effects. Dose equivalent is same as the absorbed dose for beta and gamma radiation but larger than the absorbed dose for alpha and neutron radiation that are more damaging (Nida Tabassum Khan 2017).

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1.1.Sources of Radiation Exposure

Radiation sources can be grouped into two main categories namely: natural sources and man- made sources. The natural sources mainly consist of cosmic rays, terrestrial, internal and radon (about 82%). The man - made sources are artificially produced.

Most peoples are exposed to Naturally Occurring Radioactive Material (NORM) and artificial radioactive element through air, food, soil and water within our environment. Monitoring radioactive material are therefore of primary importance for human and environmental protection. The radiation from radionuclide can cause damage to living tissues only when the energy is absorbed in that tissues and one of the major pathways through which it passes to people is food (Anas M.et al 2017). The main objectives of this document are to give an overview on the characterization of ionizing radiation and asses the amount of dose effect.

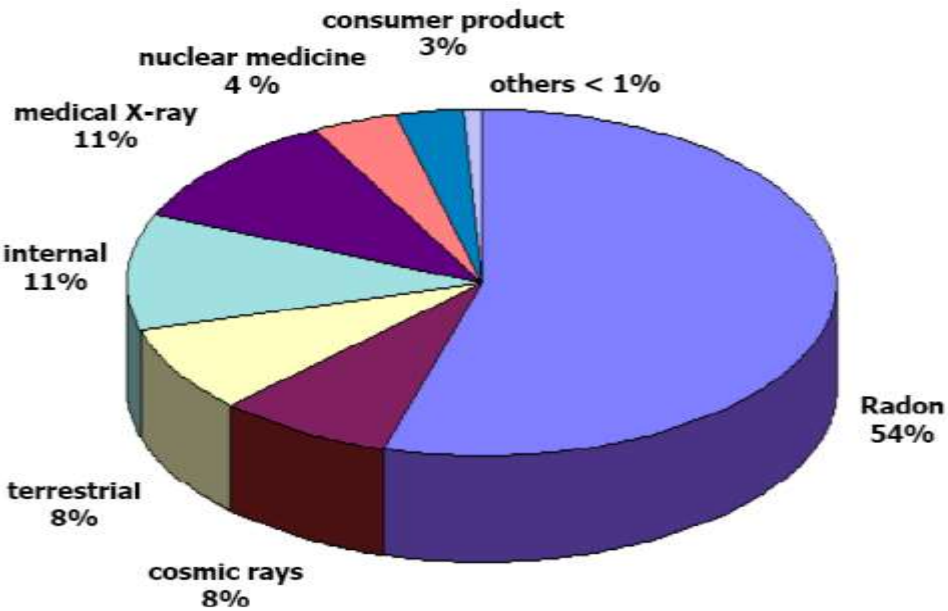

Fig.1: Sources of radiation exposure (Gabriel A., 2013).

Ionizing radiation can be very hazardous to humans and steps must be taken to minimize the risks. The primary aim of radiation protection and safety is to provide appropriate standards of protection and safety for people without unduly limiting the benefits of practice that gives rise to exposure.

1.2 Radiation Dose to Tissue or Organ

Expressing the size of a radiation dose is most conveniently done by specifying the amount of energy deposited by the incident radiation. The basic measure of radiation dose is called absorbed dose.

1.2.1 Absorbed Dose

The interaction of radiation with matter involves a transfer of energy from the radiation to the matter. Ultimately, the energy transferred either to tissue or to a radiation shield is dissipated as heat. The radiation dose depends on the intensity and energy of the radiation, the exposure time, the area exposed and the depth of energy deposition. The Absorbed Dose is given by:

$$D = \frac{E}{M} \quad \text{.........} \quad 1$$

The unit is J/kg or Gray (Gy) formally rad.1Gy = 100 rad. It is possible to calculate the absorbed dose in a material if the exposure is known.

1.2.2 Equivalent Dose

The absorbed dose does not give an accurate indication of the damage that radiation can do. An absorbed dose of 0.1Gy of alpha radiation, for example, is more harmful than an absorbed dose of 0.1Gy or beta or gamma radiation. To reflect the damage done in biological systems from different types of radiation, the equivalent dose is used.

$$H_T = W_R \times D(Gy) \qquad (2)$$

Where H is the equivalent dose in tissue, and WR is the radiation weighting factor .The unit is sievert (Sv) formally rem. 1Sv = 100rem (Ibrahim, *2014*).

1.2.3 Effective Dose

The effective dose of radiation received by a person is, in simple terms, the sum of the equivalent doses received by all tissues or organs, weighted for "tissue weighting factors." These reflect different sensitivities to radiation of different organs and tissues in the human body. The SI unit for the equivalent and effective dose is the Sievert.

$$E = HT.WR \qquad (3)$$

Where H_T is the tissue or organ equivalent dose and W_R is the weighting factor of the incident radiation.

1.2.4 Tissue Threshold Dose

A threshold dose can be defined as the dose below which a tissue specific reaction does not occur. This particular dose is difficult to determine. Here, the 'threshold dose' is defined as the estimated dose that is required to cause a specific, observable effect in 1% of the exposed individuals (J.B. van de K. et.al 2016).

Table 1**:** Estimates of threshold doses for an approximate 1% incidence of morbidity for various adult human tissues and organs following acute exposure to radiation.

Organ/tissue	Threshold dose (mGy)	Biological effect	Latency period
Testis	~100	Temporary sterility	3-9 weeks
Testis	$\sim 6 \times 10^3$	Permanent sterility	3 weeks
Ovaries	$\sim 3 \times 10^3$	Permanent sterility	< 1 week
Bone marrow	~500	Depression of Haematopoiesis	3-7 days
Skin (large areas)	$< 3\text{-}6 \times 10^3$	Main phase of skin reddening	1-4 weeks
Skin (large areas)	$5\text{-}10 \times 10^3$	Skin burns	2-3 weeks
Skin	$\sim 4 \times 10^3$	Temporary hair loss	2-3 weeks
Skin (large areas)	10×10^3	Late atrophy	>1 year
Skin (large areas)	10×10^3	Telangiectasia at 5 years	>1 year
Eye	~100 per 5 years**	Cataract (visual impairment)	>20 years
Brain	100-200	Cognitive defects infants <18 months	Several years
Carotid artery	~500	Cardiovascular disease	>10 years
Heart	~500	Cardiovascular disease	>10-15 years

An equivalent dose limit for the lens of the eye of 20 mGy per year, averaged over defined periods of 5 years, with no single year exceeding 50 mGy (J.B. van de Kamer et.al 2016).

1.2.5 Principle Mechanism of NaI (Tl) Detector

Sodium iodide activated with thallium NaI(Tl) detection system is used in the detection of gamma rays. It has scintillators, a photocathode, a PMT and the associated electronics. An incident gamma ray entering the scintillators is absorbed to produce a light photon. The scintillation mechanism will convert a certain fraction of the electron energy into visible or near ultraviolet light. The photons enter the photocathode which converts them to photoelectrons. These photoelectrons are further multiplied by a series of dynodes in the photomultiplier before the signal is processed by the electronics. The dominant decay time of NaI (Tl) crystal is typically 230ns. It has high gamma ray registration efficiency but its energy resolution is inferior as compared to semi-conductor detectors (Kiplangat Elijah, 2016)

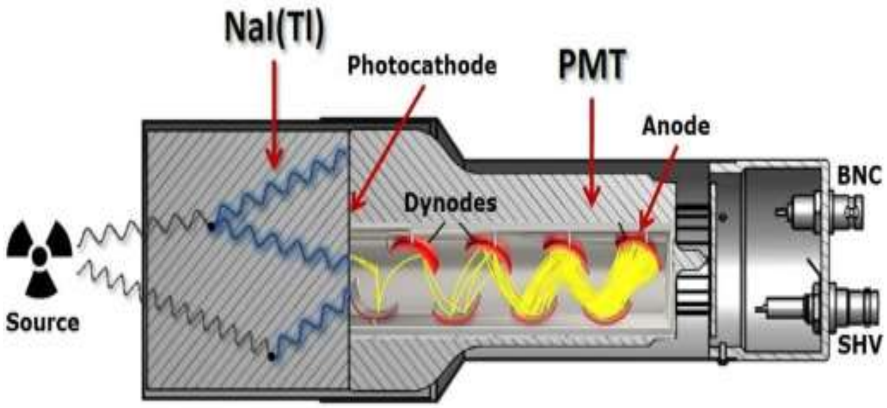

Fig.2.2: Schematic diagram of NaI(Tl) detector, PMT and connectors (Kiplangat Elijah, 2016).

2 Conclusions and Recommendation

- **Conclusions**

The method based on existing evidence we concluded that prompt dose of up to 100 mGy produce no functional impairment of tissues and are unlikely to affect the unborn child. It could be noted that the basic principle in limiting radiation exposure is as low as reasonably achievable, which in general can be achieved by using optimal techniques, equipment and procedures best practices. Nothing that in some medical diagnostic of ionizing radiation organ doses in excess of 100 m Gy may occur. The continues harm caused to cells by ionizing radiation depends on the nature of the rays, the part of the body exposed to radiation and the dose received

- **Recommendation**

The study was conducted the effect ionizing radiation. A study can be made to determine the dose of naturally or artificial occurring radiation' on human being from the sources. Further studies to giving awareness the levels of are recommended for monitoring of radiation dose while people in the area of either hospital or computer devise. The study should be focused to in agricultural farms to serialized vegetable and Tsetse-fly.

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