MANGALORE UNIVERSITY

MSc Medical Physics

MPH 452: Radiation Dosimetry and Standardization

Teaching hours: Each Unit – 12 h

Objective:

To acquaint the students with basics of ionising radiation, quantities and their units and to introduce dosimetry and standardisation techniques including familiarizing with radiation chemistry and methods of chemical dosimetry.

Outcomes:

- Students will gain the knowledge regarding radiation, radiation dosimetry, their quantities and units.
- They will understand the about radiation standards, measuring and standardising techniques.
- The students will learn about brachytherapy and standardisation of its sources.
- They will acquaint themselves with neutron standards, dosimetry and measuring equipment.
- Students will understand the importance of standardisation of radionuclides used in diagnosis and therapy and associated instrumentation.
- They will be capable of standardizing the radiation dosimetric systems and measurements.
- Students will be able to achieve safety aspects of radiation by employing proper dosimetric system and measurements.

Unit I: Radiation Quantities and Units

Units of radioactivity: Becquerel, Curie, specific activity, carrier free activity, resonance absorption and Mossbauer Effect. Biological and Effective Hal-Life - Quantities and units: Dose, roentgen unit of exposure, radiation sensitivity of biological materials, Radiation Absorbed Dose (RAD, Gray), radiation weighting factor, Relative Biological Effectiveness (RBE), Quality factors, Roentgen Equivalent Man (REM), Sievert, equivalent dose, effective dose, collective equivalent dose, total effective dose equivalent. Radiometry, Particle flux and fluence, Energy flux and fluence, Cross section, Mass energy transfer and mass absorption coefficients, LET Radiation, chemical yield, W value, Dosimetry – Energy imparted –

Absorbed dose, Radiation and tissue weighting, factors, equivalent dose, effective dose, Concepts of collective dose – KERMA-CEMA, Exposure, Air kerma rate constant – Charged particle equilibrium (CPE) – Relationship between kerma, absorbed dose and exposure under CPE, Dose equivalent, Ambient and directional dose equivalents [(H*(d) and H‘(d)], individual dose equivalent penetrating Hp(d), Individual dose equivalent superficial Hs(d).

Unit II: Dosimetry & Standardization of X and Gamma Rays Beams

Standards - Primary and Secondary Standards, Traceability, Uncertainty in measurement. Charged Particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/ Exposure.Limitations of FAIC.Bragg-Gray theory, Mathematical expression describing Bragg-Gray principle and its derivation.Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of D_{gas}, Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General definition of calibration factor - N_X, N_K, $N_{D,\ air}$, $N_{D,\ W}$. IAEATRS277: Various steps to arrive at the expression for D_W starting from N_X. TRS398: $N_{D,\ W,\ Q}$: $N_{D,\ W}$: $K_{Q,Q0}$:K_Q , Derivation of an expression for $K_{Q,Q0}$. Calorimetric standards – Inter comparison of standard

Measurement of temperature and pressure. Saturation correction: derivation of expression for charge collection efficiency of an ion chamber based on Mie theory. Parallel plate, cylindrical and spherical ion chambers, K_{sat} , Two voltage method for continuous and pulsed beams, Polarity correction. Cross calibration using intermediate beam quality. Quality Audit Programmes in Reference and Non-Reference conditions.

Standardization of brachytherapy sources - Apparent activity - Reference Air Kerma Rate - Air Kerma Strength - Standards for HDR ^{192}Ir and ^{60}Co sources - Standardization of ^{125}I and beta sources, Extrapolation Chambers - IAEA TECDOC 1274 - room scatter correction. Cross calibration of cylindrical ionization chambers – parallel plate ionization chambers – Bell Chamber - Calibration of protection level instruments and monitors.

Unit III: Neutron Standards & Dosimetry

Neutron classification, neutron sources, Neutron standards - primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulphate bath system, precision long counter, Activation method.Neutron spectrometry, threshold detectors,

scintillation detectors & multi-spheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators – Proportional counter – CR-39 Dosimetry.

Unit IV: Standardization of Radionuclides

Methods of measurement of radioactivity - Defined solid angle and 4π counting - Beta

gamma coincidence counting - Standardization of beta emitters and electron capture nuclides with proportional, GM and scintillation counters - Standardization of gamma emitters with scintillation spectrometers - Ionization chamber methods – Extrapolation chamber - Routine sample measurements – Liquid Scintillation counter – Windowless counting of liquid samples - Scintillation counting methods for alpha, beta and gamma emitter - Reentrant ionization chamber methods - Methods using (n, γ) and (n, p) reactions - Determination of yield of neutron sources - Space integration methods - Solid state detectors.

Unit V: Radiation Chemistry and Chemical Dosimetry

Definitions of free radicals and G-value-Kinetics of radiation chemical transformations - LET and dose-rate effects - Radiation Chemistry of water and aqueous solutions, peroxy radicals, pH effects - Radiation Chemistry of gases and reactions of dosimetry interest - Radiation polymerisation, effects of radiation on polymers and their applications in dosimetry - Formation of free radicals in solids and their applications in dosimetry - Description of irradiators from dosimetric view point - Dosimetry principles - Definitions of optical density, molar absorption coefficient, Beer- Lambert's law, spectrophotometry - Dose calculations - Laboratory techniques - Reagents and procedures - Requirements for an ideal chemical dosimeter - Fricke dosimeter - FBX dosimeter - Free radical dosimeter - Ceric sulphate dosimeter - Other high and low level dosimeters - Applications of chemical dosimeters in Radiotherapy and industrial irradiators.

Reference Books:

- Joseph Magill and Jean Galy, Radioactivity Radionuclides Radiation,European commission Joint research centre, Institute for TransuraniumElements, P.O.Box 2340, 76125 Karlsruhe, Germany
- IAEA TRS 374, Calibration of dosimeters used in Radiation Therapy
- F.H. Attix. Introduction to Radiological Physics and Radiation dosimetry, Viley-VCH, Verlog, 2004
- Field, clinical use of Radioisotopes.

- Howard L. A., Radiation Biophysics, Prentice Hall Inc., 1974.
- Knoll G.E., Radiation detection and measurement, John Wiley and sons, 1979.