SRM UNIVERSITY
(Under section 3 of UGC Act 1956)

Center for Environmental Nuclear Research
Directorate of Research
SRM University, Kattankulathur
Chennai- 603 203

Ph. D. SYLLABUS

Contents

Course Code	Category	Course Name	L	T	P	C
BT839	**P**	**Radionuclide Transport Models in Aquatic Ecosystem**	3	0	0	3

PURPOSE

There is a need to understand the transport of radionuclides and heavy metals in aquatic ecosystem of small medium and large sized reservoirs for which this radionuclide transport model in aquatic ecosystem will be helpful.

INSTRUCTIONAL OBJECTIVE

In this course the student will able to

1. To understand the radionuclide transport models in aquatic ecosystem the student must know about the process and sources of radiological assessment.
2. It helps in the determination of standards for controlling exposure to radionuclides in the environment.
3. Aquatic food chain pathways will help to understand the transport mechanism of radionuclides in the environment.

Unit- 1: The Radiological Assessment Process and sources. 9

Introduction, Source Term, Environmental Transport, Exposure Factors, Dose conversions, Risk Coefficients, Uncertainty Analysis, Releases of Radionuclides by human activities, Leaching, Uranium Mining, Uranium Conversion, Uranium Enrichment, Weapon Component and Fuel Fabrication , Reactors.

Unit – 2: Surface Water Transport of Radionuclides 9

Basic Transport and Fate Mechanisms, Water movement, Sediment movement, BioturbationIntermedia Transfer, Degradation & Decay of Radionuclides, Transformation of Radionuclides, Transport Models - Coastal Waters and Oceans, Lakes, Sediment Effects, Numerical Modeling

Unit - 3: Aquatic Food Chain Pathways for Transport of Radionuclides.10

Aquatic Ecosystem Classification, Conceptual Model for an Aquatic Environment, Radionuclide Uptake and Concentration Factors, Bioconcentration Factors in Screening-Level Risk Estimations, Bioaccumulation Factors in Estimating Exposure, Bioaccumulation under Nonequilibrium Conditions. Food Web Structure, Population Dynamics and Biomass Distributions, Spatial and Temporal Radionuclide Ingestion Rates, Radionuclide Transport and Distribution

Unit – 4: Radionuclide's Transfer In Fresh Water Ecosystem 8

Transfer by wash-off from watersheds, Physical processes in freshwater ecosystems, Adhesion of suspended matter to the external plant surface, Distribution of radionuclides between solid and liquid phases in freshwaters, Transfers to fresh water biota.

Unit – 5: Model Validation 9

Validation Process, Model Composition, Model Performance, Calibration, Testing of Model Performance Bias, Measures of Scatter, Correlation and Regression, Visual Display of Information. Reasons for Poor Model Performance.

Total Contact Hours-45

Reference Book:

1. Radiological Risk Assessment & Environmental Analysis, Edited by John E. Till, Helen A. Grogan, Oxford University Press, New York.
2. Sediment Distribution Coefficient and concentration factors for Biota in Marine Environment. IAEA Report Series No. 422.
3. Modelling Radiation Exposure and radionuclide's transfer for non - human Species. IAEA Report of EMRAS Programme.
4. Quantification of Radionuclide's transfer in Terrestrial Fresh Water Environment for Radiological Assessment, IAEA Technical Document 1616.

Course Code	Category	Course Name	L	T	P	C
BT840	**P**	**Environmental Sampling & Analysis**	3	0	0	3

PURPOSE

- To make the student understand the different sample collection methods and the preparation of heavy metals for analysis.
- To know how to determine the gross alpha, beta and gamma rays.
- To familiarise about the principles of different radiation detectors.

INSTRUCTIONAL OBJECTIVE

In this course the student will able to

1. To provide an overview of the techniques commonly used at present for taking many different kinds of environmental samples.
2. To know the principle involved in the quality control of the analysis involved in heavy metal and radionuclides.
3. To study differentmethods for the detection and measurements of Radiation.

Unit – 1: Introduction to Environmental sampling 6

Introduction, Scope of Environmental Sampling, Environmental Sampling Design, Environmental Sampling Approaches (Judgmental Sampling, Simple Random Sampling, Stratified Random Sampling, Systematic Sampling), Various techniques for environmental sampling, Techniques for Sampling Various Media (Water, Soil, Sediment, Hazardous Waste, Biological Sampling & Air). Sample Preservation and Storage.

Unit – 2: Sample Collection & Preparation for Heavy Metals 7

Types of Samples, Preparation for Sample Collection, Errors Introduced during Sampling, Waste Disposal in the Field, Automatic Samplers, Special Sampling Procedures for Different Matrices, Acid Digestion & Microwave digestion for metals.

Unit – 3: Heavy metal analysis 10

Spectroscopy methods for determination of heavy metals, fundamentals of spectroscopy, Molecular spectrophotometer, Atomic Absorption Spectrometry(AAS) - working Principle, components, calibration, interferences, quality control. Inductively Coupled Plasma Atomic Emission Spectroscopy (ICPMS) - General characterises, instrumentation, interferences, Calibration and analysis. Quality control in metal analysis.

Unit – 4: Radiochemical analysis 10

Radiochemical Methodologies for the Determination of Gross Alpha, Gross beta and Gamma Rays. Radiochemical separation for the determination of Polonium-210, Radium- 226 and Radium-228 and Lead -210 in environmental matrix.

Unit – 5: Radiation detection and measurements 12

Radiation interactions, Counting statics and Error prediction, Properties of Radiation detectors, Alpha counters (Proportional counters), Geiger Muller counter for detection of Beta rays. PMT tubes and Photodiodes in various counters, Scintillation detectors for Radiation spectroscopy, Background and detector shielding.

Reference Books:

1. Radiation Detection and Measurements by Glenn F. Knoll, John Wiley and Sons Inc., New York
2. Environmental Sampling and Analysis for Metals, by Maria Csuros and CsabaCsuros, Lewis Publishers, A CRC Press Company, Washington DC.
3. Fundamentals of Environmental Sampling and Analysis by C.C. Zhang, Wiley – Interscience, John Wiley and Sons Inc., New York.

Course Code	Category	Course Name	L	T	P	C
BT841	P	Geochemistry & Hydrodynamic Modelling in Aquatic Ecosystem	3	0	0	3

PURPOSE

- To understand the role of geochemistry in advanced geothermo dynamics
- To study the transport mechanism of contaminants.
- To determine the biologically and chemically mediated transformation during the transport of contaminants.

INSTRUCTIONAL OBJECTIVE

In this course the student will able to

1. To understand the interaction between subsurface components with chemical contaminants.
2. To know different transformation and transport methods of contaminants.

Unit -1:Geochemistry Aspects 7

Characterization of the Subsurface Environment- Solid Phase, Liquid Phase and Gaseous Phase, Aquifers, Thermodynamics and Equilibrium (Enthalpy, Entropy, and the Lawsof Thermodynamics, Equilibrium, Kinetic Considerations and ReactionRate Laws)-Weathering, Adsorption.

Unit – 2:Contaminant Partitioning in the Subsurface 5

Sorption, Retention, and Releaseof Contaminants- Surface Properties of Adsorbents, Quantifying Adsorption, Kinetics, Adsorption of Ionic and Non-Ionic Contaminants, Non - adsorptive Retention of Contaminants, Reversible and Irreversible Retention.

Unit – 3:Transport of Contaminants. 12

Transport of Passive Contaminants-Advection, Dispersion, and Molecular Diffusion, Preferential Transport, Non-Fickian Transport.Transport of Reactive Contaminants - Contaminant Sorption, Colloids and Sorption on Colloids, Dissolving and Precipitating Contaminants, Transport of Immiscible Liquids&Runoff.

Unit – 4: Transformations of Contaminants 12

Abiotic Contaminant Transformations in Subsurface Water and Natural Subsurface Water, Factors Affecting Contaminant, Transformations.Abiotic Transformation at the Solid-Liquid Interface – Catalysis, Surface-Induced Transformationof Organic& Inorganic Contaminants.Biologically mediated Transformations- Subsurface Microbial Populations, Biotransformation of Organic& Inorganic Contaminants.

Unit – 5: Environmental Transport Processesand Modelling Tools 9

Diffusive transport- steady state, unsteady state and multiphase conditions, dispersive &advective transport, Interphase mass transport-two-film theory. Adsorption and desorption, settling and re-suspension, volatilization and absorption, bio - uptake.

Software for developing mathematical models- spread sheet-based software, equation solver-based software, anddynamic simulation-based software. Modelling examples – Radionucleotide in lake sediment,

Reference Books :

1. Contaminant Geochemistry- Interactions and Transporting the Subsurface Environment by Brian Berkowitz, IshaiDror, Bruno Yaron, Published by Springer, (Heidelberg,2008)

2. Modelling Toolsfor EnvironmentalEngineersand Scientists, by NirmalaKhandan, N.Published by CRC Press LLC (New york).

3. Modelling in transport phenomena- A conceptual approach, by ISMAIL TOSUN Publisher- Elsevier (London-2002)

4. Theoretical ChemicalEngineering - Modelling and Simulation by Christo Boyadjiev published by Springer-Verlag Berlin Heidelberg, 2010.

5. Chemical and IsotopicGroundwater Hydrology (Third Edition) by Emanuel Mazor, Published by Marcel Dekker, Inc., (New York, 2004)

Course Code	Category	Course Name	L	T	P	C
BT842	P	Processing and Analysis of Contaminant in Food Samples	3	0	0	3

PURPOSE

- Processing of food samples is the first step for analysing the chemical contaminant in the food samples. The different instruments which are used to process the food samples with no cross contamination for detection in the ultra trace element.
- Analysing the chemical contaminant in food samples by using advanced techniques will help in the detection of trace element.
- Calculation and conversion of radionuclide elements and other heavy metals will help in reporting the trace element contaminant to the public.

INSTRUCTIONAL OBJECTIVE

In this course the student will able to

1. Study the different advanced instruments used for processing and analysing for understanding the principles and mechanism of instruments.
2. Acquiring the working knowledge of laboratory cleanliness and chemical analysis of food samples.
3. Learn the calculation, conversion and reporting of trace element/nuclides in the food samples to the public.

Unit I: Sample processing and storage 9

Rinsing of samples, Homogenization of food samples, Processing of tissue sample, Equipment's for processing: freeze dryer, tray dryer, muffle furnace, hot air oven, Food Blenders, Food Processors, Rotor Mills, Mortar, Grinders, Cryogenic Mills; Sample storage

Unit II:Analytical instruments for measuring contaminants in diet samples 9

Inductively Coupled Plasma Mass Spectrometry (ICP –MS), Neutron Activation Analysis (NAA), gamma spectrometry, alpha spectrometry; beta counters, alpha counters; Atomic Absorption Spectrometry (AAS)

Unit III: Contamination Control 9

Laboratory Cleanliness – Types of Clean rooms and clean benches, Importance of clean room for quantification of trace elements, Decontamination of laboratory wares and equipment, Methods to prevent cross contamination materials.

Unit IV: Radiochemical analysis 9

Acid digestion method, alkali-fusion digestion method, Microwave assisted acid digestion method, extraction chromatography, electro-deposition and precipitation method, Tracers, carriers and radiochemical recovery monitoring.

Unit V: Calculation and Reportingof Elements/Nuclide concentration and Effective Dose 9

Conversion and reporting of contaminant levels to daily dietary intakes – Total diet studies, duplicate diet studies, Duplicate portion studies; Dose conversion; Conversion of daily dietary intake per kilogram of body weight; Calculation of extreme intakes,

Reference:

1. Elemental Analysis Manual (EAM), Food and Drug Administration (FDA), 2008.
2. Handbook of radioactive contamination and decontamination by Jan Severa, JaromírBár by Elsevier scientific publishing company, 1991.
3. WHO – Guidelines for the study dietary intakes of chemical contaminants, 1985

Course Code	Category	Course Name	L	T	P	C
BT843	P	Radiation Biology	3	0	0	3

PURPOSE

- To know the applications of dose concepts in radiation biology dosimetry.
- To determine the toxicity of heavy metal sand radionuclides on living organisms
- To study the radiation induced biological effects.

INSTRUCTIONAL OBJECTIVE

In this course the student will able to

1. To teach the students about the various radiation sensitizers and protectors
2. To understand the types of DNA damage by heavy metals, Radionuclides and radiation.
3. To study the techniques involved in the cytogenetic analysis of DNA damage.

Unit – 1: Concepts in radiation biology 9

Physics and chemistry of radiation interactions with matter, Types of ionizing radiation, Particulate radiations, Linear energy transfer, Radiation dose and units, Principles of radiation dosimetry, Direct and indirect effects, Application Of Dose Concepts In Biological Dosimetry,

Unit - 2: Molecular and Cellular Radiobiology 9

Radiation lesions in DNA, Major types of DNA repair, Damage recognition and signalling consequences of unrepaired DNA damage, chromosome damage, Radiobiological definition of cell death, Survival curves and models, Cell cycle effects, Relative biological effectiveness (RBE), Cellular repair exemplified in survival curves, Cellular hyper-radiosensitivity (HRS) and induced repair (IRR), Other molecular targets: bystander (epigenetic) effects, Radiation sensitizers, Radiation protectors.

Unit - 3: Toxicity of Heavy Metals and Radionuclide. 9

Toxicytosis, Types of Toxic Effects: Acute Effects, Chronic Effects, Lethal Effects, Sub - lethal Effects . TWO D'S (Dose and Duration) LD50 (Lethal Dose 50), Classification of Toxic Substances, Metal Toxicity, Toxic Effects of Selected Representative Metals, Toxicity of Selected Transition Metals

Unit – 4: Radiation Induced Biological Effects. 9

Radiation Effects on DNA (review of DNA structure, type of damage causedby ionizing radiation, DNA repair mechanisms). Genetic Effects of Radiation (chromosome and

chromatid aberrations,radiation induced mutations, nature of radiogenic lesions in the genome). Radiation-induced changes in signal transduction.

Unit – 5: Cytogenetic Analysis Methods 9

Dicentric& Translocation analysis - Culturing, fixation, staining and analysis. Painting the chromosomes, Scoring criteria, Premature Chromosome Condensation (PCC) Analysis-culturing, fixation, staining, analysis. Micronucleus assay, Comet assay and FISH .

Reference Books

1. Cytogenetic analysis for Radiation Dose assessment – International Atomic Agency - Technical report Series 405.
2. Radiation Biology International Atomic Agency - Technical report Series number 42
3. Radiation Biology Volume I & II. Edited by Alexander – Hollanender, Tata Mcgraw-Hill Publishers,

Course Code	Category	Course Name	L	T	P	C
BT844	**P**	**FOOD SAMPLING METHODS FOR RADIONUCLIDES AND HEAVY METALS**	3	0	0	3

PURPOSE

- The guidelines of risk assessment of chemical contaminant in the diet will help in conducting the food sampling method.
- Conducting the new and old methods will help in improving the assessments of chemical contaminants in the food samples for consuming in different age groups.
- Selection of different age groups will help in improving the statistical analysis of the samples.

INSTRUCTIONAL OBJECTIVE

In this course the student will able to

1. Understand the various sampling methods.
2. Importance of Total diet study and Duplicate diet study will help in monitoring the food sampling methods.
3. Learn the survey, collection of food items and packing, preparation of charts and representative samples will help in quality assurance of the method.

Unit - I:Risk assessmentof contaminants in Diet 5

Guidelines of conducting intake studies of heavy metal and radionuclides. Selection of a sample population for study. Various sampling methods – individual food intake assessment and population food intake assessment.

Unit- II:Total Diet Study (TDS or Market Basket) 5

Sampling selection; sample collection and transportation; Advantage and disadvantages of the TDS; Total Diet analytical approach - composite approach, individual food approach; total diet laboratory and kitchen

Unit- III: Duplicate diet studies: 10

Selective studies of individual foods; sampling selection; advantage and disadvantage of selective analysis of individual foodstuffs; utilization of food consumption data and contaminants level in food;

Unit -IV: Quality Assurance 10

Selection of age dependent population groups; study period; concurrent development of related information; Preparation for study and analysis. Validity and precision of the study. Advantages and disadvantages of the method.

Unit -V: 15

Food consumption data – development of food list, development of preparation guides, development of a shopping list, selection of representative samples of food; heavy metal contamination in food and packing material; radionuclide pollutants in food; monitoring and surveillance of food

References:

- Mineral components in food by PiotrSzefer and Jerome O. Nriagu published by CRC press.
- WHO – Guidelines for the study of dietary intake of chemical contaminants.

Course Code	Category	Course Name	L	T	P	C
BT845	P	Environmental Toxicology	3	0	0	3

PURPOSE

- Environmental toxicology involves the studying of sources, pathways, transformations, and effects of chemicals that are harmful in the environment.
- The study of these harmful effects extends from individuals and populations of organisms to the ecosystem level.
- To specialize within the area of environmental monitoring of organic and inorganic chemical toxicants.

INSTRUCTIONAL OBJECTIVE

In this course the student will able to

1. Focus on fate and effects of pollutants, and how they are distributed in the environment (including air, water, soil and food chains) both on a local and a global scale.
2. Study the interaction between environmental toxicants and organisms, and how this impacts on populations and ecosystems.
3. Learn the methods of field work and/or experimental exposure studies in laboratory on individual organisms (in vivo).

Unit – 1: Concepts of Environmental Toxicology: 5

Study of environmental toxicology, Worldwide development in recent decades, environmental pollution and law, Importance of environmental toxicology, Assessment of toxicity, Toxicity at the molecular level (Carcinogenesis, Genotoxicity assays, Chromosome studies), Damage Process and action of Toxicants, Metabolism of Environmental Chemicals. Defence responses to toxicants.

Unit – 2: Toxicant Uptake, Route, Kinetics 10

Route of toxicant uptake (skin, lungs, gills, digestive system), Uptake at the tissue and cellular level, Toxicokinetics, Single-compartment model, Two-compartment model, Volume of distribution, Transporter-mediated transport, Lethal body burden (critical body residue).

Unit - 3: Methodological approaches & Factors 12

Concepts and principles for biological indicators, Tolerance and resistance to potentially toxic substances, Biological & biochemical markers, Community and higher level indicators: The ecological approach to toxicology, Modelling, Advantages, Limitations & pitfalls in the modelling for environmental toxicology. Biotic and Abiotic Factors affecting toxicity.

Unit – 4: Toxicology Chemicals and Ionising Radiation: 12

Properties and environmental behaviour of metals and metalloids, Analytical methods, temporal and spatial distribution of metals and metalloids in the environment (Pb, Cd, Cu, Ni, Se,Hg), Organotins, Metabolism of organics, Environmental mobility of organic compounds.

Introduction to Ionising Radiation, Effects of radiation at the molecular and cellular level, Assessment of risk from radiation, Ecological effects of radiation

Unit – 5: Risk assessment, Recovery & Rehabilitation 6

Basic components of a risk assessment, Use and Importance of ecological risk assessment, Frameworks for ecological risk assessment, Factors triggering risk assessment, Routes for recovery, Recent regulatory approaches to contaminated sites, Updating risk assessment

Reference Books

1. Fundamentals of Analytical Toxicology by Robert J Flanagan et al., John Wiley & Sons Ltd.
2. Environmental Toxicology, Edited by David A Wright and Pamela Welbourn, Cambridge University Press.