

35. FISHERIES RESOURCES MANAGEMENT

Unit 1: Fisheries Resources

Major fisheries resources of the world, global trends in production; Target and non-target fisheries resources of the Indian subcontinent and the EEZ; Distribution, composition, trends and dynamics of major exploited fishery resources in hill streams, rivers, reservoirs, lakes, lagoons, estuaries, territorial waters, oceanic waters, deep sea oceanic islands; Straddling/shared stocks and non-conventional resources; Sports, game and ornamental fisheries; Major commercially exploited stocks, their potentials, status, bionomics, methods of capture and yields; Issues related to capture fisheries; Endangered and threatened species, *in-situ* and *ex-situ* conservation; Fisheries and Biodiversity Acts; Juvenile fishing, destructive gears, by-catch and discards; Status and impact of exotic species, accidental introductions; Guidelines and policies for exotics.

Unit 2: Fishery Biology

Life history of economically important fish species; Food and feeding habits, methods of studying food and feeding habits; Reproductive biology, maturity stages, fecundity, ova diameter studies and breeding cycles; Length- weight relationships; Condition Factor, Gonado-Somatic Index; Age and growth studies - methods for determination of age, study of growth rates, direct and indirect methods; Taxonomy of major fish groups; Recruitment, growth and mortality of fish in natural water bodies; Different analytical and Holistic models for fish stock assessment, their advantages and disadvantages; Catch per unit effort, Concept of Maximum Sustainable Yield and Maximum Economic Yield; Application of remote sensing and Geographical Information System (GIS) in resource mapping and forecasting; Mechanisms, methods and status of fish yield data acquisition, storage, retrieval and processing for national estimates; Ecosystem-based fisheries management tools; Monitoring, control and surveillance (MCS) systems for major fisheries; Computer softwares in stock assessment; Use of Virtual Population Analysis and Predictive models.

Unit 3: Aquatic Environment

Various aquatic habitats and fish faunal compositions, trophic relationships, distribution and abundance; Fisheries oceanography and marine fisheries; Limnological parameters; Influence of environmental parameters on fish abundance, distribution, resource resilience; Impact of fishing, aquaculture, other anthropogenic activities on the environment and fish stock. Disaster management in fisheries; Methods for increasing productivity of water bodies (Use of thermal energy and deep sea water through artificial upwelling, Use of ranching, Artificial reefs, FADs and their uses); Habitat degradation and its impact on fisheries; Pollution of water bodies and its impact; Bioindicators and Bioremediation; Protected areas (sanctuaries, marine parks, biosphere reserves and Ramsar sites); Potential fishing zones.

Unit 4: Fisheries Management

Concepts and principles of fisheries management; Fisheries Acts and Legislations, revisions and amendments; Fisheries policies, instruments and mechanisms for inland, coastal and open ocean fisheries management; Management of riverine, reservoir and lacustrine fisheries; Management of marine fisheries; Modes of fisheries management - Open access, regulated, advisory; participatory, user rights; International fishery regulations, treaties and instruments; Input control measures such as access control, size, type, number and power of boats, duration of fishing; Output control measures such as Total Allowable Catch, Catch Quotas, Licensing, Technical control measures such as size limitations, closed fishing areas, closed seasons, size of nets and mesh size regulations, limited entry; Impediments to

fisheries governance; UNCLOS, FAO Code of Conduct for Responsible Fisheries; India's commitment to international treaties and resolutions.

Unit 5: Fishing Technology

Different types of craft and gear, their operation and their maintenance; Selectivity of fishing gears, by-catch reduction devices in trawls, turtle excluder devices; Use of modern techniques and equipment for fish finding and capturing.

Unit 6: Economics and Marketing

Supply, demand and price dynamics in the fisheries sector; domestic and export marketing of fish and fish products, trends, channels, mechanisms, regulations, trade and non-trade barriers, concerns and strategies; modern marketing methods and channels, cold chains, storage; value addition; domestic and international market demands; International regulations and practices affecting Indian fisheries trade; WTO and Indian fisheries scenario; Issues in branding and labelling; Quality concerns; Growth of domestic and exports markets; Market trends and diversification; Emerging consumer preferences and trade practices; Fisheries co-operatives; Institutional support for fisheries development.

Unit 7: Fisheries Livelihood

Relevance of capture fisheries in food, nutrition, employment, income and livelihood securities of fishers; Vulnerability of fishers to changes in resource availability, exploitation and utilization patterns; Marginalization of fishermen, small scale processors and traders due to changing scenarios of product diversification, markets and trade; Impact of dams, river linking, CRZ, Biodiversity Bill, protected/closed area, fishing bans, closed seasons, protected areas, mangroves, sanctuaries and parks on the fisher communities. Land and water body use issues in fisheries. Role of extension in fisheries, mechanisms and modes of extension and their impact on capture fisheries and fisher's livelihood, alternative livelihood options; Management of conflicts within sub-sectors in fisheries; Women in fisheries, status, role, impact, future; Vulnerability of fishers to natural disasters and coping mechanisms in disaster management.

36. FISH PROCESSING TECHNOLOGY

Unit 1: Craft Technology

Fishing crafts of the world; Principles of design and construction; Corrosion protection; Craft materials - wood, marine plywood, fibreglass, reinforced plastic, aluminium, steel, ferro-cement; Bio-deterioration and preventive measures; FAO classification of fishing vessels; Different types of fishing vessels in India; General arrangements of fishing vessels; Basic principles of fishing vessel design; Stability of fishing vessels - factors affecting stability; Powering of fishing boats; Deck machinery for trawlers, seiners, gill netters and liners; Winches- net haulers, line haulers, power blocks, special purpose winches; Engine installation- types of engines for fishing vessels, four stroke cycle, two stroke cycle; Selection of engine for fishing vessels; Transmission systems - Reduction/reverse gear boxes; Modern navigation equipment, navigation and fishing lights; Life saving devices - life jacket, life buoy, life raft, SART, EPIRB.

Unit 2: Gear Technology

Gear Materials - Netting yarns, natural fibres and their classification, origin, properties & preservation; Synthetic fibres- Classification, manufacture, identification and comparative properties; Construction of netting twines; designation of netting yarns and twine twist-coefficient; direction, yarn numbering system; Specification and characteristics of netting; Fishing accessories- Floats, buoys and sinkers, connectors and swivels, ground gear shear devices, hooks; Classification of fishing gear. Fishing gears used in India; Fish behaviour in relation to fishing techniques; Factors affecting fishing gear design; Fishing gear selectivity - Selectivity of trawls, gill nets and lines; Model testing of fishing gear - flume tank; Structure and operation of trawls; Otter boards - principles of operation, variation in design; Structure, design variation and operation of purse seines, gillnets and trammel nets, lines and traps. Electrical fishing; Harvesting machines; Selective fishing gear and practices: By catch and discards, By catch reduction devices (BRDs), Turtle excluder devices (TEDs); Fish aggregating devices.

Unit 3: Process Biochemistry

Major and minor constituents of fish, their distribution and function- moisture, proteins, lipids, carbohydrates, vitamins and minerals; Glycogen in fish and its functions; Structure, classification and constitution of proteins; Use of functional properties of proteins for developing fish products; Essential amino acids and limiting amino acids and their requirements; Post-mortem changes -rigor mortis, autolysis, auto-oxidation and their significance; antioxidant mechanisms; Biochemical and microbial spoilage of fish; Lipids in fish -their structure and classification; Enzymes in fish -their classification and mechanism of action; Vitamins in fish - vitamin deficiency diseases; Minerals and trace elements in fish; Toxins and toxic substances in fish, their bioaccumulation and biomagnification; Biogenic amines.

Unit 4: Fish Processing Technology

Factors affecting spoilage of fish; Principles of fish preservation; Preservation of fish by curing (drying, salting and smoking); Water content, water activity (aw) and storage stability; Onboard handling of fish; sanitary and phyto-sanitary requirements for maintenance of quality; grading of fish; Chilling and freezing of fish - principles of chilling and freezing, crystallisation, nucleation, crystal growth, methods of chilling, transportation and marketing of chilled fish, the application of freezing systems in fish processing; Changes in quality of chilled and frozen products during storage; Canning of fish and fish products- principles of canning, can materials, can shapes, process value calculation and spoilage of canned food; Modified atmosphere

packaging (MAP) of fish and fish products; Accelerated freeze drying (AFD); Surimi and fish-mince products- the surimi process; Fish muscle proteins; Newtonian and non-Newtonian fluids; Irradiation- Radiation sources, units, dose levels, radurization, radicidation, radurization; Effects of irradiation on protein, fat and vitamin; Packaging and transportation of fish and fishery products - temperature modeling and relationships in fish transportation; transportation containers; Safety and quality and spoilage of fish during transportation; Fishery products and by-products exported from India; Packaging- aim, purpose and objectives, packaging and transportation of fresh fish, cured fish, canned fish, frozen fish, freeze-dried fish, by-products and value-added products; Additives- classes of additives, preservatives, antimicrobial additives.

Unit 5: Microbiology, Quality Management and Certification

Roles of bacteria and moulds in fish preservation; Modification of intrinsic and extrinsic parameters for fish preservation; Spoilage of fresh fish, chilled fish and processed fish products; Micro-organisms in frozen, canned and dried products, and their control; Human pathogenic bacteria, virus, molds and parasites in fish and fishery products; Sources of contamination and control measures; Fish quality evaluation and different indices of quality; Quality management in seafood processing- Concepts of Total quality management, HACCP, practical aspects of planning and implementing HACCP systems; Hazards in sea foods; Risk assessment; National and international standards - ISO 9000 series, ISO 22000. Codex alimentarius, ICMSF; Food Safety and Standards Act of India 2006; Role of BIS and EIA; Traceability issues in international trade.

Unit 6: Fishery Engineering

Selection of site for fish processing plant, layout and design- Canning plant, fish meal plant, surimi plant, freezing plant; Ideal requirements for construction of cold storage; Different types of cold storage; Seafood waste management; Refrigeration engineering- fundamental principles of refrigeration, refrigeration cycle; Refrigerants definition, type of refrigerant and their properties; types of condensers, type of boilers, type of evaporators; Machinery for handling and processing fish- Debonner, filleting machine, freshness analysers.

Unit 7: Economics and Marketing

Fisheries enterprise management; Trends of domestic and export marketing of fish and fishery products, modern marketing methods and channels - supply chain management, cold chain facilities and infrastructure; Value-addition; Institutional support for fish harvest and post- harvest practices.

37. FISH NUTRITION

Unit 1. Principles of Fish Nutrition

Nutrients, sources, structure, classification, biosynthesis. Metabolism of proteins, lipids, carbohydrates, nucleic acids, vitamins and minerals. Essential amino acids, functions and deficiency symptoms, Vitamins and minerals, their role in fish nutrition, deficiency symptoms, Vitamin and mineral requirements in herbivores, carnivores, major fresh water, marine and brackishwater cultured species. Metabolic pathways of proteins, lipids and carbohydrates, Sparing action, P:E ratio, Assessing nutritional requirements of larvae, fingerlings, young fish, growout, fattening, reproductive energy needs, basic fish bioenergetics, energy partitioning, energy budget.

Unit 2. Nutritional Physiology

Morphology, anatomy and physiology of the digestive systems of various types of fish such as herbivores, planktivores, omnivores, carnivores, detritivores, mixed diet. Nutrient digestion and digestive processes. Control and regulation of digestion. Factors affecting feed intake, digestion, absorption, assimilation. Microbial digestion; Digestibility and factors affecting. Digestive enzymes in fish; Gastric, pancreatic and intestinal secretions and role of microorganisms in digestion. Transport of nutrients in the body, storage, conversion and utilization. Role of liver and muscles in fat and glycogen storage and release. Digestive hormones, nutrient regulation of endocrine functions, role of nutrition in reproduction, transport and use of fat and protein for reproductive purposes.

Unit 3. Feed Formulation, Feed Technology and Feeding Management

Principles of feed formulation, feed ingredients, international coding of feed ingredients, evaluation of ingredient quality, conventional unconventional and novel ingredients, feed additives and feed binders, antinutritional factors and their prevention; Methods of feed formulation, feed processing units and processes, various feed types such as moist, semi-moist, dry, crumble, pellet, sinking, slow sinking, floating, microbound, microencapsulated, micro-coated, high energy. Fortification of micronutrients in larval and broodstock diet, exogenous enzymes in fish feed, Feed storage, packaging and prevention of spoilage.

Unit 4. Nutrition and Fish Health

Nutrients and their effects on fish health. Nutritional diseases, antinutritional factors, nutraceuticals for fish health, nutrients and immunity, nutrients and flesh quality, hyper and hypo vitaminosis. Mycotoxins in fish feed, nutritional imbalances. Dietary lipid and stress tolerance in fish larvae. Myco-toxin in fish feed. Phytase and phytate in feed ingredients. Anti-nutritional factors in feed ingredients. Anti-nutrients and metabolism. Nutrient deficiency diseases.

Unit 5: Nutrigenomics

Nutritionally important genes, gene regulation by lipids and carbohydrates, metabolic control analysis, transcriptomics, proteomics and metabolomics, nutrient-gene interaction and expression, reverse transcription and CDNA synthesis, genetic control of metabolic pathways, functional food aids in prevention of human health disorders.

38. FISH HEALTH

Unit 1. Introduction to Fish Health and Pathology

Definition of health and disease in fish. Predisposing factors, biotic and abiotic factors, Stress and general adaptation syndrome. Role of physical (injuries, health, cold) chemical (pH, salinity, toxins, ammonia, nitrogenous waste, endogenous chemical metabolites, free radicals, oxidants) soil and water parameters in fish health. Host-pathogen-environment interaction, toxins and nutritional factors in disease process.

General pathology- degeneration, necrosis, apoptosis, inflammation, classification of inflammation, biology of inflammatory phenomenon, signs and pathology of inflammation, chemical mediators release from inflamed cells and tissues involved and their function, immunoglobulins, memory system, antigens, haptens and carriers, monoclonal antibodies, lymphoid organs, B lymphocytes, T lymphocytes, subsets and nature of receptors, macrophages, RES, cell-mediated immune responses, complement system, MHC, autoimmunity, immunological tolerances, macrophages, fibroblasts, myofibroblasts, endothelial cells, extracellular matrix and growth factors in healing and defense.

Unit 2. Diseases of Fish

Major bacterial, viral, fungal, parasitic, non-infectious diseases of fish and shellfish in aquaculture systems. Cell lines and their use in virus isolation, bacterial metabolism, bacterial toxins and pathogenesis, diverse bacterial species infection fish and shellfish, evolution and classification of viruses, virus-host relationship, replication of virus, molecular pathogenesis, viral vaccines, new antiviral compounds, virus and gene therapy, RNA and DNA viruses in fish and shell fish and their antigenicity, cultivation, pathogenesis, diagnosis, epidemiology, diagnosis, treatment, prophylaxis and immunity. Patho-epizootiology, treatment and control of mycotoxicosis, EUS, saprolegniasis and other fungal pathogens of fish and shellfish, diseases caused by trematodes, cestodes, nematodes, crustaceans, acanthocephalans, protozoans, algal blooms, microbial toxicity.

Unit 3. Aquatic Environment and Fish Health:

Kinetics of microbial population in the aquatic environment, bio-films, microbial interactions. Water pollution-microbial changes induced by inorganic and organic pollutants, industrial effluents, domestic sewage and their effects on fish and shellfish. Biological pollution-algal blooms and their effect on fish production, biological and chemical control of algal bloom. Metals as pollutants-accumulation of mercury, cadmium, lead, etc. in fishes.

Unit 4. Disease Diagnosis

Principles of disease diagnosis, conventional and rapid diagnostic methods, bacterial, viral, fungal, parasitic, non-infectious diseases of fish and shellfish. Clinical pathology and diagnosis of disease. Clinical pathology and diagnosis of disease. Clinical laboratory examination of various biomaterials from fish and shellfish, normal picture of blood, serum enzymology, disorders and their interpretations, examination of skin scrapings, gill, internal organs, other tissues, various immunological, serological and molecular diagnosis using PCR, RT-PCR, and real time PCR and the principles involved in ELISA. Primer designing for probes.

Unit 5. Defence Systems and Tumours.

Immune systems in fish and shellfish. Innate and acquired immunity, non specific immunity, Antibody and cell mediated immunity in fish, immunity in shellfish, immune complex, memory function and immunological tolerance. Structure, types of antibodies, antigen-antibody reaction, phagocyte systems, TOLL link receptors, cell mediated immune response and its components, abnormalities in cell growthaplasia, hypoplasia, atrophy, metaplasia dysplasia. Tumours and neoplasm growth, etiology, classification, morphology and behaviour, structure of tumour cell, tumour immunology, tissue responses to tumours, pathological features of neoplasms.

Unit 6. Disease Prevention and Control:

Disease prophylaxis and therapeutics, use of chemicals, antibiotics, conventional vaccines, prebiotics and probiotics, biochemical applications in disease control, DNA and RNA vaccines, recombinant vaccines, use of RNA interference, SPF and SPR brood stock, certification, surveillance and reporting, biosecurity. Disease control through environmental management.

39. FISH GENETICS & BREEDING

Unit 1. Principles of Fish Genetics and Breeding

Mendel an inheritance, genetic variation, chromosome theory, genetic basis for sex determination and sex linked genes in fish, Gametogenesis, linkage and crossing over, DNA as a genetic material, gene code and protein synthesis, DNA replication, DNA and plasmid isolation, chromosome manipulation, ploidy induction, sex reversal, gynogenesis, natural and induced.

Unit 2. Population and Quantitative Genetics

Genetics of population, changes in allelic and genotypic frequency, effective population size, inbreeding and coefficients, Fitness, qualitative and quantitative traits, components of variance, additive and non-additive variance, Genetic variability and differentiation, Genetic similarity and Nei's genetic distance, Genetic bottle neck and mutation drift equilibrium, null alleles, population genomics, outlier loci and adaptive variation in trait-related genes.

Unit 3: Genetic Tools for Aquaculture Application

DNA markers in stock identification: Allzymes, RFLP, RAPD, AFLP, Microsatellites, ESTs, SNPs, Type I and II markers, mtDNA and nuclear DNA markers, Real-time PCR and EST markers, Lab assays for markers. Next generation sequencing, Applications for species identification, hybridization, stock identification, genetic diversity and conservation, Parentage, Linkage and QLT mapping, microarray genes, karyotyping and chromosome banding. Transgenics, GMO and biosafety regulations, designer ornamental fish, transgenic containment.

Unit 4: Breeding of Fish and Shellfish

Genetic basis for Selection of fish for breeding, QLT and marker assisted selection, sire and dam evaluation, selection for threshold characters, inbreeding effects, cross breeding and hybridization, selection and mating designs for select traits, selection for disease resistance, monosex, cryopreservation of gametes. Endocrine control of reproduction in fish and shellfish, synchronization of spawning, broodstock development and management, use of happa, care of fertilized eggs, assessing stripping, induced normality and mortality. Live feed development for larvae, larval feeding and maintenance, packaging and transport of shrimp post larvae, fish and fingerlings, eyed larvae or spat of molluscs. Nursery systems and their operation.

Unit 5: Conservation, bioinformatics

Breeding strategies for threatened species for restocking and live gene bank (LGB), *in situ* and *ex situ* conservation, pluripotent embryonic stem (ES) cells and germ cells, primary and established cell line cultures, cell cloning, cell hybridization, hybridoma technology, data mining tools, submission of DNA sequences, GenBank sequence database, Genome diagnostics, genome and transcriptome analysis, protein information resources, EST database, phylogenetic analysis, microarray informatics.

40. AGRICULTURAL CHEMICALS

Unit 1: General chemistry

Surface chemistry, pH, Buffer solutions; Redox reactions, Chemical kinetics, Stereochemistry and chirality, diastereoisomerism, tautomerism, atropisomerism, asymmetric synthesis, nomenclature of organic molecules, displacement, elimination, addition, rearrangement, SN1 and SN2 reactions, reaction involving free radicals, and carbene intermediates, Organic reagents and catalysts in organic synthesis, Beckmann, Claisen condensation, Hofmann-Löffler-Freytag reaction, Petrucci-Buchi reaction, Curtius, Michael, Kolbe, Arndt-Eistert and Wittig reaction. Reformatsky reaction, Barton reaction, Umpolung reaction, Norrish Type I & II reactions.

Unit 2: Chromatography and spectroscopic techniques

Basic principles and application of chromatography; column, paper, thin layer, and ion exchange chromatography; gas liquid chromatography (GLC); high performance liquid chromatography (HPLC); UV, FT-IR; NMR and mass spectroscopy; GC-MS and LC-MS techniques and their applications.

Unit 3: Chemistry of natural products

Extraction of natural products; Classification, structure, chemistry, properties and function of carbohydrates, proteins, amino acids, enzymes, nucleic acids, vitamins, lipids, and polymers. Chemistry of terpenoids, alkaloids, phenolics, plant pigments, steroidal and triterpenic saponins and saponin; juvenile and moulting hormones; Plant derived nutraceuticals; Chemistry of natural antioxidants and food colorants and their application in human and crop health. Biosynthetic pathways of natural products.

Unit 4 : Naturally occurring insecticides:

Natural pyrethroids, nicotine, rotenone, neem and karanj based botanical pesticides; microbial macrolides (avermectins and milbemycins), agricultural antibiotics, semiochemicals; insect pheromones-types and uses, insect hormones, insect growth regulators; Plant hormones, phytoalexins, essential oils and their pest control properties; advantages and limitations of natural pesticides; juvenile hormones, juvenile hormone mimics and anti-JH; chemosterilants, insect antifeedants, insect attractants and repellents; microbial pesticides; Application of plant biotechnology in crop protection, herbicide tolerant and insect resistant transgenic plants.

Unit 5: Synthetic insecticides, fungicides, nematocides and rodenticides

History, scope and principles of chemical insect control; Insecticides and their classification Chemistry of major groups of insecticides (organo-chlorine, organo-phosphorus, organo-carbamates, synthetic pyrethroids, neonicotinoids), fungicides (inorganics, dithiocarbamates, OP's, phenols, quinines, carboxamides, azoles, methoxyacrylates), rodenticides, Insect growth regulators; Chitin synthesis inhibitors, insecticide synergists, fumigants. Mode of action of different groups of insecticides, fungicides and nematocides.

Unit 6: Herbicides and plant growth regulators

Physical, chemical and toxicological properties of different groups of herbicides (phenoxyacids, carbamates, amides, triazines, phenyl ureas, dinitroanilines, bipyridiliums, sulfonyl ureas), Herbicide safeners, Plant growth regulators – auxins, gibberellins, cytokinins, ethylene, abscisic acid; Brassinolides; Mode of action of different groups of herbicides.

Unit 7: Agrochemical formulations

Basic concepts of pesticide formulation - classification, solid and liquid formulations; preparation, properties, uses; controlled release formulations; Formulants - carriers/diluents, surfactants, encapsulants, binders, anti-oxidants, stabilizers; Application - devices and quality of deposits; Types of spray appliances, seed treatment and dressing; nanotechnology in crop protection, Tools to develop and measure nanoparticles.

Unit 8: Pesticide residues and their dynamics in the environment

Pesticide residues- concepts and toxicological significance; pesticide dynamics in agro ecosystem, biotic and abiotic transformations affecting fate of pesticides. Experimental design, sampling, principles of extraction and clean-up from different substrates; Application of ELISA and radiotracer techniques in pesticide residue analysis; new cleanup techniques, QUECHERS, ASE (Accelerated solvent extraction); Multi-residue methods; Bound and conjugated residues; Method validation - linearity, LOD and LOQ, microbial and photochemical degradation, adsorption/ desorption, leaching in soil.

Unit 9: Agrochemicals – regulation and quality control

Production, consumption and trade statistics of pesticides and fertilizers; banned and restricted pesticides, registration and quality control of insecticides; Laws, Acts and Rules governing registration and regulations of agrochemical production and use; key provisions of the Insecticides Act (1968), Environmental Protection Act (1986). Pesticide Management Bill, EPA, Food Safety and Standards Act, WHO, FAO, CODEX and national/international guidelines; Quality Control, Sanitary / phyto-sanitary issues in relation to food safety, good laboratory practices, Accreditation certificate, Pesticide stewardship

Unit 10: Natural Resource Management

Soil, plant and microbial biodiversity, Characteristics and classification of natural resources; Major soil groups of India their characteristics, management strategies for natural resources; integrated pest and pesticide management; Essential plant nutrients (major, secondary and micro), organic manures (farm yard, compost, sewage sludge, green manure, biogas slurries, etc); production and manufacture and uses of various nitrogenous, phosphatic, potassic and complex fertilizers and fertilizer mixtures, liquid fertilizers, biofertilizers, integrated plant nutrient systems; **benefits, disadvantages and environmental toxicity.** Nitrification inhibitors to enhance nitrogen use efficiency, Hydrogels and their application in agriculture, soil conditioners and amendments, **toxicity issues.**

Unit 11: Environment pollution: Implications and remediation

Problems of pesticide hazards and environmental pollution; Adverse effects of pesticides on micro-flora, fauna and on other non-target organisms; Effect of pesticide on soil health, persistent organic pollutants, and their effect on ecosystem. Adverse effect of industrial effluent on the soil and aquatic environment; disposal of obsolete and outdated pesticides; physical, chemical and microbial decontamination and detoxification of pesticides. **Agrochemicals and homeland security, misuse of agrochemicals (pesticides and fertilizers), hazard mitigation plans or strategies, analytical and bioassay techniques to assess off-farm migration of agrochemicals into natural waters, ozone depletion causing agrochemicals**

Unit 12: Data analysis

Methods of statistical analysis as applied to agricultural data – standard deviation, standard error, accuracy and precision, analysis of variance (ANOVA), correlation and regression; Hest, chi-square (X²), F test., Probit analysis.