**Department of Marine Living Resources**

 **Andhra University**

 **Revised Syllabus with effect from 2019-2020 admitted batch**

 M.Sc. Marine Biology & Fisheries, III Semester

 Paper 3.1: Fishing Technology & Fishery Management

Evolution of Fishing craft: boat types and their classification. Boats used in India.

Evolution of Fishing gear: Classification of fishing gear; Descriptions of hand-line, troll line and pole line. Description, design and fabrication of trawl nets, purse-seine and gill nets.

Pelagic, demersal and deep sea fishing, By catch reduction in trawl fishing, Turtle Excluder Devices.

Stock assessment: Collection of basic data; stock size, yield models (Methods).

Fishing regulations: Potential fishing zones, code of conduct for responsible fishing, duration of fishing output control measures, Total available 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.

The effects of exploitation: The over-fishing problem, Management techniques.

Modern navigation equipment life saving devices (Buoy, jacket, raft, SART, EPIRB, SCUBA).

**References:**

 **Aitikin A** Fish handling & processing

 **Baranov F I** Selected works on fishing gear

 **Brandt AV** Fish catching methods of the world

 **Cushing DH** Marine ecology & fisheries

 **Sanisburry JC** Commercial fishing methods

 Practicals:

1. Fishing Crafts: Catamaran, Masula boat, Dugout Canoes, Rampani and Trawler

2. Fishing Gears: Gill net, Purse Seine, Cast net, Ottor Trawl net, Beam trawl net, Hook & Line,

 Traps, Stake net and Dip net.

3Mess size in different fishing gears

4. Fishing gear knots: Square knot, Clove Hitch knot, Fisherman’s knot

5. Fishing Gear Material: Nylon, Terylene, Polyethylene, Polypropylene

6. Other Fishing devices: Floats, Sinkers, buoy, raft

7. Length-frequency analysis of marine fishery resources

8. Gear selectivity

9. MSY-Stock recruitment relationship.

 Paper 3.2: Aquaculture

 Significance of aquaculture, Global aquaculture scenario, production, Consumption and emerging trends.

 Criteria for selection of species for aquaculture.

 Technical and non-technical considerations in site selection.

 Design & construction of ponds, cages, pens, racks, rafts and long lines.

 Selection of material and equipment for aquaculture.

 Monoculture, polyculture, integrated and multitrophic aquaculture, Sewage fed farming, Recirculating Aquaculture Systems, organic farming, Biofloc system.

 Seed production through finfish and shellfish hatcheries.

 Culture practices of finfish (carps, mullets, milk fish, Pompano and cobia), crustaceans (shrimps and prawns), mollusks (abalone, mussels, edible oysters and cephalopods) and seaweeds.

 Viral, bacterial, fungal, parasitic, nutritional and environmental diseases of cultured fish

 and shellfish.

**References:**

 **Bardach JE et al** Aquaculture Wiley Interscience

 **Pillay & Dill** Advances in aquaculture FAO

 **Stickney RR** Principles of Warmwater aquaculture Wiley Interscience

 **Pillay TVR** Aquaculture: principles & practices FNB

 **Alilis AE** Fish and shellfish pathology Academic Press

 **Milne PH** Fish & shellfish farming in coastal waters FNB

 **Stickney RR** Principles of aquaculture Wiley & sons

 **Imai T** Aquaculture in shallow seas Amerind

 Practicals:

1. Design and construction of shrimp hatchery
2. Design and construction of fish farm
3. Aquaculture equipment:

Nets (Cast net, Scissor net), Sand filters, FRP-tanks, Harvesting buckets, Secchi disc,

PH meter, Salinometer, Spectrophotometer)

1. General calculations in Aquaculture management:

Survival Rate, Specific growth rate, Quantifying the seed for transport, Calculation of amount of soil required for construction of dike.

 5. Identification of Cultivable finfish, Shellfish and Sea weeds*.*

 6. Identification of Predators, weed fishes, aquatic weeds and larval forms.

 7. Fertilizers used in aquaculture.

 Paper 3.3: Fish Nutrition & Feed Technology

Fish nutrition: principles of fish nutrition and terminologies, nutritional requirements of cultivable finfish and shellfish: larvae, juveniles and adults

Nutritional biochemistry: classification, structure, quality evaluation of proteins, lipids, carbohydrates, vitamins and minerals.

Nutritional bioenergetics: fish as an open thermodynamic system, energy requirement of fishes, digestible energy , nitrogen balance index , protein sparing effect, optimal foraging theory, mathematical modeling of ingestion, metabolic rate, energy budgets, reproductive energetics in fish and shellfish.

Nutritional pathology: Anti nutritional factors and anti metabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms.

Feed Resources: Nutritional value of feed ingredients, feed additives (attractants, growth stimulants and probiotics and binders), high energy feeds, isocaloric diets.

Feed Manufacture: Feed formulation and processing, On-farm feed manufacture, Commercial feed manufacture, Feed storage

Feeding Practices: Supplementary feed–theory and practice, complete diet - theory and practice, Feeding methods and scheduling, ration size, feed performance.

**References:**

**S. Athithan** Practical book on fish nutrition and feed technology

**Cyrino EP & bureau D & Kapoor BG** Feeding & Digestive Functions in fishes Science Publ.

**De Silva SS & Anderson TA** Fish Nutrition in aquaculture. Champman & Hall

**Elena M.** Nutrition, Physiology and Metabolism in Crustaceans. Science Publishers

**Halver J & Hardy RW.** Fish Nutrition. Academic Press

**Lovell RT.** Nutrition and Feeding of Fishes Chapman & Hall

**CIFE. 1993.** *Training Manual on Culture of Live Food Organisms for AquaHatcheries***.**

**Hagiwara A, Snell TW, Lubzens E & Tamaru CS.** 1997. *Live Food inAquaculture*. Proceedings of **the** Live Food and Marine LarvicultureSymposium. Kluwer.

**Halver JE & Hardy RW.** 2002. *Fish Nutrition*. Academic Press.

**Practicals:**

1. Quantitative analysis: of protein, carbohydrate, and lipid from muscle of finfish and shell fish.

2. Fish feeds- Biochemical composition

2. Different types of feeds

3. Feed formulations

4. Calculation of FCR and FCE

5. Calculation of daily ration of feed

Paper 3.4: Marine Pollution and Bio-deterioration

Sources of marine pollution: dynamics, transport paths and agents.

Composition of domestic, industrial and agricultural discharges; their fate in the marine environment. Toxicity and treatment methods.

Wastes from fish processing units and their treatment- removal of nitrogen and phosphorus, Aquatic macrophytes in treatment of waste water.

Oil pollution: Sources, composition and its fate in marine habitats. Toxicity and treatment methods.

Thermal and radioactive pollution: sources, disposal systems of heated effluents, effects and treatment.

Solid dumping, mining and dredging operations: their effects on marine ecosystem, management of solid waste.

Biofouling and biodeterioration: Biofilm formation-primary, secondary, tertiary colonizers.

Effects of biofouling and control measures: manual, mechanical, and chemical

Borers: Effects and control measures.

Corrosion- definition, reactions, classification. Factors and preventive measures.

Global environmental monitoring methods: status, objectives and limitations.

Monitoring strategies of marine pollution: critical pathway approach and mass balancing

Assessment of damage and problems of measuring the impact. Environment Impact Assessment.

Role of biotechnology in marine pollution control and bio-deterioration.

 **References:**

 **NielsenSE** Tropical pollution

 **Kinne O** Marine Ecology Vol. V John Wiley

 **Johnson R (Ed)** Marine pollution Academic Press

 Patin SA Pollution and boil.Resources of oceans Butterworths

 Goldberg, E. D. 1974. The Health of the oceans, UNESCO Press. Paris.

 Park, P .K, Kester D.R., J.W. Deudall and B.H Ketchum, 1983. Wastes in the Ocean.

 Vols. 1 to 3. Wiley Interscience Publishers, New York.

 **Eckenfelder WW**. 2000. *Industrial Water Pollution Control*. McGraw Hill.

 **Gray NF.** 2004. *Biology of Wastewater Treatment*. Oxford University Press.

 **Trivedy RK. 1998.** *Advances in Wastewater Treatment Technologies*. Global Science.

**Practicals:**

1. Determination of BOD in the polluted sea water sample.

2. Determination of nutrients in the polluted sea water sample: nitrites, nitrates, silicates,

 phosphates

3. Determination of toxic elements in the polluted sea water sample: ammonia, sulphide

4. Estimation of particulate organic matter in the polluted sea water sample

5. Spotters: Foulers- primary, secondary and tertiary colonizers; Borers

**Department of Marine Living Resources**

 **Andhra University**

 **Revised Syllabus with effect from 2019-2020 admitted batch**

M.Sc. Coastal Aquaculture and Marine Biotechnology – III Semester

Paper 3.1: Biochemistry and Fish Nutrition

Carbohydrates, proteins, lipids and their metabolism.

Biological membranes: transport of molecules.

Enzymes: classification, types, factors affecting enzyme catalysis, control of enzymatic action and immobilization of enzymes.

Nutritional requirements of cultivable finfish and shellfish: Nutritional value of commonly used fish as food.

Feed formulation: General principles, different steps of feed formulation, Pearson’s method, quadratic equation linear programming, and limitations. Computerized least cost formula and criterions for aquafeed formulation. Feed additives - Use of natural and synthetic carotenoids

Texture and size of feed: Dry - pellets, flakes, powdered, micro-encapsulated, micro-bound and micro-coated diets, non-dry, Farm made feeds.

Experimental diets: Reference diet, purified and semi-purified diet, Compact pellet feed, floating and slow sinking pellet feeds, high energy diet, vacuum coating with lipid

Equipment used in feed manufacture - Pulverizer, grinder, mixer, pelletizer, crumbler, drier, Extruder/ Expander, Vacuum coater, fat sprayer in feed manufacture: Grinding, Dosing, Homogenization; Extrusion cooking; Complimentary processes; Drying, crumbling, coating; Use of binders.

Effects of processing on the nutritional value of feed: vitamins and trace minerals.

Quality control in fish feed manufacturing, Quality control procedures, raw materials, finished products.

Feed storage: Hydro-stability of feed and their storage; Prevention of spoilage from rancidity, fungus and associated toxins.

Feed economics and evaluation criteria: FCR, AFCR, SGR, PRE, ERE, PER, NPU.

**References:**

**Stryer H** Biochemistry

**Lehninger AL** Principles of biochemistry CBS

**Plummer** An introduction to practical biochemistry

**Practicals:**

1) Determinationof moisture in muscle of fish/shrimp.

2) Estimation of proteins, lipids and carbohydrates in fish/shrimp muscle

3) Different types of pelleted feeds and their proximate analysis.

 4) Estimation of maltose by 3, 5- dinitrosalicylate reagent method.

5) Assay of amylase in saliva.

6) Preparation of feed table

7) Visit to feed manufacturing unit

Paper 3.2: Genetics in Aquaculture

Principles of Genetics: Mendelian principles, probability of Mendelian inheritance, modification to Mendelian ratios.

Chromosome theory of inheritance; genetic basis of determination of sex in fish and shellfish.

Chromosome manipulation: Induction of chromosomal ploidy, polyploidy & aneuploidy, gynogenesis, androgenesis, sex reversal, transgenesis and its applications in aquaculture.

Genome size in fishes, Mechanism of variations in genome size.

Sex control and its role in aquaculture, cryopreservation of gametes, in-vitro fertilization, artificial insemination.

Role of genetics in Aquaculture: Genetic selection, inbreeding, cross breeding, hybridization, karyotyping, heterosis, hybrid vigour, introgression.

Genetic tools for aquaculture applications: DNA markers in stock identification- allozymes, RFLP, RAPD, AFLP, Microsatellite, ESTs and SNPs, mt DNA.

**References:**

**Carvalho GR & Pitcher TJ. (Eds.). 1995.** *Molecular Genetics in Fisheries*. Chapman & Hall.

**Falconer DS & Mackay. 1996.** *Introduction to Quantitative Genetics*. 4th Ed. Longman.

**Kanakaraj P. 2001.** *A Text Book on Animal Genetics*. International Book. Distributing Co.

**Nair PR. 2008.** *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.

**Padhi BK & Mandal RK. 2000.** *Applied Fish Genetics*. Fishing Chimes.

**Pandian TJ, Strüssmann CA & Marian MP. 2005.** *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

**Purdom CE. 1993.** *Genetics and Fish Breeding*. Chapman & Hall.

**Reddy PVGK. 2005.** *Genetic Resources of Indian Major Carps*. FAO Publ.

**Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005.** *Text book of Fish Genetics and Biotechnology*. ICAR.

**Ryman N & Utter F. (Eds.). 1988.** *Population Genetics and Fishery Management*. Washington Sea Grant Programmes, USA.

**Tave D. 1996.** Genetics for Fish Hatchery Managers. 2nd Ed. AVI Publ.

**Thorpe JE, Gall GAE, Lannan JE & Nash CE. (Eds.). 1995.** *Conservation*

 *of Fish and Shellfish Resources*, *Managing Diversity*.

 Practicals:

1. Metaphase plate preparation of fish kidney/spleen

2. Numericals on inbreeding, cross breeding, ploidy and genetic selection

3. Karyotyping

4. Computational tools for RFLP, RAPD, AFLP analysis

5. Numericals on DNA markers

6. Chi- square test for verifying Mendelian ratios

7. Assessment of genetic gain through selection

8. Calculation of selection differential and selection response

9. Estimation of inbreeding and path co-efficient

10. C-banding from heterochromatin

 11. G-banding from heterochromatin

Paper 3.3: Molecular Biology

Cell structure and function in prokaryotes and eukaroytes. Cell cycle and its regulation.

Biological membranes: cell membrane, nuclear membrane, ion transport, Na/K phase, Molecular basis of signal transduction.

Nucleic Acids: Structures of DNA and RNA; Stereochemistry of bases and secondary structures; Chromatin structure; Properties of DNA -Tm, hyperchromicity, kinetic classes, buoyant density.

DNA replication: Models of DNA replication in prokaryotes and eukaryotes; Mechanics of DNA replication; DNA methylation, Structure and function of DNA polymerases; Types of priming.

Transcription in Prokaryotes and eukaryotes – enzymes, initiation, elongation and termination. Post transcriptional modifications; Structure and synthesis of rRNA and tRNA.

Genetic code, codon bias, types and structures of ribosomes, Wobble hypothesis.

Translation in prokaryotes and eukaryotes: initiation, elongation, termination, and post-translational modifications, concept of polysomes and protein structure.

DNA recombination: Molecular models - homologous and site-specific recombination, crossing over, Holliday junction, transposition.

Types of mutations, Mutagens – nitrous acid, UV, aflatoxin, bleomycin, ethidium bromide.

Types and mechanisms of DNA damage and Repair

Regulation of gene expression in prokaryotes and eukaryotes - Operon concept, regulatory sequences and transacting factors.

Environmental regulation of gene expression.

References:

**Paul J** Cell Biology Hinemanu

**Friefelder D** Microbial genetics

**Albert et al** Molecular biology of Cells

**DeRoberties** Cell and molecular biology

**Watson et al** Molecular biology of the gene B Cummings

**Practicals:**

1. Plasmid DNA and Genomic DNA isolation & quantification: Plasmid mini-preparations

2. Agarose gel electrophoresis

3. Purification of DNA from an agarose gel

4. Restriction digestion of DNA

5. Preparation of competent cells

6. DNA ligation

7. Equipments in molecular biology

Paper 3.4: Marine Pollution and Bio-deterioration

Sources of marine pollution: dynamics, transport paths and agents.

Composition of domestic, industrial and agricultural discharges; their fate in the marine environment. Toxicity and treatment methods.

Wastes from fish processing units and their treatment- removal of nitrogen and phosphorus, Aquatic macrophytes in treatment of waste water.

Oil pollution: Sources, composition and its fate in marine habitats. Toxicity and treatment methods.

Thermal and radioactive pollution: sources, disposal systems of heated effluents, effects and treatment.

Solid dumping, mining and dredging operations: their effects on marine ecosystem, management of solid waste.

Biofouling and biodeterioration: Biofilm formation-primary, secondary, tertiary colonizers. Effects of biofouling and control measures: manual, mechanical, and chemical

Borers: Effects and control measures.

Corrosion- definition, reactions, classification. Factors and preventive measures.

Global environmental monitoring methods: status, objectives and limitations.

Monitoring strategies of marine pollution: critical pathway approach and mass balancing

Assessment of damage and problems of measuring the impact. Environment Impact Assessment.

Role of biotechnology in marine pollution control and bio-deterioration.

**References:**

**NielsenSE** Tropical pollution

**Kinne O** Marine Ecology Vol. V John Wiley

**Johnson R (Ed)** Marine pollution Academic Press

**Patin SA** Pollution and boil. Resources of oceans Butterworths

Goldberg, E. D. 1974. The Health of the oceans, UNESCO Press. Paris.

Park, P .K, Kester D.R., J.W. Deudall and B.H Ketchum, 1983. Wastes in the Ocean. Vols. 1 to 3. Wiley Interscience Publishers, New York.

**Eckenfelder WW. 2000.** *Industrial Water Pollution Control*. McGraw Hill.

**Gray NF. 2004.** *Biology of Wastewater Treatment*. Oxford University Press.

**Trivedy RK. 1998.** *Advances in Wastewater Treatment Technologies*. Global Science.

**Practicals:**

1. Determination of BOD in the polluted sea water sample.

2. Determination of nutrients in the polluted sea water sample: nitrites, nitrates, silicates and

 phosphates

3. Determination of toxic elements in the polluted sea water sample: ammonia, sulphide

4. Estimation of particulate organic matter in the polluted sea water sample

5. Spotters: Foulers- primary, secondary and tertiary colonizers; Borers

**Department of Marine Living Resources**

 **Andhra University**

 **Revised Syllabus with effect from 2019-2020 admitted batch**

M.Sc. Marine Biotechnology – III Semester

**Paper 3.1: Health management in Aquaculture**

Disease: Definition, Host-pathogen- environment relationship, environmental stress, Inflammation response to diseases.

Parasitic and mycotic diseases in fish and shrimp: General characteristics, Epizootiology, Diagnosis, Life Cycle, Prevention and treatment.

Infectious bacterial and viral diseases in fish and shrimp: General characteristics, Epizootiology, Diagnosis, Prevention and treatment.

Non-infectious Diseases: Nutritional diseases, water, soil, environmental parameters and their effect on fish health.

Diagnostic techniques in aquaculture: Microbiological, haematological, histopathological, immunological and molecular techniques, Disease surveillance and reporting.

Disease control and management: Environment management, chemotherapeutic agents, host

management, prophylaxis-vaccines, adjuvents, immunostimulants and probiotics.

Use and abuse of antibiotics and chemicals in health management.

Fish health and quarantine systems. Seed certification, SPF and SPR stocks- development and

applications.

 **References:**

 **Bardach JE et al.,** Aquaculture Wiley- Interscience

 **Pillay TVR Aquaculture:** Principles & practices FNB

 **Santhanam R et al .,** Coastal aquaculture CBS

 **Inglis V, Roberts RJ and Bromage NR.** Bacterial diseases of fish . Blackwell

 **Iwami G & Nakanishi T (Eds.).** The fish immune system- organism, pathogen and environment. Academic Press.

 **Roberts RJ.** Fish Pathology 3rd Ed. WB Saunders

 **Schaperclaus W.** Fish diseases. Vols. I, II. Oxonian Press.

 **Shankar KM and Mohan CV. 2002.** Fish and Shellfish Health Management. UNESCO Publ.

 **Sindermann CJ.** Principal diseases of marine fish and shellfish. Vols. I, II. 2nd Ed. Academic Press.

 **Stickney RR.** Principles of aquaculture Wiley & Sons

 **Practicals:**

 1. Procedure of disease diagnosis.

 2. Tissue fixation, Microtomy and histology of various fish/shrimp tissues.

 3. Isolation of pathogenic bacteria/fungi and their identification.

 4. Disease diagnositic methods: Necroscopy, Agglutination tests.

 5. Identification of various parasites

 6. Diseases of fin fish and shell fishes.

 7. PCR for disease diagnosis, serological techniques in disease diagnosis.

 8. Diseased fish/shrimp specimens.

 9. Fish/Shrimp haemotological parameters- TEC, DLC, TLC, Hb, Total protein, lipid

 profile, creatine Urea and enzymes in blood.

Paper 3.2: Immunology

Immunity and types of immunity.

Fundamental concepts and anatomy of the immune system, components of innate and acquired

immunity, Phagocytosis, Complement and inflammatory responses, Organs and Cells of the immune system-primary and secondary lymphoid organs, Lymphatic system, Lymphocyte circulation, Lymphocyte homing, Mucosal and Cutaneous associated Lymphoid tissue (MALT & CALT); Mucosal immunity.

Antigens: Types and properties. Major Histocompatability Complex(MHC) - MHC genes, Immune responsiveness and disease susceptibility and HLA typing.

Immunoglobulins: Structure, types and functions.

Immunogenetics: Genetic basis of antibody diversity.

Molecular biology of B and T cells. Complement proteins and cytokines.

Disorders of immune system: autoimmunity- types of autoimmune diseases.

Immunodeficiency- Primary immuno deficiencies, Acquired or secondary immuno deficiencies, hypersensitivity.

Immunotherapy, Immunostimulants-beta glucagons; vaccines- Live, killed, attenuated, sub unit vaccines and antibodies. Non-specific immunity of shellfish.

Active and passive immunization; hybridoma technology- mono and polyclonal antibodies.

ELISA, RIA and Immuno electrophoresis applications.

Transplantation- Immunologiocal basis of graft rejection.

Tumor immunology- Tumor antigens; immune response to tumors and tumors evasion of the immune system, Cancer immunotherapy.

 **References:**

 **Eli Benjamini** Immunology – a short course

 **I. Riott** Essentials of immunology Blackwell

 **I Riott et al** Immunology Molsby

 **Aruna B** Manual of practical immunology Palani- paramount

Practicals:

1. Preparation of antigens, Immunization and methods of bleeding, serum separation

 and storage.

2. Antibody titre by ELISA method.

3. Isolation and purification of Ig G from serum or Ig Y from chicken egg.

4. Blood smear identification of leucocytes by Giemsa stain.

5. Separation of leucocytes by dextram method.

6. Demonstration of phagocytosis.

7. Immuno electrophoresis, Isolation of antibody from serum, Nonspecific immune

 response (NBT and Prophenol oxidase tests).

Paper 3.3: Enzymology and Enzyme Technology

Nomenclature & classification of Enzymes.

Enzyme structure and properties, co-enzymes, co-factors.

Enzyme specificity; factors affecting enzyme action.

Mechanism of enzyme action: activation energy; characterization of active site; activators and inhibitors,

Enzyme kinetics: Michaelis- Menten Kinetics, steady state kinetics; single and multi substrate interactions, Competitive, non competitive and uncompetitive enzyme substrate kinetics.

Multi-enzyme complex; single and multi-substrate systems.

Regulatory enzymes: Allosterism, covalent modification and feedback mechanisms; ATPase, glutamine synthetase.

Haemoglobin and myoglobin.

Membrane-bound enzymes: Extraction, purification, assay and enzyme storage

 Immobilization of enzymes: methods of enzyme immobilization; applications ; Merits and demerits of immobilized enzymes.

Biosensors and modifications.

Synthetic enzymes, isozymes and their importance.

Enzymes of industrial and diagnostic importance.

 **References:**

 **Boyer P D** The Enzymes Freeman

 **Fersht A R** Enzyme structure & mechanism Freeman

 Palmer T Enzymes Horwood

 **Siseman** A Handbook of Enzyme technology

 **Trevan M D** Immobilized enzymes Wiley & Sons

 **Plowman K M** Enzyme kinetics MacGraw Hill

 **Rehm & Reed** Biotechnology Vol II: Bioreactors

 **Practicals:**

1. Preparation of maltose standard curve using 3, 5- Dinitrosalicylate reagent.
2. Assay of amylase in saliva.
3. Preparation of ammonia standard curve using Nessler’s Reagent
4. Assay of urease activity.
5. Time course of enzyme activity.
6. Effect of temperature on enzyme activity.
7. Effect of pH on enzyme activity.

 8) Common instruments used in enzymology

Paper 3.4: Marine Pollution and Bio-deterioration

 The present status of coastal pollution in India and future strategies.

 Sources of marine pollution, its dynamics, transport paths and agents.

 Composition of domestic, industrial and agricultural discharges. Their fate in the marine environment. Wastes from fish processing units and their treatment- removal of nitrogen and phosphorus.

 Role of aquatic macrophytes in treatment of waste water. Toxicity and treatment methods.

 Oil pollution: Sources, composition and its fate in marine habitats. Toxicity and treatment methods.

 Thermal and radioactive pollution: sources, effects and remedial measures. Solid dumping, mining and dredging operations: their effects on marine ecosystem.

 Biofouling and biodeterioration: Biofilm formation-primary, secondary, tertiary colonizers. Effects of biofouling and control measures.

 Borers: Effects and control measures.

 Corrosion- definition, reactions, classification. Factors and preventive measures.

 Global environmental monitoring methods: status, objectives and limitations.

 Monitoring strategies of marine pollution: critical pathway approach and mass balancing

 Assessment of damage and problems of measuring the impact. Environment Impact Assessment.

 Role of biotechnology in marine pollution control and bio-deterioration.

 **References:**

 **NielsenSE** Tropical pollution

 **Kinne O** Marine Ecology Vol. V John Wiley

 **Johnson R (Ed)** Marine pollution Academic Press

 Patin SA Pollution and Boil. Resources of oceans. Butterworths

 Goldberg, E. D. 1974. The Health of the oceans, UNESCO Press. Paris.

 Park, P .K, Kester D.R., J.W. Deudall and B.H Ketchum, 1983. Wastes in the Ocean. Vols. 1 to 3. Wiley Interscience Publishers, New York.

 **Eckenfelder WW. 2000.** *Industrial Water Pollution Control*. McGraw Hill.

 **Gray NF. 2004.** *Biology of Wastewater Treatment*. Oxford University Press.

 **Trivedy RK. 1998.** *Advances in Wastewater Treatment Technologies*. Global Science.

 **Practicals:**

 1. Determination of BOD in the polluted sea water sample.

 2. Determination of nutrients in the polluted sea water sample: nitrites, nitrates, silicates and phosphates

 3. Determination of toxic elements in the polluted sea water sample: ammonia, sulphide

 4. Estimation of particulate organic matter in the polluted sea water sample

 5. Spotters: Foulers- primary, secondary and tertiary colonizers; Borers.