# Annexure I - Course Structure and Syllabus of 3rd and 4th Semester of Innovative M.Sc-Marine Microbiology

## Semester III

<table>
<thead>
<tr>
<th>Paper code</th>
<th>Title of the paper</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MM-301</td>
<td>Marine Pollution &amp; Microbial Remediation</td>
<td>3 1</td>
</tr>
<tr>
<td>MM-302</td>
<td>Marine Microbial Prospecting and Technology</td>
<td>3 1</td>
</tr>
<tr>
<td>MM-303</td>
<td>Marine Microbial Genomics</td>
<td>3 1</td>
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<tr>
<td>MM-304</td>
<td>Marine Environment &amp; Public Health management</td>
<td>3 1</td>
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<td>MM-305</td>
<td>Marine Extremophilic Microorganisms</td>
<td>3 1</td>
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<td>MM-306</td>
<td>Marine Virology</td>
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## Semester IV

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<tr>
<th>Paper code</th>
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<tbody>
<tr>
<td>MM-401</td>
<td>Microbial Ecology of deep marine environment</td>
<td>3 1</td>
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<tr>
<td>MM-402</td>
<td>Fishery Microbiology</td>
<td>3 1</td>
</tr>
<tr>
<td>MM-403</td>
<td>Polar Microbiology*</td>
<td>3 1</td>
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<tr>
<td>MM-404</td>
<td>Remote Sensing &amp; GIS**</td>
<td>3 1</td>
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<tr>
<td>MM-405</td>
<td>Bioinformatics***</td>
<td>2 1</td>
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<tr>
<td>MM-406</td>
<td>Marine Mycology</td>
<td>3 1</td>
</tr>
<tr>
<td>MM-407</td>
<td>Cruise</td>
<td>2</td>
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<tr>
<td>MM-408</td>
<td>Summer training/Field trip/Study tour</td>
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</tr>
<tr>
<td>MMD</td>
<td>Dissertation</td>
<td>8</td>
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**Note:**

All the papers of 3rd and 4th semester are optional.

Dissertation is optional which commences in IIIrd Semester and must be completed at the end of IVth Semester.

*Polar Microbiology (MM-403) will not be offered during forthcoming academic session.

** In lieu of Remote Sensing and GIS (MM-404), the students may opt Paper BOO-405 of Botany department.

***Bioinformatics already approved by BOS (Microbiology) may be opted by the students.
MM301-Marine Pollution and Microbial Remediation
Course credit: 4 (Three credits for theory and one for practical)

1 Coastal, estuarine and marine Hazards:
Oil spills, heavy metals, domestic sewage, industrial wastes, liquid and solid waste,
Persistent organic pollutants (POPs): Polyaromatic hydrocarbons (PAHs), Aliphatic hydrocarbons, other recalcitrants and xenobiotics, inorganic nutrient excess.

2 Impacts of pollution on marine ecosystems and community structure:
Eutrophication, Primary producers, toxicity, anaerobiosis, biomagnification, biofouling, bioadhesion, biocorrosion and sulphate reducing bacteria (SRB). Methane emission and impact on climate changes: productivity and sustainability of marine econiche.

3 Biomonitoring and bioremediation:
Bioindicators, biotracers, and biosensors
biosorption, biosedimentation, biodegradation - reactions, enzymes and pathways.
Cometabolism, microbial adhesion and emulsification, mechanisms and significance in marine ecosystem, applications of microbial consortia in bioremediation

Practicals
Isolation of hydrocarbon degrading organisms.
Study of aromatic ring cleavage
Surfactant and Emulsification studies
Determination of bioindicators of pollution
Use of biosensors
Remediation methods – biosorption, biosedimentation, biodegradation

Reference Books:
1. Marine Microbial Diversity: David Karl & Merry Buckley
2. Microbial Ecology of the Oceans: Ralph Mitchell
3. Ocean & health: Pathogens of the Marine Environment Rita Colwell & ShinishonBelkin
4. Biological Oceanography-Charles Meller
MM-302 Marine Microbial Prospecting and Technology
Course credit: 4 – (Three credits for theory and one for practical) (CH)

1. **Bioprospecting**: Concept of exploiting marine microbial resource and their cellular components from marine environment and marine invertebrates

2. **Sampling and search strategies for novel targets under**: microbial cultures, enzymes, therapeutics, antimicrobials, biotransformations and biofuels.


4a. **Conventional and High throughput screening strategy**:
   i. **Conventional**: Plating, Enrichment, Extinction culturing; Microscopic techniques, Micro manipulations (FISH), Optical tweezers, Microautoradiography.
   ii. **Novel**: Function based screens (proteomics and metabolomics), Sequence based screens (genomics), substrate induced gene expression screens (SIGEX) catabolic gene expression screens. Metagenomics, Microarrays, Combinatory chemistry, combinatory biosynthesis and biochemistry assays. Data bases, Natural product libraries

4b. **Deposition of microbes and biomolecules**:
   Culture collection/ Repository, deposition of sequences of nucleic acids, proteins and structures of microbial molecules and products

5. **Case studies on Marine Products and process development using Microbes**: Archaea, cyanobacteria and Proteobacteria; microbial products (MEOR)

**Practicals**
Isolation and Screening for marine microbes from sediments, marine organisms (bionts) for: pigments, enzymes, antibiotics, therapeutic and industrially molecules. Microbial transformation.

**Books and reference material**:
1. Microbial Diversity and Bioprospecting Alan Bull Amazon Publishers
3. Relevant research papers and review articles on the subject
MM-303: Marine Microbial Genomics

Course credit: 4 – (Three credits for theory and one for practical)

1. Significance of Marine Microbial Genomics (4)

2. Marine microbial genomics & Microbial diversity:
   i) Nucleic acid based methods to study marine microbial diversity
   ii) Sequencing of ribosomal RNA genes
   iii) PCR, DGGE,TGGE and TRFLP analysis
   iv) Genomic fingerprinting to analyze culturable microbes
   v) G:C ratio and DNA-DNA Hybridization
   vi) DNA Sequencing: Whole genome Sequencing, Pyrosequencing

3. Microbial genomics of select microorganisms (7)
   (bacteria, cyanobacteria, archaea and viruses):
   i) Organization of Prokaryotic microbial genomes: sizes and ORF contents
   ii) Prokaryotic genomes: Bioinformatic analyses and Gene distributions
   iii) Organization of Eukaryotic microbial genomes

4. Other genomes and evolution of genomes: (5)
   i) Genomes of Organelles
   ii) Evolution and gene families
   iii) Genomic mining

5. Molecular analysis (Culture independent) of Microbial communities (8)
   i) Viability and Quantification using staining techniques
   ii) Genetic stains
   iii) Linking specific genes to specific organisms using PCR
   iv) Environmental genomics (Metagenomics)

6. Microbial gene transfer and ecological perspective (2)

7. Tools to study Microbial Genomics: (8)
   i) Genomic cloning techniques:
      a) Vectors for genomic cloning and sequencing
      b) Sequencing the genome: Conventional and High throughput sequencing
      c) Annotating the genome
   ii) Gene function and regulation studies: Proteomics, Microarrays and Transcriptomics
Genomics of specific marine bacteria

i) Quorum sensing in luminescent bacteria
ii) Hydrocarbon degradation by marine bacteria
iii) Adaptation to extremes of temperature and pressure

Practicals

1. Extraction of environmental DNA from marine/coastal sediments and electrophoresis
2. Screening of marine bacteria for presence of plasmid
3. Extraction of genomic DNA from marine bacterial strains and electrophoresis.
4. Spectrophotometric determination of concentration of DNA from environmental samples.
5. Determination of purity of environmental DNA samples.
6. PCR amplification of 16S rDNA using environmental (metagenomic) DNA samples as template DNA and electrophoresis.
7. Demonstration of Metagenomic library construction and Screening of Metagenomic clones.

Reference Books:

MM 304 – Marine Environment and Public Health Management
Course credits: 4 (Three credits for theory and one for practical)

1

1.1 Environmental variables related to marine, coastal and aquatic ecosystems; (CH)
Water quality and sediment characteristics; Climate change and impact on
human health – migration of Vibrio, flooding of coastline; El Nino Southern
Oscillations; disaster management (outline); Understanding marine ecosystem
and human health with DPSIR model

1.2 Marine and coastal pollution - effects on living organisms. Water pollution -
microbial changes induced by inorganic and organic pollutants, industrial
effluents and domestic sewage.
Impact of bioaccumulation and biomagnifications of mercury, cadmium, lead,
etc. in fishes, role of microbes. Microbial pollution in industries-corrosion of
iron, acid-mine drainage, cooling systems and others. and its impact on marine
ecosystems.

1.3 Impact of pollutants on environment and living resources; Challenges for
monitoring and control of pollution and overfishing; Standards for various
types of water;

2

2.1 Biological indicators and indices of water quality; Microbial indicator systems –
Fecal Indicator Bacteria (FIB), uses and limitation of FIB, development of ideal
indictor system (Clostridium, Cryptosporidium, adenoviruses, Bacteroides,
Coliphages) – status, uses and limitation Sanitation in aquaculture systems.

2.2 Human pathogens - autochthonous and allochthonous pathogens, pathogen
distribution; bacterial pathogens and diseases transmitted through marine and
coastal water, faecal contamination, Vibrio, Wound sepsis, entro-viruses.
Disease monitoring and surveillance.

2.3 Biological pollution – Algal blooms and environmental microflora, their effect
on fish production, biological and chemical control of algal bloom, Microbial
toxins, Nitrogen balance in aquatic ecosystem.

3

3.1 Bioinvasion, Ballast water - impact, monitoring, rules and regulation, (4)
quarantine, certification and import risk analysis

3.2 Commonly used drugs/chemicals in aquaculture, drug delivery; Vaccines and
vaccination, probiotics and bioremedial measures

3.3 Application of health management protocols and biosecurity principles in
aquaculture; Long term strategy in health management; Advances in disease
control and management; Principles of SPF/SPR. Biosecurity in aquaculture
4 Practical:

1. Estimation of major pollutants using spectrophotometry.
2. Hematological, histopathological and biochemical analysis of fish exposed to specific pollutants.
3. Testing the efficacy of aquaculture sanitizers
4. Microbial pollution of water, detection and characterization of different indicator and pathogenic organisms such as S. aureus, E. coli, V. cholerae, Salmonella, Shigella, by conventional and rapid methods, antibiotic resistant microbes in the marine environment.

Reference Books:

7. Aquatic Microbiology by Rheinheimer
8. Marine Pollution by Clark
11. Bacteria from Fish and Other Aquatic Animals: A Practical Identification Manual (Cabi Publishing) by Nicky B. Buller and John A. Plumb
Concept of Extremophiles v/s conventional Microbial forms & Archaea. (1)

Extreme Marine Econiches: Marine trenches and ridges, Submarine vents, Deep sea basins and Antarctic sea ice and lakes. (2)

Key Molecular components, Unique Physiological features, Adaptation strategies, growth kinetics, significance in biogeochemical cycles of the following:

a) **Anaerobes**: Anaerobrancahorikoshi, Methanobacteriumthermoautotrophicus; **Barophiles/ Peizophiles**: Actinobacteria

b) **Cryophiles, Psychrophiles, Psychrotrophs –& Thermophiles –**
Polaromonas, Shewanella, Flavobacterium, Desulphovibrio Bacillus infermus, Aqifex, Rhodothermus

c) **Oligotrophs, Osmophiles, Halophiles &Xerophiles**-
Plagibacter; Rhodotorula; - Halomonas, Marinococcus, Walmia

d) **Radiofibes, Metallophiles & Xenobiotic utilizers** –
Deinococcus, Hymenobacter, Feroplasma, Pseudomonas, Caulobacter

e) **Alkaliphiles, Acidophiles & Neutrophiles**
Aeromonas, Rhodotorula, Caulobacter, Geobacillus

Practicals (15x3)

Culturing of Anaerobes, Oligotrophs.

i. Tolerance levels of: Thermophiles, Metallophiles and xenobiotics.

ii. UV resistance

iii. Detection of Osmolytes in halophiles

Reference Books:


MM -306 MARINE ViroLOGY

Course credit: 3 – (Three credits for theory )

I Virus Structure, Diversity and Assay

1. Viruses - Introduction, nature, structure and classification
2. Marine phages and their host: Archaea, bacteria and cyanobacteria, phytoplanktons, algae
3. Marine viruses and their hosts: fish and shrimp; Giant marine virus
4. Metagenomic approaches to study the diversity of marine viruses

II Multiplication and Assay of Phages and Viruses

1. Bacteriophage life cycles - lysogenic (latent) and lytic (virulent)
2. Viral multiplication
3. One step growth profile.
4. Assay: plaque assay (PA); most-probable number (MPN); transmission electron microscopy (TEM); epifluorescence microscopy (EfM); flow cytometry (FC)

Significance of viruses in marine ecosystem

1. Movement of viruses between biomes
2. Effect of viruses on ecology of the marine ecosystem
3. Marine viruses and global climate change
4. Viral pathogens of fish: Lymphocystis virus, Infectious pancreatic necrosis virus (IPNV), Nervous necrosis virus (NNV), Infectious salmon anaemia virus (ISAV), Salmon Alphavirus (SAV), Infectious haematopoietic necrosis virus (IHNV), Viral hemorrhagic septicemia virus (VHSV),
5. Viruses in shell-fish and health hazards: Norwalk virus and Hepatitis virus A

Reference books and Materials

(MM-401) Microbial Ecology of Deep marine Environment

Course credit: 4 – (Three credits for theory and one for practical) (CH)

1. Basic and in-depth conceptualisation of Marine Microbes, Microbial Communities, Interdependence, Ecoenergetics and Sustainance processes in different deep subsurface habitats. (5)

2. Abyssal plains, Hydrothermal vents, Marine basalts (5)

3. Icy niches, cold seeps, endoliths, permafrost sediments, Antarctic continent and Southern ocean (5)

4. Oil reservoirs, souring of oil reservoirs, shales, Methane hydrates (15)

5. Marine Deposits: Sapropel, Carbonates, Phosphorite, Ancient halite, Metallic nodules. (15)

6. Case study
   Isolation and characterisation of deep sea microbes using Novel samplers, Growth and physiological studies using anaerobic and pressure cultures chambers/ systems (15)

Reference books and other research materials

1. Marine Microbiology Ecology and Applications by Colin Munn, Garland Sc, Taylor and Francis N.Y

2. Feast and Famine- Microbial life in the deep sea bed. Mat. Rev. 5 770-781.


4. Other relevant researchpapers
Type of fishes, shellfishes and other coastal aquatic and marine living resources present in Indian Ocean, Arabian Sea and Bay of Bengal, concept of aquaculture and marine culture of fishes.

1.2 Microbiology of Raw fish and processed fish, Various methods for processing of fishes; Biopreservation, food processing, fermentation and aquaculture; effect of heat, chilling, freezing and chemical preservatives on bacteria, yeasts and fungi associated with fishes.

1.3 Quality control and regulations for microbial quality of fishes, shellfish and Marine living resources used for food and drugs

Bacteria associated with fish and Shellfish

2.1 Commensals and pathogens; Classification of diseases; Methods of disease prevention; Detailed study of bacteria pathogenic to finfish and shellfish with emphasis on morphology, epidemiology, pathogenesis, treatment and control: *Flavobacterium, Flexibacter, Edwardsiella, Pseudomonas, Vibrio, Aeromonas, Renibacterium, streptococcus, Yersinia, Mycobacteria and Nocardia.*

3.1 Human bacterial Pathogens associated with fishes and their products - *Aeromonas spp., Clostridium botulinum, Clostridium perfringens, Listeria spp., Plesiomonas, Salmonella spp., Staphylococcus aureus, Vibrio cholera, Vibrio parahaemolyticus, Vibrio vulnificus* and common Enterobactereacea


4. **Practicals**

1 Examination of moribund fish; Sampling techniques for microbiological investigation;

2 Methods for examination and analysing fish for health certification/diagnosis of disease condition, techniques for sample collection and processing for bacteriological agents

3 Isolation of various bacterial pathogens; microbial identification; molecular
techniques for disease diagnosis,

**Reference Books:**

1. MICROBIOLOGY HANDBOOK: FISH AND SEAFOOD, Edited by Rhea Fernandes
2. Fish diseases and disorders: Vol 3: viral, bacterial and fungal infections by Woo and Bruno
3. Fish Pathology by R.J. Roberts
5. Textbook of fish health by George Post.
7. Fish disease diagnosis and by Edward C. Noga
8. Fish diseases and disorders by J. F. Leatherland and PKT Wook
10. Molecular diagnosis of Salmm disease by Carey E. Cunningham
11. Health maintenance and principal microbial diseases of cultured fishes by John a. Plumb
12. Principal diseases of marine fish and shellfish by Carl J. Sindermann
13. Bacteria from Fish and Other Aquatic Animals: A Practical Identification Manual (Cabi Publishing) by Nicky B. Buller and John A. Plumb
16. Manual of Diagnostic Microbiology By Wadher and Boosreddy
17. Diagnostic Microbiology by Fingold
18. Manual of Practical Microbiology and Parasitology by Chakraborty and Pal
I Fungal diversity and distribution (15)

1. Fungi
   Phylogeny and detailed classification

2. Econiches of Marine Fungi
   (a) Polyhaline Coastal Environment – salt marsh, mangrove, estuarine and Oceans
   (b) Hypersaline environment – solar salterns, Salt Lake, Dead Sea
   (c) Deep Sea – Hydrothermal vents

3. Extremophilic Fungi
   Halophiles, Xerophiles, Oligotrophs, Barophiles, Psychrophiles, Thermophiles

II Techniques to study marine and extremophilic fungi (05)

(a) Isolation – Sample collection and isolation procedures
(b) Identification - Morphotyping; Secondary metabolites; Molecular fingerprinting: FAME, Karyotyping, Gene sequencing and RAPD analysis.

III Physiology and Genetics (10)

1. Growth and development
   (a) Growth cycle
   (b) Fungal hormones- attractants, morphogenesis and differentiation
   (c) Secondary metabolites: pigments, mycotoxins

2. Fungal genetics
   Cross over and tetrad analysis, gene conversion, mating type switching; Deuteromycotina: parasexuality, cytoplasmic inheritance.

IV Fungal associations and diseases (5)

1. Mycoses
   Diseases of fish and bivalves by Saprolegnia, Aphanomyces, Branchiomyces, Ichthyophonus

2. Fungal associations
   Saprophytes, parasites and symbionts on higher forms of marine life

V Bioprospecting and bioremediation (10)

1. Industrially important enzymes
2. Natural products – nutraceuticals, antimicrobials, antitumour agents
3. Secondary metabolites – pigments
4. Biodegradation and bioremediation

Reference books:
5. Kendricks. The Fifth Kingdom
7. Introduction to Genetics – S. W. Strickberger

PRACTICALS
1. Study of representative fungal cultures: (a) Colony and (b) Morphological characteristics
2. Isolation of fungi from mangroves
3. Identification of fungi
4. Extraction of fungal DNA and gel electrophoresis
5. Screening for enzyme production
6. Application of fungi in bioremediation

Reference Books
4. www.drfungus
5. Research journals