Pre-Ph.D.

Course Curriculum & Syllabi - 2020

Department of Marine Sciences, Berhampur University

Introduction:

Department of Marine Sciences was established in the year 1978 in Berhampur University. Berhampur University is the only university in the state which offers M.Sc, M.Phil. and Ph. D/D.Sc. courses in Oceanography and Marine Biology. The prime objective to establish such a department was to prepare quality manpower in the field of Marine Sciences, both through teaching and research, to meet the demand of the state as well as the country.

Faculty Members:

1. Dr. Pratap Kumar Mohanty, Professor (Oceanography)
2. Dr. Shesdev Patro, Assistant Professor (Marine Biology)

Facilities:

P.G. Department of Marine Sciences has following facilities available for students and research scholars:

Seminar and Library:

Department has an independent Seminar Hall with audio-visual system where weekly students seminar are conducted under the supervision of a Teacher-In-Charge. Department has its own library with about 1200 books and several journals / newsletters.

Computing facilities:

The department has a centralized computer laboratory equipped with internet facility, PC and Server. Softwares such as ERDAS Imagine, Arc-view, MATLAB, Surfer, Statistica and other statistical packages are available.

Laboratories:

The Department has six practical laboratories viz, Marine Biology, Marine Microbiology, Marine Chemistry, Marine Geology, Physical Oceanography & Meteorology and Remote Sensing.

Syllabus for Pre-Ph.D. (Marine Biology)

The Syllabus includes theories/dissertations/seminar presentations wherever necessary. A list of Text Books is provided against each paper for all Semesters. However, students may also make use of authentic online sources for their benefit.

General Course Framework & Structure

Total Credits- 16 & Core papers (C): 04; Elective Papers (E): 01

Course Code	Title of the Paper	Total Mark	Credit
MARB MPC1	Research Methodology	100	4
MARB MPC2	Advances in Biological Oceanography	100	4
MARB MPC3	Research and Publication Ethics	50	2
MARB MPC4	Literature Review & Seminar Presentation (*Presentation with a review report based on review of 05 important published research articles of reputed journals*)	50	2
MARB MPE1	Marine Plankton and Productivity	100	4
MARB MPE2	Benthic Ecology	100	4
MARB MPE3	Marine Ecology and Biodiversity Conservation	100	4
MARB MPE4	Marine Fisheries	100	4
MARB MPE5	Coastal and Marine Aquaculture	100	4
MARB MPE6	Marine Biotechnology	100	4
MARB MPE7	Marine Microbiology	100	4
Total Marks/Credit (C 04 + E 01)		**400**	**16**

A student has to opt any one among the elective papers (E) related to their research interest

Details of Syllabus

Course Name: Research Methodology **Course No.:** MARB MPC1

Credits: 04 **Core/Elective:** Core

Course Details

Units	Contents	Hours
Unit 1	**Statistical analysis and computer application** Use of MS office word, Ms office excel, PowerPoint presentation Standard deviation, mean, median, mode, simple correlation and regress analysis, analysis of variance, one way and two way ANOVA	15
Unit 2	**Research methodology in plankton studies** Collection and preservation of phytoplankton Quantitative and qualitative analysis of phytoplankton Standing stock measurement and estimation of biomass of phytoplankton Collection and preservation of zooplankton Methods of qualitative and quantitative analysis of zooplankton Standing stock measurement/biomass estimation of zooplankton	15
Unit 3	**Research methodology in study of benthos and ecological sensitive areas** Methods of collection of benthos from rocky, sandy and muddy shore using quadrate sampling and core sampling Preservation of benthos Standing stock assessment of macro and meiofauna Qualitative and quantitative analysis of macrofauna and meiofauna Survey methodology for salt marsh, seagrass, mangrove and coral reef ecosystems	15
Unit 4	**Research methodology in fishery** Methods of population size estimation of pelagic and demersal fishes	15

Units	Contents	Hours
	Collection, Transportation and preservation of fish sample for biochemical and karyological studies Methods of fish seed collection from natural environment Methods of transportation of seed materials	

References/text books

1. Raymont, J.E. G, 1973. Plankton and Productivity in the Ocean (Vol.-1) Pergamon Press, London
2. Lalli & Person: Biological Oceanography, Pergamon Press, London
3. English, S., Wilkinson, C., Baker, V., 1997. Survey Manual for Tropical Marine Resources, Australian Institute of Marine Science, Townsville
4. Venkataraman, K., Sivaperuman, C. 2015. Marine faunal diversity in India: Taxonomy, ecology and conservation, Academic Press
5. King, M. 1995. Fisheries biology Assessment and Management. Fishery News Books.

Course Name: Advances in Biological Oceanography **Course No.:** MARB MPC2

Credits: 04 **Core/Elective:** Core

Course Details

Units	Contents	Hours
Unit 1	**Marine biodiversity, ecology and conservation** Plankton: classification, distribution and factors affecting their distribution Benthos: classification, distribution and factors affecting their distribution Marine Ecosystems and their function: seagrass, salt marsh, mangrove and coral reef	15
Unit 2	**Marine Fisheries and Aquaculture** Major fisheries of the world, Estuarine and marine fishery resources of India,	15

Units	Contents	Hours
	Status of capture fisheries from Indian seas, Marine and estuarine fishery potential of Odisha coast, Status of brackish water and mariculture in India and Odisha	
Unit 3	**Marine Biotechnology and Molecular Biology** History of genetics and mendelism Structure and function of gene Molecular structure of DNA and its replication Molecular structure and function of RNA (m-RNA, r-RNA, t-RNA) DNA as the genetic material Chromosomal basis of inheritance Marine biotechnology and its applications in biological oceanography	15
Unit 4	**Marine Microbiology** General introduction to microbiology marine microbiology-Definition, importance and its significance in oceanographic studies	15

References/text books

1. Parsons, J.R. M. Takahasi and hargrave 9IIed), 1977, Biological oceanographic Processes. Pergaman Press, Oxford.
2. Lalli & Person: Biological Oceanography, Pergamon Press, London
3. Barnes R. S. K, 1999, Introduction to Marine Ecology, Blackwell Science.
4. Venkataraman, K., Sivaperuman, C. 2015. Marine faunal diversity in India: Taxonomy, ecology and conservation, Academic Press
5. King, M. 1995. Fisheries biology Assessment and Management. Fishery News Books.
6. Pillay, T.R. ed. 1982, Coastal aquaculture in Indo-Pacific region, Fishing News (Books) Limited London
7. Dey, V.K. Ornamental fishes, hand book on Aquafarming, Presented by MPEDA, Kochi.
8. Nayak. L. 2001, Recent trends in aquaculture, Berhampur University.
9. Y. Le Gal and H.O.Halvorson 1998, New Developments in Marine Biotechnology. Springer
10. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill

Course Name: Research and Publication Ethics **Course No.:** MARB MPC3

Credits: 02 **Core/Elective:** Core

Course Details

Units	Contents	Hours
Unit 1 (Theory)	**Philosophy and ethics** Introduction to philosophy: definition, nature and scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgements and reactions	3
Unit 2 (Theory)	**Scientific conduct** Ethics with respect to science and research Intellectual honesty and research integrity Scientific misconducts: falsification, fabrication and plagiarism (FFP) Redundant publications: duplicate and overlapping publications, salami slicing Selective reporting and misrepresentation of data	5
Unit 3 (Theory)	**Publication ethics** Publication ethics: definition, introduction and importance Best practices/standards setting initiatives and guidelines: COPE, WAME etc Conflicts of interest Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types Violation of publication ethics, authorship and contributorship Identification of publication misconduct, complaints and appeals Predatory publishers and journals	7
Unit 4 (Practice)	**Open access publishing** Open access publications and initiatives SHERPA/RoMEO online resources to check publisher copyright & self-	4

Units	Contents	Hours
	archiving policies Software tool to identify predatory publications developed by SPPU Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester etc	
Unit 5 (Practice)	**Publication misconduct** *A. Group discussions (2 hrs)* Subject specific ethical issues, FFP, authorship Conflicts of interest Complaints and appeals: examples and fraud from India and abroad *B. Software tools (2 hrs)* Use of plagiarism software like Turnitin, Urkund and other open source software tools	4
Unit 6 (Practice)	**Databases and research metrics** *A. Databases (4 hrs)* Indexing databases Citation databases: Web of Science, Scopus etc. *B. Research metrics (3 hrs)* Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite score Metrics: h-index, g index, i10 index, altmetrics	7

References/text books

1. Bird, A. (2006). Philosophy of science. Routledge
2. MacIntyre, A. (1967) A short history of ethics. London.
3. Chaddah, P. (2018) Ethics in competitive research: Do not get scooped; do not get plagiarized.
4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009). On being a scientist: A guide to responsible conduct in research: third edition. National Academic Press.

5. Resnik, D.B. (2011) Wht is ethics in research and why is it important. National Institute of Environmental health Sciences, 1-10.
6. Beall, J. (2012) Predatory publishers are corrupting open access. Nature, 489 (7415), 179-179.
7. Indian National Science Academy (INSA), Ethics in science education, research and governance (2019).

Course Name: Literature Review & Seminar Presentation **Course No.:** MARB MPC4

Credits: 02 **Core/Elective:** Core

Course Details

Units	Contents	Hours
	Review of literature: meaning, significance and techniques of reviewing the literature for the specific topic/research paper. Developing guidelines for review of literatures. Selecting five research papers on any topic of marine sciences/marine biology and reviewing all. Preparing a report on the review papers based on at least 05 research papers and presentation through PPT	

Course Name: Marine Plankton and Productivity **Course No.:** MARB MPE1

Credits: 04 **Core/Elective:** Elective

Course Details

Units	Contents	Hours
Unit 1	**Phytoplankton** Distribution of phytoplankton in the ocean and the environmental factors affecting their distribution Phytoplankton bloom, Red tide, Harmful algal bloom (HAB), causes and consequences of HABs	12

Units	Contents	Hours
Unit 2	**Primary productivity** Definition of primary productivity Factors effecting primary productivity in the marine environment Methods of estimation of primary productivity- phytoplankton standing crop, analyzing the pigment (Chlorophyll estimation), estimation of dissolved oxygen, C^{14} method Comparison of primary productivity in Bay of Bengal and Arabian sea	12
Unit 3	**Zooplankton** Holoplankton and meroplankton Distribution of zooplankton and the environmental factors affecting their distribution Migration of zooplankton – Dial vertical migration and seasonal vertical migration Zooplankton as bioindicator	12
Unit 4	**Secondary productivity** Methods of estimation of secondary production, Factors affecting secondary production, Regional difference in secondary production with special reference to the Bay of Bengal and the Arabian Sea.	12
Unit 5	**Plankton ecology** Interrelation between phytoplankton and zooplankton primary and secondary productivity in different marine ecosystems- estuary, ocean, mangrove and coastal lagoons	12

References/text books

1. Wimpunny, R.S. 1966. Plankton of the Sea. Feber and Feber Limited, London
2. Raymont, J.E. G, 1973. Plankton and Productivity in the Ocean (Vol.-1) Pergamon Press, London.
3. Raymont, J.E.G. 1973. Zooplankton (Vol-II) Pergamon Press, London.

4. Parsons, J.R. M. Takahasi and hargrave 9IIed), 1977, Biological oceanographic Processes. Pergaman Press, Oxford.
5. Spoel S.Vender and Heyman, R.P. 1983. Comperative atlas of Zooplankton biological patterns in the oceans, Springer, Verlag, Berlin.
6. Tomas, C.R., 1993. Marine phytoplankton: A guide to naked flagellates and coccoithophores. Academic Press
7. Mitra, A., Banerjii, K., Gangopadhyay, A., 2011, Introduction to marine plankton

Course Name: Benthic Ecology **Course No.:** MARB MPE2

Credits: 04 **Core/Elective:** Elective

Course Details

Units	Contents	Hours
Unit 1	**Intertidal zone** The inter tidal, subtidal and deep sea Ecology of Rocky shore, Sandy shore and Muddy shore communities Zonation in Rocky shore Sediment-Organism Interrelations Ecology of Meiobenthos	15
Unit 2	**Subtidal zone** Definition and salient features of continental shelf and slope Adaptation of sub-tidal communities Importance of subtidal benthos on fisheries	15
Unit 3	**Deep sea** General characteristic features of bathyal; abyssal and hadal regions Adaptation of deep sea organisms Economic importance of deep sea animals Methods of collection of deep sea benthos, qualitative and quantitative estimation of deep sea benthos, species diversity in the deep sea Parallel level bottom communities.	15

Units	Contents	Hours
Unit 4	**Marine borers and foulers** The marine borers and foulers Influence of environmental parameters in succession of fouling community. Economic importance of marine fouling organisms Antifouling measures for the protection of marine structures Relation between fouling and corrosion.	15

References/text books

1. Jaffery S. Levinton, 1982. Marine Ecology. Prentice Hall Inc. New Jersey.
2. Balakrishna Nair, N. and D.M. Thampy, 1980. A text book of Marine Ecology, the MacMillan Co. India Ltd. New Delhi.
3. Gage, J.D. and P.A. Tyler, 1991, Deep-sea Biology, Cambridge University Press, Cambridge.
4. Hedgepetch, J.W. (Ed.) 1974, Treatise on marine Ecology and Pale ecology, Vol.II Geological Society of America, New York.
5. Vewell, R.C. 1970, Biology of Intertidal Animals. Marine Ecological Survey Ltd. Pavershan, Kent, U.K.
6. Watt. K.E.F. 1966, systems analysis in Ecology Academic Press, New York.
7. Nybakken, J.W. Readings in marine ecology.
8. Lalli & Person: Biological Oceanography, Pergamon Press, London

Course Name: Marine Ecology and Biodiversity Conservation **Course No.:** MARB MPE3

Credits: 04 **Core/Elective:** Elective

Course Details

Units	Contents	Hours
Unit 1	**Introduction** Introduction to marine biodiversity Factors affecting marine biodiversity- environmental (salinity,	10

Units	Contents	Hours
	temperature and bathymetry) and biological factors (reproduction and food availability)	
Unit 2	**Marine ecology** Population ecology - Population growth and factors a affecting population growth; Concept of Carrying capacity Community concept - Structures and functions of ecological community, Diversity and stability in community- species diversity, species richness, species evenness Ecosystem function - Energy flow in ecosystem, Food chain and food web in marine and estuarine environment; Bio-geo-chemical cycling of nutrients Species interaction: Types of interactions- interspecific and intraspecific competition, Predation, Mutualism/Symbiosis, Commensalism, Ammensalism	15
Unit 3	**Biodiversity assessment in marine ecosystems** Mapping of marine ecosystems Methods for biodiversity assessment in mangrove, seagrass, salt marsh, coral reef, sand dunes – quadrat method, line transect method	10
Unit 4	**Threats to marine biodiversity** Anthropogenic impact on marine biodiversity Impact of pollution on marine biodiversity- Domestic, industrial and agricultural Biological invasion Eutrophication Climate change impact on marine ecosystem and biodiversity Habitat destruction and fragmentation	15
Unit 5	**Biodiversity conservation and management** IUCN categories Marine scheduled species of India Conservation Laws and strategy – Wildlife Protection Act, 1972;	10

Units	Contents	Hours
	Forest Conservation Act, 1980; Biological Diversity Act, 2002; Water (Prevention and Control of Pollution) Act, 1974, Coastal Regulation Zones (CRZ), Biosphere reserve, National Park, Sanctuary, Ramsar site Ecosystem services	

References/text books

1. Barnes R. S. K, 1999, Introduction to Marine Ecology, Blackwell Science.
2. Martens et al., 2006, Marine Biodiversity Patterns and Processes, Assessment, Threats, Management and Conservation, Springer, Dordrecht
3. Hiscock, K. 2014. Marine biodiversity conservation: A practical approach, Routledge
4. English, S., Wilkinson, C., Baker, V., 1997. Survey Manual for Tropical Marine Resources, Australian Institute of Marine Science, Townsville
5. Venkataraman, K., Sivaperuman, C. 2015. Marine faunal diversity in India: Taxonomy, ecology and conservation, Academic Press

Course Name: Marine Fisheries **Course No.:** MARB MPE4

Credits: 04 **Core/Elective:** Elective

Course Details

Units	Contents	Hours
Unit 1	**Fishing gears and crafts** Common fishing crafts and gears with special reference to Indian coast, Indigenous crafts used along the Odisha coast, design and construction of fishing crafts and fishing boats. Methods of detection of fish in the sea, Fish Aggregating Device (FAD) Seine net, trap net, drop net, cast net, gill net, fixed net, bag net, scoop net, hooks and lines	10
Unit 2	**Anatomy and physiology** Basic anatomy of fishes	15

Units	Contents	Hours
	Detail structure and function of gills Types of air breathing organs in fishes Structure and function of swim bladder Food and feeding habit of pelagic and demersal fishes Reproductive system in fishes and reproductive mechanism Endocrine organ and their functions	
Unit 3	**Fish Ecology** General attributes of fish population growth Mortality and recruitment of the fishes in the oceans Principle of tagging in fish population studies and their significance Hydrography in relation to fisheries, Factors affecting the maturation and spawning of fishes Age determination in fishes	15
Unit 4	**Fish products and their preservation** Diversified fish products and by products dried and cured Fish meal and oil, fish oils, fish liver oil, liver rinsed fish insilage, fish maws and isinglass Fish preservation, canning mechanism, freezing of fish, spoilage of wet fish and causative factors	10
Unit 5	**Fishery resources of India** Acts of overfishing and its effect on sustenance of marine fisheries The major marine fishery resources of Indian seas- Sardine, Mackerel, Pomfrets, Tuna and Hilsha fishery resources The fisheries of Chilika lake Estuarine fishery resources of Odisha Methods of resource assessment, Survey of fish eggs and fish larvae with reference to fish population features	10

References/text books

1. Nedelee: FAO catalogue at small scale fishing gear.
2. Sohile: FAO catalogue of fishing gear designs.
3. Trgung: Fishing boats of the world, Vol.1, 2 & 3
4. K.F, Lagler T.E. Bardach and R.R. Miller, 1962. Ichthyology. John Wiley and Sons and Inc. New York.
5. Carl, E. Bond, 1979. Biology of fish, W.B. Saunders Company. Philadelphia.
6. King, M. 1995. Fisheries biology Assessment and Management. Fishery News Books.
7. Jones, E.R.H. 1980. Fish Migration Edward Arnold Ltd, London.
8. Nikolski, G.V. 1969. Theory of fish population dynbamics as th biological background for rational exploitation and management of fishery resources. Otto Roeltz Science publishers. Berling.
9. Saint and Shury: Commercial fishery methods.
10. D.V. Bal and K.V. Rao, 1984: Marine Fisheries.
11. Jhingran, J.V: Fish and Fisehries of India.

Course Name: Coastal and Marine Aquaculture **Course No.:** MARB MPE5

Credits: 04 **Core/Elective:** Elective

Course Details

Units	Contents	Hours
Unit 1	**Introduction** Fundamentals of aquaculture Types of aquaculture scope and importance of coastal aquaculture	10
Unit 2	**Construction of aquaculture farm and hatchery** Design and construction of fish farm Design and construction of shrimp hatchery Site selection, factors of consideration and development of infrastructure	15
Unit 3	**Seed Production and transportation** Methods of seed collection- Induced breeding and wild	15

Units	Contents	Hours
	Packing and transportation of fish seed	
Unit 4	**Culture** Mono culture and poly culture, Traditional, Extensive, semi-intensive and intensive System of culture, Cages, Pen and Raft culture, Culture of mullets, milk fish, ornamental fish, prawn, crabs, oysters, mussels and seaweeds, Culture of live feeds	10
Unit 5	**Maintenance of aquaculture farm** Common aquatic weeds in fish farm and their methods of control Fish diseases in culture fishes and their control Effect of pollution on aquaculture	10

References/text books

1. Inversion, E.s. 1976, Farming on the edge of the sea. Fishing News (Books) Limited, London.
2. Chen, T.P. 1976, Aquaculture Practices in Taiwan Fishing News (Books) Ltd. London.
3. Chapman V.J. 1980: Sea weeds and their uses, Chapmans Hall, London.
4. Kurien C.V. and Subastian, V.O. 1982, Prawn and Prawn fisheries of India, Hindustan Publishing Corporation (India), Delhi.
5. Pillay, T.R. ed. 1982, Coastal aquaculture in Indo-Pacific region, Fishing News (Books) Limited London.
6. Bal. D.V. and D.V.Rao, 1984. Marine Fisheries Tata, Mc.Graw. Hill Publishing Co.Ltd., New Delhi.
7. Meske, C. 1985, Fish aquaculture-technology and experiments, Pergamon Press Ltd. London.
8. Guasim, S.Z. 1998, Glimpses at the Indian Ocean, University Press (India) Hyderabad.
9. Dey, V.K. Ornamental fishes, hand book on Aquafarming, Presented by MPEDA, Kochi.
10. Nayak. L. 2001, Recent trends in aquaculture, Berhampur University.

Course Name: Marine Biotechnology **Course No.:** MARB MPE6

Credits: 04 **Core/Elective:** Elective

Course Details

Units	Contents	Hours
Unit 1	**Introduction** Marine biotechnology - History and its applications in marine biology	10
Unit 2	**Basics of genetic engineering** Plasmid and bacteriophages DNA isolation and cloning Insertion of foreign DNA into host cell Recombinant DNA technology	15
Unit 3	**Marine natural products** Bioactive marine natural products - anti tumor compounds, anti inflammatory / analgesic compounds, anti viral agents Isolation of bioactive compound- liquid extraction, membrane separation, chromatography Identification of marine bioactive compounds- IR, UV, NMR and mass spectroscopy Commercial development of marine natural products- Agar, chitin	15
Unit 4	**Application of biotechnology in aquaculture** Induced breeding in marine organisms, In-vitro fertilization, cryopreservation, Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes.	10
Unit 5	**Tools and techniques in marine biotechnology** RIA, ELISA, FISH, PCR Gene probes	10

References/text books

1. Italy, E (Eds). 1998, New Developments in Marine Biotechnology, Plenum Pub. Corp.
2. Milton Fingerman and Rachakonda Nagabhushanam, 1996, Molecular Genetics of Marine Organisms, Science Pub Inc.
3. Y. Le Gal and H.O.Halvorson 1998, New Developments in Marine Biotechnology. Springer.
4. David H. Attaway, 2001. Marine Biotechnology, Volume 1, Pharmaceutical and Bioactive Natural Products.
5. Rita R. Colwell 1984. Biotechnology in the Marine Sciences (Advances in Marine Science & Biotechnology) Wiley Interscience.
6. Scheupr, P.J. (Ed.), 1984. Chemistry of Marine Natural Products, Chemical and Biological Perspectives. Vol. I III, Academic Press, New York.

Course Name: Marine Microbiology **Course No.:** MARB MPE7

Credits: 04 **Core/Elective:** Elective

Course Details

Units	Contents	Hours
Unit 1	**Diversity and distribution of marine microbes** Ecology of coastal, shallow and deep sea microorganism - importance and their significance Diversity of microorganism - Archaea, bacteria, cyanobacteria, algae, fungi, viruses and actinomycetes in the mangroves and coral environment	10
Unit 2	**Culture method and identification** Methods of collection of water and sediment samples for microbiological studies Methods of isolations and culture of marine bacteria Enumeration of marine bacteria by total and viable counts Identification of marine bacteria by total and viable counts Identification of marine bacteria based on their morphological, physiological and biochemical characteristics Structure and biology of marine bacteria	15

Units	Contents	Hours
Unit 3	**Microbial nutrition** Common nutrient requirements of microbes Requirement for carbon, hydrogen and oxygen Nutritional types of microorganisms Requirements of nitrogen, phosphorus and sulfur, uptake of nutrients by cell	10
Unit 4	**Ecological role of microbes** Microbial role in cycling of N, P, S, and C Concept of microbial loop in relation to marine food web dynamics Role of micro-organisms in DOM production and consumption Role of marine microbes sequestering of carbon dioxide Pollution indictor and pathogenic marine microbes	15
Unit 5	**Microbial genomics** Principles and applications of TFF for microbial molecular analysis DNA/RNA extraction, principles and methods Principles and applications of PCR GEL electrophoresis, DNA purification and visualization techniques	10

References/text books

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2. John Paul 1999. Marine Microbiology, Elsevier.
3. Munn and Munn 1996. Marine Microbiology: Ecology and Applications. BIOS Scientific publisher.
4. Atlas, R.M 1988. Microbiology, Fundamentals and applications Maxwell McMillan International Editions
5. Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications
6. Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons.
7. The Prokaryotes: 1992 A Handbook on the biology of Bacteria. Vol. 1-4 Springer & Verlag New York