Title of the Course: MARINE MICROBIOLOGY [T]

Course Code: MIC-629

Number of Credits: 3, Theory

Contact hours: 45

Effective from Academic Year: 2022-23

Prerequisites	Basic understanding of the unique properties of water, features of marine environments and microorganisms.	
Objective:	• Students will learn microbial diversity in context of various characteristics of marine and coastal environments. • Students will understand specialized tools and techniques used in study of microorganisms present marine and coastal ecosystems.	
Content:		
1.		**(15)**
1.1	Introduction to oceanography: the world's oceans and seas and its demarcations, zonation of the water column with respect to depth and light. Impact of water column zonation on biology. Properties of seawater, physico-chemical factors in the marine environment such as temperature, density, nutrients, salinity, dissolved gases. Ocean phenomena: waves, tides, oceanic currents, Ekman transport and upwelling- its significance and impact on biology in coastal regions and open ocean, Coriolis effect, eddies, gyres, El Nino-Southern Oscillation (ENSO), and its significance.	**9**
1.2	Marine microbial habitats: water column, sediments, estuaries, mangroves, salt marshes, beach ecosystems, coral reefs, deep sea hydrothermal vents, cold seeps.	**6**
2.	**Marine Microorganisms**	**(15)**
2.1	Marine microbes – viruses, bacteria, fungi, phytoplankton, zooplankton: their growth, physiology and contribution to ocean processes. Modes of microbial growth: viable but non-culturable (VBNC) microorganisms, biofilms, microbial mats, epibiosis.	**5**
2.2	Physiology of marine microbes: metabolic diversity and energy-yielding processes: Microbial carbon pump, microbial loop; marine snow; phototrophy and primary productivity, aerobic respiration, anaerobic respiration (denitrification, sulphate reduction, methanogenesis); nitrification, annamox, sulphur oxidation, methanotrophy; fermentation. Carbon dioxide fixation in autotrophs; the role of microorganisms in biogeochemical cycling: carbon, nitrogen, phosphorous, sulphur, iron, manganese.	**5**
2.3	Role of microbes in climate change and global warming. Microbes - a tool of carbon sequestration.	**2**
2.4	Mesocosm- quantification of global warming impact- species	**3**

	composition and turnover, distribution of functional traits, ecological processes; Microcosm- Quantification of global warming on bacterial metabolic rates, productivity.	
3.	**Methods in marine microbiology**	**(15)**
3.1	Sampling equipment: water samplers such as CTD rosette- Niskin sampler, sediment samplers -different types of grabs such as Van Veen grabs, Shipek grabs, Eckman grab and different types of corers- Piston corer, box corer, gravity corer.	**5**
3.2	Analysis of primary productivity: the radiocarbon method; Analysis of bacterial productivity: the thymidine uptake method; Analysis of bacterial productivity: the thymidine uptake method; Measurement of respiration rates: light-dark bottle method	**5**
3.3	Tools to study marine microbial diversity: flow cytometry (bacteria, picoplankton, picoeukaryotes, viruses); molecular approaches such as metagenomics, community fingerprinting and Fluorescence *in situ* hybridization (FISH), Microsensor, Biosensors.	**5**
Pedagogy:	Lectures/tutorials/assignments	
References/ Readings	Belkin, S. and Colwell, R. R., Ocean & Health: Pathogens in the Marine Environment, Springer. (2005)	
	Grasshoff, K., Ehrhardt, M. and Kremling, K., Methods of Seawater Analysis, Verlag Chem., Weinheim. (1999)	
	Hunter-Cevera, J., Karl, D. and Buckley, M., Marine Microbial Diversity: the Key to Earth's Habitability, American Academy of Microbiology. (2005)	
	Intergovernmental Oceanographic Commission, Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. DOI: https://doi.org/10.25607/OBP-1409 Intergovernmental Oceanographic Commission Manuals and Guides : 29 -JGOFS Report; 19. (1994)	
	Meller, C. B., Wheeler, P. A., Biological Oceanography, Wiley-Blackwell Publishers. (2012)	
	Gasol, J.M. and Kirchman, D. L., Microbial Ecology of the Oceans, Wiley- Blackwell Publishers. (2018).	
	Munn, C., Marine Microbiology: Ecology and Applications, Garland Science, Taylor and Francis, N.Y. (2003)	
	Nybakken, J. W. and Bertness, M. D., Marine Biology: an Ecological Approach, Benjamin Cummings, San Francisco. (2005)	
	Parsons, T. R., Maita, Y. and Lalli, C. M., Manual of Chemical and Biological Methods for Seawater Analysis, Pergamon Press, New York. (1984)	
	Strickland, J. D. H. and Parsons, T. R., A Manual of Seawater Analysis, Queen's Printer and Controller of Stationery, Ottawa. (1972)	
	Sournia, A., UNESCO Monographs on Oceanographic Methodology, Vol. 6, Phytoplankton Manual, UNESCO Publishing, Paris. (1978)	
	Tomas, C. R., Identifying Marine Phytoplankton, Academic Press, San	

	Diego, CA. (1996)	
Course Outcomes	● Integrate microbial diversity in context of various characteristics of marine and coastal environments ● Connect the microbes and their role in marine and coastal habitats. ● Categorize and select different methods and tools to study microorganisms in marine and coastal ecosystems. ● Illustrate the various biogeochemical cycles in context of microorganisms.	