2.	Identification of the isolates	
2.1	Biochemical tests for characterization of the halophilic archaea.	
2.2	Extraction of archaeal pigment and characterization using UV-Vis spectroscopy.	
2.3	Cellular lipids - Extraction and chromatographic resolution of lipids.	
3.	Screening for hydrolytic enzymes.	
Pedagogy:	Hands-on experiments in the laboratory, video, online data	
References/ Readings	As given under Theory Course MITC-408	
Learning Outcomes	1. Skill development for Isolation, culturing of Archaea and identification of archaea. 2. Screening the archaea for bioactive molecules.	

Discipline Specific Optional Courses

Programme: M.Sc. (Microbiology)
Course Code: MITE-401
Title of the Course: ENVIRONMENTAL MICROBIOLOGY AND BIOREMEDIATION [T]
Number of Credits: 3, Theory
Contact hours: 45
Effective from Academic Year: 2022-23

Prerequisites	It is assumed that the students have a basic knowledge of ecosystem structure and environmental pollution.	
Objective:	To introduce the concepts of microbial diversity, community structure, role of microorganisms in biogeochemical cycles, sustainable development and bioremediation.	
Content:		
1.	**Microbial Ecology**	**(15)**
	Ecosystems: Concept of ecosystem, habitat, econiche. Components and functioning of ecosystem, Microbial interactions with biotic environment. Ecological pyramids, energy flow, food chain and food web. Concepts of microbial guild, *r* and *k* selection concept, role of microbes in ecological succession. **Microbial diversity in ecosystem and Community structure:** The expanse and estimates/measurement of microbial diversity- Rank-abundance curve (species richness and eveness), indices of diversity (Shannon index, simpson index, Gini-simpson index), Culture based microbial diversity, Newer high throughput approaches (extinction culture, diffusion chamber/ichip, gel micro droplet method, co-culture method, flow cytometry) for exploring microbial diversity from	

	environmental samples. Culture independent molecular methods (DGGE, FISH, phylochips, metagenomic library) for understanding microbial community structure. Metabolic diversity of microbial communities in diverse environments (aquatic and terrestrial). **Microbial biofilms in environment**: Quorum sensing in bacteria; Nature and significance, Microbial mat.	
2.	**Biogeochemical processes, Pollution and sustainable devvelopment**	**(15)**
	Biogeochemical cycles: Physiological, biochemical, microbiological aspects of carbon, nitrogen, phosphorous, sulphur, Fe and Mn cycles.	
	Impacts of pollution on ecosystem and Concepts of sustainable development: Effect of marine pollutants on productivity and sustainability of aquatic and terrestrial econiche. Eutrophication, HABs, biomagnification. Ballast water and significance of invasive microorganisms. Climate change and occurrence of microbial diseases. Environment impact assessment (EIA) studies. Concept of sustainable development and application of microorganisms towards sustainable development; Microorganisms for clean energy.	
3.	**Biomonitoring and microbial bioremediation of pollutants.**	**(15)**
	Application of microorganisms for pollution Biomonitoring-biotracers and biosensors, microbes as Bioindicators. **Bioremediation technologies**: Microorganisms for bioremediation of oil spills (biodegradation, bioaugmentation, biostimulation, biosurfactants) heavy metals, xenobiotics (biotransformation, co-metabolism) and recalcitrant pesticides. **Waste water treatment plants**: Primary, secondary and tertiary treatment of waste water. Concept of microbial consortia and microbial biofilms in waste management and pollution abatement. **Valorization of agro waste**: Containing lignin, cellulose and pectin. Intimate coupling of photocatalysis and microbial biodegradation (ICPB) for advanced treatment of organic pollutants.	
Pedagogy:	Lectures/tutorials/assignments	
References/ Readings	Cavicchioli, R., Ripple, W. J., Timmis, K. N., Azam, F et al. (2019). Scientists' warning to humanity: microorganisms and climate change. Nature reviews microbiology, 17, 569- 586.	
(Latest editions)	Kennish, M. J. Practical Handbook of Estuarine and Marine Pollution. CRC Press, Francis and Taylor.	
	King, R. B., Sheldon, J. K., & Long, G. M. Practical Environmental Bioremediation: The Field Guide. CRC Press.	
	Liu, W-T. and Jansson, J. K., Environmental Molecular Microbiology, Caister Academic Press.	
	Medigan, M. T., Bender, K. S., Bukley, D. H., Sattley, W. M., & Stahl, D. A. Brock Biology of Microorganisms. Pearson.	
	Mitchell, R. and Kirchman, D. L., Microbial Ecology of the Oceans, Wiley Publishers.	
	Munn, C., Marine Microbiology: Ecology and Applications, Garland	

	Science, Taylor and Francis Group, N.Y.	
	Murugesan, A. G. and Rajakumari, C., Environmental Science and Biotechnology: Theory and Techniques, MUP Publishers.	
	Naik, M. and Dubey, S. K., Marine Pollution and Microbial Remediation, Springer Publications.	
	Norris, J. R. and Ribbons, D.W., Methods in Microbiology, Vol. 18 & 19, Academic Press	
	Osborn, A. M. and Smith, C. J., Molecular Microbial Ecology, Taylor and Francis.	
	Satyanarayana, T., Johri, B. and Anil, T., Microorganisms in Environmental Management, Springer Publishers	
	Scragg, A. H., Environmental Biotechnology, Longman Publishers.	
	Sharma, P. D., Environmental Microbiology, Alpha Science International.	
	Willey, J. M., Sherwood, L. M., & Woolverton, C.J. Prescott's Microbiology. McGraw-hill Education.	
Learning Outcomes	Applying the understanding of the microbial diversity, community structure and role of biogeochemical cycling of nutrients, for bioremediation and sustainable development.	

Programme: M.Sc. (Microbiology)
Course Code: MIPE-401
Title of the Course: ENVIRONMENTAL MICROBIOLOGY AND BIOREMEDIATION [P]
Number of Credits: 1, Practical
Contact hours: 30
Effective from Academic Year: 2022-23

Prerequisites	It is assumed that the students have a basic knowledge of environmental pollution and microbiology.	
Objective:	To familiarize with the techniques of waste water analysis, biodegradation of aromatic pollutants and bioremediation of metal/metalloid pollutants.	
Content:		**(30)**
1.	Analysis of water samples for COD, BOD and microbial load.	
2.	Isolation of hydrocarbon degrading microorganism (degradation of sodium benzoate/Naphthalene).	
3.	Isolation of biosurfactant producing microorganisms.	
4.	BATH assay for microbial adherence.	
5.	Isolation of selenite/tellurite resistant microorganisms for application in bioremediation.	
Pedagogy:	Hands-on experiments in the laboratory, video, online data	
References/ Readings	As given under Theory Course MITE-401	
Learning Outcomes	1. Able to perform waste water analysis; biodegradation of aromatic pollutants 2. Able to demonstrate the role of microorganisms in bioremediation.	