Periyar University

Periyar Palkalai Nagar, Salem – 636 011

Department of Environmental Science

M.Phil. Environmental Science

Syllabus

(w.e.f. 2018-2019 onwards)

PERIYAR UNIVERSITY

M.Phil. ENVIRONMENTAL SCIENCE

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

(Candidates admitted from 2018-2019 onwards)

1. INTRODUCTION

Since the beginning of industrialization and urbanization, we have been facing with numerous environmental issues keep on with increasing population such as air, water and soil contamination, energy crisis, land degradation, deforestation, loss of biodiversity, global warming and climate change on rise, etc., Considering the above issues, addressing environmental problems from a scientific perspective is utmost important for today's world. So, there is a need to develop the next generation as skilled professionals at research levels in a multidisciplinary Environmental Science programme to solve the environmental issues.

2. PROGRAMME OBJECTIVES

The general objective of Master of Philosophy in Environmental Science programme is to provide the students with the scientific principles, concepts, and methodologies required to understand the interrelationships of the organisms and ecosystem, and sustainable development in research level.

The specific objectives of the programme are:

- To understand the structure and function of ecosystems.
- To train and generate skilled graduates to identify and analyze environmental problems both natural and engineered.
- To generate skilled graduates to evaluate the environmental issues, and to find alternative solutions to resolve or prevent.
- To produce students with research capabilities in major areas of environmental science to provide innovative solutions to mitigate all the environmental issues.

3. LEANING OUTCOMES

After successful completion of the two years programme, the students are expected to have the following:

- Complete knowledge in ecosystem, natural resources, biodiversity and its importance, environmental biogeochemical processes, and geographical information.
- Skills in remote sensing and Geographic Information Systems technology to monitor the environmental issues.
- Capability in applying microbes for potential environmental cleanup and energy production, and to generate value added products through waste recycling.

- Good knowledge and skills in environmental impact assessment, auditing pollution monitoring and management.
- Expertise to become environmental consultants / managers at local, regional and national levels industrials/ institutions/organizations.
- Skills to become an entrepreneurs in all fields of Environmental Science.
- Qualification to be employed as a researcher / scientist / faculty in colleges / universities / Research and Development in research organizations at local and across the nation.

4. ELIGIBILITY

Candidates who have qualified for postgraduate degree (any biological science) of this University or any other University recognized by the syndicate as equivalent there to shall be eligible to register for the Degree of Master of Philosophy (M. Phil.,) in their respective subject and undergo the prescribed course of study in an approved institution or department of this University.

Candidates who have qualified their postgraduate degree on or after 1st January, 1991 shall be required to have obtained a minimum of 55% of marks in their respective postgraduate degrees to become eligible to undergo the prescribed course of study in an approved Institution or department of this University.

For the candidates belonging to SC/ST community and those who have qualified for the Master's degree before 01.01.1991 the minimum eligibility marks shall be 50% in their Master's Degree.

5. DURATION

The duration of the M. Phil., course shall extend over a period of one year from the commencement of the course.

6. COURSE OF STUDY

Course of study for the degree shall consist of (a) Part-I, comprising three written papers according to the syllabus prescribed from time to time and (b) Part-II Dissertation.

Part–I shall consist of Paper–I - Research Methodology and Paper - II an advanced paper in the main subject. There shall be a third paper which shall be the background paper relating to the proposed Dissertation conducted internally by the College/Departments.

Part-II is Dissertation.

7. SCHEME OF EXAMINATIONS

Part-I Written Examination (Papers I, II & III)

The examination of papers I, II and III shall be held after the completion of 90 working days of the course. The duration for each paper shall be 3 hours carrying a maximum of 100 marks.

Paper–III examination will be conducted by the College/Departments and the marks obtained by the candidate along with the question paper and valued answer scripts shall be sent to the University at least 15 days before the commencement of the examinations of paper I and II.

The examiners will be appointed from the panel of four names for each paper (I and II) submitted by the college/Departments concerned. If one examiner awards a pass mark and the other fail mark, the paper will be valued by a third examiner whose award of marks will be final.

Part-II: Dissertation

The exact title of the Dissertation shall be intimated within one month after the completion of the written examination. Candidates shall submit the Dissertation to the University through the Supervisor and Head of the Department at the end of the year from the commencement of the course which shall be valued by internal examiner (supervisor) and one external examiner appointed by the University from a panel of four names sent by the Supervisor through the Head of the Department/Principal at the time of submitting the Dissertation.

The examiners who value the Dissertation shall report on the merit of candidates as "Highly Commended" (75% and above) or "Commended" (50% and above & below 75%) or "Not Commended" (Below 50%).

If one examiner commends the Dissertation and the other examiner, does not commend, the Dissertation will be referred to the third valuation and his valuation shall be final. Submission or resubmission of the Dissertation will be allowed twice a year.

Scheme of Examinations

The allotment of marks for (i) Theory (ii) Dissertation and Viva-Voce are as follows:

(i) Theory Papers

Internal	: 25 Marks
External	: 75 Marks
Total	: 100 Marks

(ii) Project Dissertation

Dissertation	: 100 Marks
Internal	: 50 Marks
Viva-Voce	: 50 Marks
Total	: 200 Marks

Internal assessment for course I, II and III

Test	: 10 Marks
Seminar	: 10 Marks
Attendance	: 05 Marks
Total	: 25 Marks

S. No.	Paper	Title of Paper	Exam Hrs.	Max. Marks
Part I				
1.	Paper I	Research Methodology	3	100
2.	Paper II	Advances in Environmental Science	3	100
3.	Paper III	Research Specialization Paper	3	100
Part II		Dissertation	-	200
				Total 500

8. PASSING MINIMUM

A candidate shall be declared to have passed Part-I of the examination if he/she secures not less than 50% of the marks in each paper including Paper-III for which examination is conducted internally.

A candidate shall be declared to have passed Part-II of the examination if his/her dissertation is at least commended, or else the candidate shall be declared to have failed in the examination.

9. RESTRICTION IN NUMBER OF CHANCES

No candidate shall be permitted to reappear for the written examination in any paper on more than two occasions or to resubmit a Dissertation more than once. Candidates shall have to qualify for the degree passing all the written papers and dissertation within a period of three years from the date of commencement of the course.

10. CONFERMENT OF DEGREE

No candidate shall be eligible for conferment of the M. Phil., degree unless he/she is declared to have passed both the parts of the examination as per the regulations.

11. QUALIFICATIONS FOR PERSONS CONDUCTING THE M. PHIL., COURSE

No teacher shall be recognized as a Supervisor unless he possesses a Ph. D., degree or two years of PG teaching experience after qualifying for M. Phil., or M.Litt., Degree.

Only the postgraduate departments of affiliated colleges and departments of the University will be recognized for conducting the M. Phil., course provided; however, the Syndicate shall have the power to decide any other institutions of higher learning / research within the University area for conducting the M.Phil., course on merits.

M.Phil., ENVIRONMENTAL SCIENCE (Choice Based Credit System)

Part	Course	Course code	Name of the Course	Credit	Marks		
					IA	UE	Total
I	I	18MPDEVS01	Research Methodology	4	25	75	100
	II	18MPDEVS02	Advances in Environmental Science	4	25	75	100
	III	18MPDEVS03	Research Specialization paper	4	25	75	100
II	IV	18MPDEVS04	Dissertation and Evaluation Viva-voce	8+4 (12)	50	100 50	150 50
			Total	**24**	**125**	**375**	**500**

PAPER - I

RESEARCH METHODOLOGY

Paper-I

RESEARCH METHODOLOGY

Course Objectives:

The purpose of this course is to make the students to get introduced to the methods of doing research on focused areas of the subject, to make them understand the basic principles and instrumentation of all analytical equipments and to equip the students to write and publish research articles.

UNIT I - Scientific Writings

Need for Basic and Applied Research in Environmental Science – Designing, planning and execution of experiments – Laboratory safety - Literature collection and citations – Components of research report – Significance of tables and figures in research article – Preparation of research articles – Preparation of review articles – Research thesis writing – ISSN and ISBN - *Research quality indicators*: SCI Impact factor and 'h' index – *Reference Materials*: Google scholar, Scopus, Thomson Reuters, Web of Science and Pubmed - *Research bodies and funding agencies*: MoEF, UGC, DBT, DST, CSIR, ICMR, ICAR, DAE and DRDO

UNIT II - Statistical Analysis Tools

Basic elements and tools of Statistical analysis – Arithmetic, Geometric and Harmonic means, Test of significance - Student's 't' test, Chi-square test, F test, ANOVA, Duncan's Multiple Range Test, Correlation and Regression – SPSS statistical software in biological research

UNIT III - Bioinformatic Tools

An overview of Bioinformatics - Computing tools phylogenetics and computational biology. Application of bioinformatics in bioremediation – Biodiversity informatics – Eco-informatics – Genomic databases – Designing of biomolecules – 'Omic' approaches with special reference to green environment

UNIT IV - Experimental Separation Techniques

Centrifugation: Basic principles – Density garadient, isopycnic and refrigerated super speed ultra-centrifugation - *Chromatography:* Principle and applications of column chromatography, GC-MS and HPLC - *Electrophoresis:* Principle and applications of Agarose, SDS PAGE, 2D Gel electrophoreses - DNA, RNA extraction methods - Blotting techniques - Cell culture maintenance - Primary cell and NGM culturing techniques - Techniques in gene amplification analysis - DNA cloning techniques.

UNIT V - Sampling Methods and Analytical Instrumentation

Sampling Methods and Standards with special reference to air, water and soil - *Microscopy*: Basic principle and applications (Bright field, Dark field, Fluorescent, Confocal and electron) – *Instrumentation*: Basic principle and applications of UV – VIS Spectrophotometer, Flame photometer, AAS, ICP- MS, NMR Spectrophotometer and XRD, PCR – RT PCR, ELISA - Working mechanism and concepts of Flow cytometry - GM Counter and Soft Laser Screening Densitometer

Learning Outcomes:

After completing this course, the students will be able to:

- Know the principles of research methods and instruments.
- Identify research problems and design their specific research plans to conduct research.
- Understand the methods of literature collection and publishing research works.
- List required instruments for their specific research experiments.
- Handle the instruments and perform the analysis.
- Collect appropriate quantitative and qualitative research data, and analyze.
- Have developed good scientific communication, including writing, oral communication and presentation skills.
- Use biostatistics and bioinformatics as the research analysis tools.

References

1. de la Guardia M and Garrigues S (2012) Handbook of Green Analytical Chemistry, John Wiley & Sons Ltd., UK.
2. Evans D, Gruba P and Zobel J (2011) How to Write a Better Thesis, Melbourne University Publishing Ltd., Australia.
3. Fulekar, MH (2009) Bioinformatics: Applications in Life and Environmental Sciences, Springer, Netherlands.
4. Fuscaldo AA, Erlick BJ and Hindman B (2012) Laboratory Safety – Theory and Practice, Elsevier, UK.
5. Gurumnani N (2006) Research Methodology for Biological Sciences (1st Edition). MJP Publishers, A unit of Tamil Nadu Book House, Chennai.
6. Hooda P (2010) Trace Elements in Soils, Blackwell Publishing Limited, UK.
7. Hubbard SJ and Jones AR (2010) Proteome Bioinformatics, Humana Press, USA.
8. Manly (2001) Statistics for Environmental Science and Management, Chapman and Hall / CRC Press, Boca Raton, FL, USA.
9. Murray R (2011) How to Write a Thesis, 3rd edition, Open University Press, UK.
10. Rodriguez-Ezpeleta N, Hackenberg M and Aransay AM (2012) Bioinformatics for High Throughput Sequencing, Springer, New York.
11. Sahu PK (2013) Research Methodology: A Guide for Researchers in Agricultural Science, Social Science and Other Related Fields, Springer, India.
12. Suchmacher M and Geller M (2012) Practical Biostatistics with Microsoft Excel, Academic Press, USA.
13. Sundar Rao PSS and Richard J (2012) Introduction to Biostatistics and Research Methods, 5th edition, PHI Learning Private Limited, New Delhi.
14. Tariq H (2012) Basic Bioinformatics, LAP Lambert Academic Publishing, Germany.
15. Webster R and Lark M (2012) Field Sampling for Environmental Science and Management, Routledge, UK.

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2. http://www.ugc.ac.in/
3. http://www.dst.gov.in/
4. http://www.bgbm.org/BioDivInf/def-e.htm
5. http://eol.org/info/234
6. http://www.dcmsme.gov.in/emerge/website_material_on_IPR.pdf
7. http://www.ceeraindia.org/documents/ecomarkindia.htm
8. http://www.csa.com/discoveryguides/gmfood/overview.php
9. http://www.google.com/intl/en/scholar/metrics.html
10. http://images.webofknowledge.com/WOK45/help/WOS/h_citationrpt.html
11. http://www.harzing.com/download/hjournals.pdf
12. http://www.ecoinfoindia.org/
13. http://www.indiaenvironmentportal.org.in/
14. http://www.icar.org.in/files/ICAR-ITP-2010/iiss.pdf
15. http://cpcb.nic.in/Water_Quality_Criteria.php
16. http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php
17. http://www.anketimvar.net/documents/Statistical_Methods_in_Bioinformatics.pdf

PAPER II

ADVANCES IN ENVIRONMENTAL SCIENCE

Paper II

ADVANCES IN ENVIRONMENTAL SCIENCE

Course Objectives:

The purpose of this course is to equip students the advanced concepts of Environmental Science such as toxiciology risk assessment techniques, global environmental issues, natural resource management and ethical policies

UNIT I - Environmental Toxicology and Risk Assessment

Toxicoinformatics – Biomonitoring of environmental contaminants - *Caenorhabditis elegans* as bioindicator of environmental pollutants – Aquatic Toxicology - Pesticides, heavy metals, hydrocarbons, Volatile organic compounds and radiation – Molecular Oncology and Carcinogenesis - Reproductive and Endocrine Toxicology – Xenobiotics – Risk Assessment Procedures.

UNIT II - Global Environmental Issues and Impact Assessment

Climate change, Natural hazards and disasters - Environmental Impact Assessment (EIA) - General guidelines for the preparation of Environmental Impact Statement (EIS) - Scope and types of environmental audit - Environmental Management Plan (EMP) - Environmental quality assessment – ISO standards and certification - Environmental Policies in India - International Conventions, Protocols and Treaties - *International Organizations for Conservations of Environment*: UNEP, WWF, UNESCO, IGBP, IUCN, GEF.

UNIT III - Environmental Contaminants and Remediation Technologies

Organic and inorganic environmental pollutants – Soil and water quality parameters – Physical, chemical and biological remediation technologies – Bioremediation – Mycorrhizoremediation – Phytotechnologies used for remediation of contaminated terrestrial and aquatic environments – Advantages and Limitations of remediation technologies

UNIT IV - Natural Resources and Management

Status and exploitation of water, land, forest, mineral, energy and wild life resources - Sustainable use of resources – CO_2 sequestration - Renewable and non-renewable energy resources - Energy recovery from wastes, Energy conservation policies - Energy balance and energy audit - Principles of remote sensing, GIS and its environmental applications.

UNIT V - Environmental Ethics and Intellectual Property Rights

Composition of Institutional evaluation Ethical Committee (IEC) – GM crops and its environmental issues - *Environmental ethics*: Stewardship ethics and Lifeboat ethics of Garret Hardin - *Intellectual Property Right (IPR)*: Definition – *Types of Intellectual Property Right (IPR)*: Patents, Copyrights, Industrial Design Rights, Trademarks, Trade Dress and Trade secrets
- Case studies of patents with special reference to basmati rice, turmeric and neem – Ecomark – Patent procedure in India

Learning Outcomes:

After completing this course, the students will be able to:

- Understand the advancement and recent developments in the field of Environmental Science.

- Know global environmental issues and methods for their mitigation.
- Understand the significance of natural resources and their conservation.
- Know various strategies for environmental remediation.
- Know the principles of environmental ethics and policies.
- Think about intellectual properties rights (IPR) and patents.
- Practice conservation of natural resources.
- Understand the Advanced GIS environmental applications.

References

1. Amiard-Triquet C, Amiard J-C and Rainbow PS (2013) Ecological Biomarkers – Indicators of Ecotoxicological Effects, CRC Press, Boca Raton, FL, USA.
2. Aswathanarayana U (2012) Natural Resources: Technology, Economics and Policy, Taylor and Francis, UK.
3. Botkin DB and Keller EA (2012) Environmental Science, 8th edition, Wiley India Pvt. Ltd., New Delhi.
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6. Grebner DL, Bettinger P and Siry A (2013) Introduction to Forestry and Natural Resources, Academic Press, UK.
7. Kreipe M (2010) Genetically Modified Food - Trade Regulation in view of Environmental Policy Objectives, Diplomica Verlag, GmbH, Germany.
8. Ostrom LT and Wilhelmsen CA (2012) Risk Assessment – Tools, Techniques and their Applications, John Wiley & Sons Inc., NJ, USA.
9. Steinberg P (2013) High-Throughput Screening Methods in Toxicity Testing, John Wiley & Sons Inc., USA.
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14. Wu Y, Carroll JJ and Du Z (2011) Carbon Dioxide Sequestration and Related Technologies, John Wiley & Sons Inc., USA.
14. Yoe C (2012) Principles of Risk Analysis – Decision making under uncertainty, CRC Press, Boca Raton, FL, USA.

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4. http://www.epa.gov/compliance/nepa/eisdata.html
5. http://moef.gov.in/citizen/specinfo/emp.html
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7. http://www.cf.ac.uk/biosi/staffinfo/kille/Lecturers/molbiol1.pdf
8. http://www.math.unt.edu/~rdoyle/1720/ch25-ecosystems.pdf
9. http://www.neemfoundation.org/neem-articles/patents-on-neem.html
10. http://www.csb.uncw.edu/people/eversp/classes/BLA361/Intl%20Law/Cases/Study%20of

%20Basmati%20Rice%20Intl%20Case.ssrn.pdf
11. http://www.angelfire.com/mi/libertyinstitute/st2of1.html
12. http://www.pfc.org.in
13. http://www.nature.com/scitable/knowledge/environmental-ethics-96467512
14. http://www.clu-in.org/products/tins/tinsone.cfm?num=49762463

PAPER III

SPECIALIZATION PAPERS

ENVIRONMENTAL BIOTECHNOLOGY AND NANOTECHNOLOGY

Course Objectives:

The purpose of this course is to introduce the students to the basic concepts, principles and mechanisms of ecotoxicology and to make them aware of biomonitoring procedures of environment risk assessment methods

UNIT I

Environmental Application of Microbes

Introduction to the use of microbes in environmental applications - Biodegradation - Biotransformation - Bioremediation - Bioaugmentation and Biostimulation - Bioremediation of Hazardous Pollutants - Persistent Organic Pollutants and toxic metals.

UNIT II

Biotechnological Products

Conversation of lignocellulose biomass to microbial biofuels - Bioethanol, Biobutanol, and Biogas Production - Biopesticides - Biofertilizers, Bioemulsifiers, Biosurfactants - Biochars - Bioflocculants applications - Industrial enzymes and applications - Cellulase, Laccase, Protease, Xylanase, Tannase, Lipases.

UNIT III

Environmental Bioprocess

Wastewater treatment - Domestic sewage, Industrial wastewater - textile, tannery and pulp industry wastewater - Primary treatment, Secondary Treatment - tertiary Treatment - Sewage sludge dewatering process - Sludge treatment and recycling - Bioleaching - Biomining.

UNIT IV

Nanomaterials for Environmental Applications

Preparation and characterization of metal and metal-oxide nanoparticles - Nanoscale zero valent iron; Titanium dioxide, Zinc oxide, magnetic iron-oxide nanoparticles. Bimetallic and composite nanoparticles - Fe-Pd, Fe-Cu, Fe-Ni, hydroxyapatite - Nano-flocculants - Applications of nanomaterials in water, wastewater, and soil remediation.

UNIT V

Environmental Impacts of Nanomaterials

Environmental impact of nanomaterials: Nanomaterials-bacterial interaction - Impacts of engineered nanomaterials on environmental microbial community - bioaccumulation, cytotoxic, genotoxic effects.

Learning Outcomes:
After completing this course, the students will be able to:

- Understand the potential applications of microbes for environmental cleanup.
- Develop and produce various microbial products
- Understand the background about on nanotechnology.
- Understand the different types of nanomaterials and their properties.
- Understand the wastewater treatment process.
- Acquire skills to synthesis the nanomaterials by different methods.
- Acquire knowledge and skills in nanoremediation of environmental pollutants.
- Develop ecofriendly nanomaterials.

Reference Books

1. Biofertilizers in Agriculture and Forestry, 3rd Edition, (1995) Subba Rao N.S., Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi.
2. Environmental Biotechnology. Jogdand SN (2004) Reprinted & Published by Himalaya Publishing House, Mumbai.3. Hand Book of Environmental Biotechnology (2007)Lawrence K. Wang, Volodymyr Ivanov, Joo-Hwa Tay (2007) Springer Publications.
4. Environmental Biotechnology: Principles and Applications (2013) Murray Moo-Young, W.A. Anderson, A.M. Chakrabarty, Springer Science & Business Media.
5. Nanotechnology in Water Purification Applications Caister Academic Press by T. Eugene, Michele de Kwaadsteniet, Marelize Botes and J. Manuel Lopez-Romero.
6. Encyclopedia of Nanotechnology by M. Balakrishna Rao and K. Krishna Reddy, Vol I to X, Campus Books.
7. Nano: The Essentials – Understanding Nano Science and Nanotechnology – by T. Pradeep; Tata Mc.Graw Hill.
8. Nanobiotechnology: Concepts, Applications and Perspectives (2004), Christof M.Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH
9. Nanobiotechnology - II more concepts and applications. (2007) - Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH
10. Environmental Nanotechnology: Applications and Impacts of Nanomaterials (2007) - Mark Wiesner, Jean-Yves Bottero, McGraw, Hill Professional.

MICROBIAL ECOLOGY

Objectives

The main goal is to know and understand the role of microbes in biogeochemical processes in different ecosystems. To understand the role of microorganisms as agents of environmental change. To recognize microorganisms as indicators of alteration of an ecosystem. To become familiar with current research in environmental microbiology

UNIT I - Microbial Interactions

Distribution of microorganisms in soil- Role of microorganisms in soil fertility - *Interactions among microorganisms*: mutualisms, commensalism, competition, ammensalism, parasitism and predation - *Interactions between microbes and plants*: rhizosphere, phyllosphere, mycorrhizae.

UNIT II - Microbial roles in Biogeochemical cycles

Biogeochemical cycle - Carbon cycle - Role of microbes in carbon cycle - Nitrogen cycle - Mechanism of biological nitrogen fixation - Ammonification - Nitrification - Denitrification and microorganisms involved in the processes. Phosphorous cycle and Sulphur cycle.

UNIT III - Aquatic Microbiology

Methods of water sampling for pollution analysis - *Biofilms for treatment of waste water*: Biofilm development and biofilm kinetics, aerobic biofilms. *Bioreactors for waste water treatments*: Reactor design and types - Different types of water sampling tools and it uses.

UNIT IV - Microbes in Waste Management

Types of wastes - Characterization of solid and liquid wastes; *Use of microorganisms in waste treatment:* Thermophiles, alkalophiles, acidophiles, halophiles and psychrophiles; Treatment of solid wastes - Composting, vermicomposting, silage; *Treatment of liquid wastes*: Primary, secondary (anaerobic and aerobic) – Trickling and activated sludge. *Bioremediation*: Types of bioremediation, basics of bioremediation of surface soil and sludges.

UNIT V - Microbial Applications

Production of enzymes: Cellulase, proteases, amylases; Alcohol and acetic acid production; Microbial leaching of low grade mineral ores; Petroleum pollutant biodegradation; Biodeterioration of paper, leather and wood; *Degradation of Biopolymers*: Xylan, lignin and polyhydroxy alkanoates (bioplastics).

Learning Outcomes

After completing this course, students will be able to

- Apply knowledge of the biology and distribution of certain species of microorganisms, principally bacteria, in order to use them as bioindicators of contamination and other environmental impacts.
- Apply the metabolic processes of microorganisms, principally bacteria, to industrial processes related to the environment.
- Recognize and use the properties of microorganisms, principally bacteria, to remedy problems of contamination and other environmental impacts.
- The knowledge can be used to prevent infections and to protect human and environmental health
- Understand and describe the microbial growth, their diversity and role in biogeochemical processes, and microbial issues in environment.
- Understand the role of microbes in soil fertility, biogeochemical cycles and plant growth promotion
- Know about the impact of microbial water pollutants.
- Apply the microbial processes to clean environmental cleanup.

References

1. Anitori RP (2012) Extremophiles Microbiology and Biotechnology, Caister Academic Press, Norfolk, UK.
2. Barton LL and Northup DE (2011) Microbial Ecology, John Wiley & Sons Inc., NJ, USA.
3. Belen Rodelas Gonzalez and Gonzalez-Lopez J (2013) Beneficial Plant-Microbial Interactions – Ecology and Applications, CRC Press, Boca Raton, FL, USA.
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2. www.pollutionissues.com/A-Bo/Bioremediation.html
3. http://www.personal.psu.edu/jel5/biofilms/
4. www.rdp.cme.msu.edu
5. faculty.weber.edu/mzwolinski/MicrobialEcology/.../Interactions2.pdf
6. www.cebl.auckland.ac.nz/ecogenomics/**wastewater**.html
7. www.ijcea.org/papers/95-A580.pdf
8. ejournal.icrisat.org/agroecosystem/v2i1/v2i1vermi.pdf
9. www.environmental-expert.com/Files/5306/articles/11542/259.pdf
10. www.bioplastics.com/
11. worldcentric.org/biocompostables/bioplastics

SOIL ECOLOGY AND REMEDIATION TECHNOLOGIES

Course objectives

The purpose of this course is to expand the knowledge of (i) types of environmental contaminants and suitable remediation technologies for different environmental compartments (ii) tolerance mechanisms involved in different phytotechnologies and (iii) site specific global case studies.

UNIT I - Environmental Contaminants
Organic Pollutants: Sources and impacts of pesticides, PCBs, PAHs, petroleum hydrocarbons; *Explosives*: TNT & RDX; *Inorganic Pollutants*: Sources and impacts of heavy metals on terrestrial and aquatic environments – Soil quality parameters

UNIT II - Remediation Technologies
Physical - Chemical and Biological technologies – *Isolation*: Capping & sub-surface barriers; *Immobilization*: Solidification/stabilization, Vitrification; *Extraction*: Soil washing; Encapsulation; Bioremediation – Mycorrhizoremediation – Phytoremediation - Dendroremediation – Advantages and Limitations of bioremediation

UNIT III - Terrestrial Phytotechnologies
Phytoremediation of heavy metals in soil - *Basic principles of phytoremediation*: Uptake and transport, Accumulation and sequestration – Phytoextraction – Phytodegradation - Phytovolatilization - Rhizodegradation - Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites - Role of arbuscular mycorrhizal fungi in phytoremediation

UNIT III - Aquatic Phytosystems
Blastofiltration – Rhizoremediation – Phytofiltration - Constructed wetlands - Algal blooms - Phytohydraulics – Riparian Buffers

UNIT IV - Reclamation of Contaminated Sites – Case studies
Scheme of evaluation steps in a project remediation site – Phytoremediation decision tree - Mine site rehabilitation in India - Plants used for dual benefits - Canola case studies for Se phytoremediation and biofortification in California – Phytoremediation and biodiesel production from Jatropha – Phytomining

UNIT V - Tolerance Mechanisms
Phyto and bioavailability of heavy metals in soils – Role of hyperaccumulators in phytoextraction – Continuous or Natural phytoextraction, Chelate-induced phytoextraction – Assessing the efficiency of phytoextraction – Transgenic approaches to enhance phytoremediation of metal contaminated soils - *Sulphur and nitrogen containing metabolites in metal defense mechanism*: Phytochelatins, metallothioneins, polyamines, and amino acids.

Learning outcomes

On successful completion of the course students will be able to:

- understand different types of environmental contaminants
- possess a detailed knowledge of remediation technologies available and their applicability to contaminated sites

- understand what challenges are faced in remediating different groups of contaminants and possible solutions
- critically review scientific literature covering remediation technologies
- apply knowledge and techniques in qualitative and quantitative research approaches
- demonstrate understanding of tolerance mechanism in phytoextraction strategies with global case studies

Text Books

1. Anjum NA, Pereira ME, Ahmad I, Duarte AC, Umar S and Khan NA (2013) Phytotechnologies – Remediation of Environmental Contaminants, CRC Press, Boca Raton, FL, USA.
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ENVIRONMENTAL POLLUTION AND MANAGEMENT

Course Objectives:

The purpose of this course is to gain awareness of environmental pollution and an overview of causes and consequences to natural, economic and social systems, to understand the fundamental principles, control measures and techniques concerning atmospheric, water or terrestrial pollutants.

UNIT I
Air Pollution and Management
Atmosphere: Structure and Composition - *Air pollution*: Sources, Types of pollutants, Transport and dispersion of pollutants – *Sampling*: Air sampling and monitoring (Ambient) - Collection of gaseous pollutants and particulate pollutants, Stack sampling monitoring and analysis of air pollutants - *Control measures and Standards*: Air pollution control techniques and equipment's - Air quality standards - Air quality monitoring and management.

UNIT II
Water Pollution and Management
Water pollution: Sources and effects of water pollution - Water quality standards, Physico-chemical and biological properties of the fresh water and sewage. Fresh and wastewater sampling and monitoring - Methods of analysis - *Treatment technologies for domestic and industrial waste waters*: *Primary treatment*: Pre-treatment, sedimentation and floatation - *Secondary treatments*: Activated sludge process, Trickling filter, Sludge treatment and disposal- *Water management strategies*: Rain water harvesting, Recharging of ground water, Use of domestic waste water, Recycling of waste water, Recycling of industrial effluent after treatment.

UNIT III
Soil Pollution and Management
Soil pollution: Major sources, types and effects on plants and animals - *Soil pollution management technologies*: Physical, chemical and biological methods, Reclamation and Management of waste lands, Soil erosion, Soil conservation, Rural planning and land use pattern.

UNIT IV
Solid Waste Management
Sources, types, and composition of solid wastes - Physical chemical and biological properties of municipal solid waste - Sources, types and properties of household hazardous wastes - Waste collection, handling and segregation, transport, storage and disposal methods - Waste minimization and product recovery - Hazardous waste management and treatment - Integrated waste management technologies

UNIT V
Energy Recovery from Wastes
Fundamental principles of aerobic and anaerobic biological waste treatment processes - Application of microbial systems to the domestic and industrial treatment process. *Anaerobic treatment technology*: Factors affecting anaerobic technology, Advantages. *Energy recovery from wastes*: Microbial Fuel Cell (Electricity), Microbial Electrolysis cell (methane, hydrogen, ethanol, hydrogen peroxide).

Learning Outcomes:

After completing this course, the students will be able to

- To learn about the air, water and soil pollutants, sources and its effects.
- To have clear understanding on the air, water, noise and radiation standards and its techniques.
- Apply relevant techniques, skills and modern engineering tools to solve the environmental problems.

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TOXICOLOGY AND MOLECULAR ONCOLOGY

Course Objectives:

- The course is mainly focus on understanding the role of chemicals in the natural environment and to characterize the adverse effects of chemical substances on the ecosystem and humans.
- To understand the basic processes underlying the transformation of a normal cell to its malignant counterpart, and the consequences of malignant transformation on the cellular and organism level.
- To Understand how the biological knowledge of cancer development is used in modern cancer treatment.
- To Show knowledge and skills in laboratory techniques used in experimental cancer research, and demonstrate knowledge in cancer epidemiology, use basic epidemiological research methods and describe their importance.

UNIT I - Environmental Toxicology

Introduction, Different areas of toxicology, Classification of toxic agents, Routes of exposure – Duration and frequency - Chemobiokinetics and Chemobiodynamics, Spectrum of toxicity - Regulatory toxicology – Toxicity testing and interpretation of laboratory data - Toxicoinformatics - *Caenorhabditis elegans* biology and as bioindicator of environmental pollutants.

UNIT II - Aquatic Toxicology

General principles of aquatic toxicology, Major issues, Chemical interactions – Property of toxic chemical that influence quality criteria and aquatic organisms - Toxicity testing on freshwater and marine organisms - Chronic, early life stage and whole life cycle test – Contaminants – Sewage and effluents - Physico-biochemical toxicogenomics, Remote sensing techniques in assessment of aquatic pollutants - Pesticide toxicology – Degradation, resistance and metabolism in mammals.

UNIT III - Molecular Oncology and Carcinogenesis

Introduction – Historical developments, Classification of mutational changes at the chromosomal level and gene mutations, Chemical mutagens – Alkylating agents and others, Molecular mechanism of mutations – Effects on DNA - Induction and analysis of gene mutations in mammalian cell culture - Chemical carcinogens – Reaction and mechanism of action - Environmental hazards induced carcinogenesis and preventive measures.

UNIT IV - Reproductive and Endocrine Toxicology

Overview of reproductive physiology – Gametogenesis – Spermatogenesis – Oogenesis – Organogenesis - Action of xenobiotics on reproductive process, Hormonal controls, egg production transfer of contaminants by eggs and sperms, Embryo energy metabolism - Changes in pollutant sensitivity during embryonic development in lower vertebrates and invertebrates -

Immunotoxicology and Renal toxicology – Basic concepts and mechanisms.

UNIT V - Heavy metal and Radiation Toxicology

Heavy metal pollution – Toxic effects in animals and human beings - Screening tests for common poison detection and estimation of metals - Radiation toxicology – Ionizing and non - ionizing radiation, Toxic effects of radiation.

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ECOTOXICOLOGY AND RISK ASSESSMENT

Course Objectives:

The purpose of this course is to introduce the students to the basic concepts, principles and mechanisms of ecotoxicology and to make them aware of biomonitoring procedures of environment risk assessment methods

UNIT I - Scope and Basic Concepts

Introduction to ecotoxicology – Historical perspectives and scope. Basic principles of ecotoxicology - Quantal theory of dose response – Lethal dose or concentration, Toxicity and potency, Toxicity and safety, Hypo and hyper sensitivity, Selective toxicity - Toxic responses - Biological, chemical and genetic factors influencing toxicity.

UNIT II - Xenobiotics

Xenobiotics – Classification – Pesticides – Organochlorines, organophosphates, carbamates and synthetic pyrethroids. - PCB's, PAH's, PBDE's, Dioxins and Furans - Heavy metals, Industrial chemicals, Food additives - Source of contaminants, fate, effects and its action in target organs. Normal and abnormal responses to xenobiotics.

UNIT III - Toxicity Mechanisms

Bioconcentration, bioaccumulation and biomagnification of toxicants - Biotransformation of toxicants – General biotransformation processes – Phase I and Phase II reactions - Translocation processes – Absorption, distribution and excretion - Biotransformation of pesticides - Detoxification of heavy metals – Sequestration processes.

UNIT IV - Biomonitoring Procedures

Biomonitoring of environmental contaminants – Criteria, procedures and guidelines - Concept of bioindicators, biomarkers and early warning signal mechanisms - Laboratory testing methods – *In vivo* experiments, *In vitro* and *Ex vivo* assays.

UNIT V - Risk Assessment

Risk assessment procedures - National and International guidelines - Safety evaluation methods – Sampling, testing and surveillance protocols - Usage restriction and decision making - Indian and International guidelines (ICAR, ICMR, FSSAI, FAO/WHO, USFDA, Health Canada) for risk evaluation.

Learning Outcomes:

After completing this course, the students will be able to:

- Understand the basic concepts and principles and mechanisms of toxicity
- Will carry out well planned biomonitoring programs
- Design exposure and risk assessment studies as per the statutory guidelines

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