

UNIVERSITY OF MUMBAI



Syllabus for M.Sc. Semester III & IV

Program: M.Sc.

Course: Environmental Sciences

(Credit Based Semester and Grading System with effect
from the academic year 2012–2013)

M. Sc. Environmental Sciences Syllabus
Credit Based and Grading System
To be implemented from the Academic year 2012-2013

Semester –III

Theory				
Course	Unit	TOPIC	Credits	L / Week
PSEVS301	I	Water and Wastewater Pollution Control	4	1
	II	Air Pollution Control		1
	III	Hazardous and Radioactive Waste Management		1
	IV	Biomedical Waste and Electronic (E-Waste Management)		1
PSEVS302	I	Environmental Monitoring and sampling	4	1
	II	Instrumental methods of environmental analysis-I		1
	III	Instrumental methods of environmental analysis-II		1
	IV	Statistical Aspects		1
PSEVS303	I	Basic concepts of Eco-toxicology	4	1
	II	Toxicants in the Environment		1
	III	Evaluation of toxicity		1
	IV	Organ toxicity		1
PSEVS304	I	Industrial Hygiene	4	1
	II	Industrial Work Environment		1
	III	Disaster Management and Risk Assessment		1
	IV	Safety		1
			16	16
Practicals				
PSEVS3P1		Practicals based on PSEVS301	2	4
PSEVS3P2		Practicals based on PSEVS302	2	4
PSEVS3P3		Practicals based on PSEVS303	2	4
PSEVS3P4		Practicals based on PSEVS304	2	4
Total			08	16
TOTAL			24	32

SEMESTER –IV

Theory				
Course	Unit	TOPIC	Credits	L / Week
PSEVS401	I	Introduction to Ecotechnology	4	1
	II	Sanitation -PhytosanitationAnd Green Inhibitors		1
	III	Climate Change Mitigation And Carbon Sequestration		1
	IV	Restoration Ecology& Remediation Technology		1
PSEVS402	I	Environmental Biotechnology	4	1
	II	Biotechnology in Protection and Conservation of the Environment		1
	III	Organic Farming		1
	IV	Environmental Nanotechnology		1
PSEVS403	I	Understanding sustainable development	4	1
	II	Business strategies and sustainability		1
	III	Sustainable urban development		1
	IV	Sustainability in practice		1
PSEVS404	I	Introduction to principles of Environment Management	4	1
	II	Environment Management Systems and Life Cycle Assessment		1
	III	Environmental Audit and Environmental Economics		1
	IV	Environmental Design(ED) and Modeling		1
			16	16
Practicals				
PSEVS4P1		Practicals based on PSEVS401	2	4
PSEVS4P2		Practicals based on PSEVS402	2	4
PSEVS4P3		Practicals based on PSEVS403	2	4
PSEVS4P4		Practicals based on PSEVS404	2	4
Total			08	16
TOTAL			24	32

Semester -III

PSEVS 301: Advanced Pollution Control Technology

PSEVS 302: Instrumentation and Biostatistics

PSEVS 303: Environmental Toxicology

PSEVS 304: Industrial Hygiene and Chemical Safety

Semester -IV

PSEVS 401: Eco Technology

PSEVS 402: Environmental Biotechnology and Nanotechnology

PSEVS 403: Sustainable Management

PSEVS 404: Environmental Management

SEMESTER -III

PSEVS 301

Advanced Pollution Control Technology

Unit I: Water and Wastewater Pollution Control

15 L (1 Credit)

- General scheme for the treatment of water for drinking purpose.
- Water Treatment: UV, H₂O₂, Ozonization, chemical precipitation, disinfection, adsorption, softening, desalinization / demineralization, membrane processes.
- Biological treatment processes for wastewater- **aerobic processes**: Suspended floc type- the activated sludge processes. Extended aeration, Aerated lagoons, Waste stabilization ponds, rotating biological contact system, the trickling filter process. **Anaerobic processes**: Flow through systems and contact systems. UASB reactors and modifications. Sludge types, treatment and disposal. Processing of sludges- conditioning, thickening, dewatering, drying, incineration and disposal.
- Concept of common effluent treatment plant (CETP) their importance and advantages, role in wastewater treatment. Unit processes involved. Effluent discharge standards, industry specific minimum and national standards.

Unit II: Air Pollution Control

15 L (1 Credit)

- Treatment Processes for Particulate matter: Absorption in liquids by Scrubbers, adsorption on solids. Combustion: flaring, thermal incineration, catalytic oxidation.
- Treatment Processes for other gaseous pollutants: Odour, VOCs, oxides of sulphur and nitrogen emissions.
- Indoor air quality management, principles and control measures, steps for improving indoor air quality.
- Auto-exhausts, its components. Control of auto-exhausts emissions. Emission specific control options, use of after burners, engine modifications / tuning; importance of good maintenance and driving habits.

Unit III: Hazardous and Radioactive Waste Management **15 L (1 Credit)**

- Hazardous wastes: Sources and characteristics. Classification. Health and environmental effects. Safe storage, transport and treatment of. Stabilization and disposal Criteria for selection for secured and unsecured landfill disposal sites.
- Radioactive waste: sources, classification, health and safety aspects. Control and Management of radioactive wastes

Unit IV: Biomedical Waste and Electronic (E-Waste Management) **15 L (1 Credit)**

- Biomedical Waste: Definition, Sources of generation, categories, colour coding system for segregation, transportation specifications, treatment methods: Incineration, Microwave, Plasma Pyrolysis, Hydroclave etc. Treatment and disposal of Plastic waste, Treatment and disposal of metal sharps. Biomedical Waste (Handling and Management) Rules, 1998
- E-Waste: Sources of generation, categories, segregation, transportation, treatment methods: Plastic waste treatment and disposal. E-Waste (Handling and Management) Rules 2011

TEXTS/REFERENCES

1. Wastewater Treatment for Pollution Control: Soli J. Arceivala, Tata McGrawHill Publishing Company, New Delhi.
2. Water Supply & Sanitary Engineering: G.S. Birdie
3. Textbook of Water Supply & Sanitary Engineering: S.K. Husain
4. Water Supply & Sanitary Engineering: R. C. Rangwala and S. C. Rangwala, Charotal Publishing House, Anand.
5. Wastewater Treatment: M. N. Rao, A. K. Datta, IBH Publishing Company, New Delhi.
6. A Textbook of Sanitary Engineering: Vinayak Gharpure, Engineering Book Publishing Company, Pune.
7. Water Pollution: V. P. Kudesia, Pragati Prakashan, Meerut.
8. Environmental Problems and Solution: D.K. Asthana, S.Chand and Company, New Delhi.
9. A Textbook of Environment: K. M. Agarwal and P.K. Sikdar, Macmillon India Ltd, Nagpur
10. Environmental Chemistry : B.K. Sharma, and H. Kaur.
11. Elements of Environmental Chemistry : H.V. Jadhav.
12. Environmental Chemistry : S. K. Banerjee.
13. A text book of Environmental Chemistry and Pollution Control : S.S.Dara.

SEMESTER -III

PSEVS 302

Instrumentation and Biostatistics

Unit I:Environmental Monitoring and sampling

15 L (1 Credit)

- Concepts of environmental monitoring and its significance.
- Methods of physical characterization of samples.
- Sampling of air ,water and soil:- Protocol and methods of sampling, sampling devices, Preservation, storage and processing of air, water and soil samples

Unit II:Instrumental methods of environmental analysis- I

15 L (1 Credit)

- Conductometry, Potentiometry, Voltammetry :Theory, instrumentation and applications.
- Colorimetry and spectrophotometry: Electromagnetic radiation spectrum. Interaction of radiation with matter. Beer- Lambert's law, Flame photometry.
- Conventional microscopy and Scanningelectron microscopy.
- Hyphenated techniques for analysis – GC-MS, HPTLC, GC-AES. Electrophoresis: Theory , classification , instrumentation and applications.

Unit III:Instrumental methods of environmental analysis- II

15 L (1 Credit)

- Principle, instrumentation and environmental applications of Neutron Activation Analysis, X-Ray Fluorescence, X-Ray Diffraction, Thermogravimetry.
- Continuous monitoring analysis – fluorescent analyzer for SO₂, chemiluminescentanalyzer for NO_x, NDIR for CO, Flow injection analyzer.

Unit IV:Statistical Aspects

15 L (1 Credit)

- Collection, classification and tabulation of data. Essentials of good tabular form. Preparation of one-way and two-way frequency tables. Diagrammatic and graphical representation of data (data bar, pie, picot and histograms, frequency polygons), frequency curves and cumulative curves.
- Measures of central tendency and dispersion : mean. median, mode , range, standard and relative deviation,coefficient of variation, skewness, kurtosis confidence limits and confidence intervals and normal distribution curve, Analysis of variance one way and two way classification, probit analysis
- Accuracy, precision and errors: Classification, Minimisation of errors, Rejection of data . Z, t, F, and chi-square tests
- Correlation and Regression: Pearson's coefficient, Spearman's coefficient, regression lines and their use. Curve fitting.
- Probability: Exclusive and independent events, addition and multiplication theorems, dependent events and conditional probability

TEXTS/REFERENCES

1. Fulekar, M. H. and BhawanaPathak “Bioinstrumentation” I K International Publication, New Delhi, 2013.
2. Willard. H., Merritt, L., Dean, D.A. and Settle F.A., ‘Instrumental Methods of Analysis’, 7th edition, Wordsworth, New York, 1998.
3. Galen. W. Ewing, ‘Instrumental Methods of Chemical Analysis 5th edition, McGraw Hill, New York., 1995.
4. Roger Reeve, Introduction to Environmental Analysis, John Wiley & Sons Ltd, 2002
5. Fundamentals of Analytical chemistry, D.A. Skoog, D.M. West and F.J. Holler, Harcourt Asia PTE. Ltd., 7th edition, New Delhi, 2001.
6. APHA standard methods for Water and Wastewater Examination, 20th Edition, Washington, 1998.

SEMESTER -III

PSEVS 303

Environmental Toxicology

Unit I: Basic concepts of Eco-toxicology

15 L (1 Credit)

- Introduction to ecotoxicology, Principles of toxicology, scope of toxicology.
- Types of toxic substances - degradable and non-degradable. Factors influencing toxicity, drug toxicity.
- Biochemical basis toxicity – mechanism of toxicity and receptor mediated events, acute and chronic toxicity.
- Sigmoid relationships, Corollary of toxicology. Influence of ecological factors on the effects of toxicity.

Unit II: Toxicants in the Environment

15 L (1 Credit)

- Toxic substances in the environment, their sources and entry routes.
- Transport of toxicants by air and water: Transport through food chain - bioaccumulation and biomagnification of toxic materials in food chain.
- Toxicology of major pesticides- biotransformation, biomonitoring, programs and parameters of biomonitoring, concept of bioindicator, bioindicator groups and examples.
- Environmental impacts of pesticides: Physiological and metabolic effects on flora and fauna.

Unit III: Evaluation of toxicity

15 L (1 Credit)

- Methods used to assess toxicity classification of toxic materials.
- Concepts of Bioassay- types, characteristics. Importance and significance of bioassay,

Microbial bioassay for toxicity testing, Bioassay test models and classification.

- Threshold limit value, LC50 LD50. Toxicity Testing, Concept of Dosimetry: lethal, sub-lethal & chronic tests
- Dose response curves

Unit IV: Organ toxicity

15 L (1 Credit)

- Hepatotoxicity: Common examples of hepatotoxicants, injuries caused to liver
- Nephrotoxicity: Common examples of nephrotoxicants, injuries caused to kidney
- Pulmonary toxicity: Common examples of pulmonary toxicants, injuries caused to lungs.
- Neurotoxicity: Common examples of neuro toxicants, injuries caused to nervous tissues.

TEXTS/REFERENCES

1. Principles of Environmental Toxicology: I. C. Shaw and J. Chadwick; Taylor&Francis ltd
2. Basic Environmental Health (2001): AnnaleeYassi, TordKjellstom, Theo de Kok, Tee Guidotti
3. Environmental Health : Monroe T. Morgan
4. Handbook of Environmental Health and Safety – principle and practices : H. Koren; Lewis Publishers
5. Moore, G.S., 2002, Living with the Earth: concepts in Environmental Health Science (2nd Ed.), Lewis publishers, Michigan
6. Walker, C.H., Hopkin, S.P., Sibly, R.M., and Peakall, D.B. 2001. Principles of Ecotoxicology. 2nd Ed. Taylor & Francis, London.
7. Environmental biology and Toxicology, by Sharma P.D. Rastogi and Lamporary., 1994.
8. Environmental pollution and Toxicology by MeeraAsthana and Astana D.K., Alka printers, 1990. 3. Toxicology, by A.Sood, Sarup and sons New Delhi, 1999
9. Text book of Preventive and Social Medicine, by Park J.E. and Park K., Banosidas Bharat Publishers, Jabalpur, 1985
10. Environmental Epidemiology, by AnisaBasheer, Rawat Publication Jaipur, New Delhi 1995.

SEMESTER -III

PSEVS304

Industrial Hygiene and Chemical Safety

Unit I: Industrial Hygiene

15 L (1 Credit)

- Introduction, definition, scope, significance and applications.
- Occupational environmental stresses i.e Physical, stresses – Noise, vibration, illumination, ventilation, heat stresses, Chemical stresses: Toxic chemicals, hazardous chemicals. Flammable chemical, explosive chemicals. etc. Inhalation and ingestion risks.
- Airborne Chemicals: Dust or aerosols (respirable and non respirable, inhalable and total dust), gases, fumes, vapours, mist and smoke.
- Concept of threshold limiting values(concentration), TLVs, time weighted averages (TWAs), short term exposure limits (STELs), minimal national standards(MINAS), International and national regulatory agencies like ACGIH, OSHA.

Unit II: Industrial Work Environment

15 L (1 Credit)

- Monitoring of Work Environment: Identification of contaminants. Sampling strategies: monitoring methods / protocol on procedures. Sampling of airborne contaminants, viz dust, gases, fumes, vapours, mists etc in work place environment and analysis methods for quantification – Instrumental and manual methods.
- Notifiable Diseases: Pneumoconiosis, Silicosis, Asbestosis, Bagassosis, Byssiniosis.
- Work environment control measures: Substitution, isolation, ventilation, local exhaust system and engineering control methods.
- House keeping and maintenance. Modification of the processes and operation. Process and product specific control measures. Report writing

Unit III: Disaster Management and Risk Assessment

15 L (1 Credit)

- Introduction , definitions, Natural Hazards, nature, causes impacts and occurrences. Earthquakes, volcanic activity, landslides, cyclones, floods, draughts, forest fires; their Mitigation.
- Industrial and technological hazards; types and causes of industrial accidents: fire, explosion, toxic release and dispersion.
- Disaster management: Components of disaster management plan on-site and off-site emergency plans.
- Technical hazards control system- incident reduction, incident management Techniques of hazards assessment: PHA, HAZOP, HAZAN, MCAA

Unit IV: Safety

15 L (1 Credit)

- Precautions in the processes and operations involving explosives, flammables, toxic substances, dusts, vapours, cloud formation and combating.
- Safety precautions for transportation for hazardous chemicals. Handling and storage of hazardous chemicals. Safety in pipelines and colour coding.
- Risk assessment and on site and off site emergency planning. Safety audit in chemical industry. Accidents and unusual occurrences reporting .
- Respiratory personal protective equipment (RPPE)& non respiratory personal protective equipment (NRPPE): head protection , ear protection , face and eye protection , hand protection, foot protection and body protection. Quality control of protective equipments.

TEXTS/REFERENCES

1. Industrial Hygiene & Chemical Safety - M.H.Fulekar: I. K.International Publishing House, New Delhi.
2. Industrial Hygiene Reference And Study Guide- Allan K. Fleeger, Dean Lillquist, AIHA, 01-May-2006
3. Personal Protective Equipment -Guide to Ports/Dock Workers - M.H.Fulekar : Government of India's Publication
4. Fundamentals of Industrial Hygiene-Barbara A. Plog, Patricia J. Quinlan, National Safety Council Press, 2002
5. Occupational safety management and engineering, Willie Hammer, Dennis Price, Prentice Hall, 2001
6. Industrial Safety and Health Management, C. Ray Asfahl, David W. Rieske, Prentice Hall, 31-Jul-2009
7. Fundamentals of Occupational Safety and Health, Mark A. Friend, James P. Kohn, Government Institutes, 16-Aug-2010
8. Handbook of occupational safety and health, Louis J. DiBerardinis, John Wiley, 1999
9. Occupational Hygiene. Blackwell Science, Harrington, J.M. & K. Gardiner. 1995, Oxford.
10. Industrial Hygiene Evaluation Methods. Micheal S. Bisesi. CRC Press, 28-Aug-2003

PRACTICALS

Semester -III

PSEVSP301

Advanced Pollution Control Technology

A. Minor Experiments

1. Determination of heavy metals (Fe/Cu) by spectrophotometric methods
2. Removal of suspended solids by sand filter method.
3. Detection/estimation of Cr (VI) in presence of Cr (III)
4. Estimation of mixed liquor suspended solids (MLSS) and Sludge Volume Index (SVI) in activated sludge.

B. Major Experiments

1. Jar Test (removal of suspended solids by coagulation, e.g. use of alum).
2. Waste water analysis for pH, conductivity, TDS, DO, COD, BOD, alkalinity, chloride and hardness.
3. Estimation of fluoride in waste samples by spectrophotometry.
4. Study of adsorption isotherm : Removal of Cr by activated charcoal.

PSEVSP302

Instrumentation and Biostatistics

A. Minor Experiments

1. Estimation of Chloride in water sample by conductometric titration.
2. Estimation of Fe^{+2} by potentiometric titration.
3. Determination of mean, median, mode, geometric mean, range, quartile using a given data
4. Determination of standard deviation, variance, coefficient of variation, skewness, kurtosis using a given data

B. Major Experiments

1. Separation of proteins using Polyacrylamide Gel Electrophoresis.
2. Determination Pesticides in soil/plants by GC-MS.
3. Analysis of a given data by t- test/ f test,
4. Analysis of a given data by z test /Anova

PSEVSP303
Environmental Toxicology

A. Minor Experiments

1. Study of instruments and equipment used in the Microbiology Laboratory.
2. Enrichment and Isolation of anaerobic bacteria
3. Isolation and Enumeration of microorganisms from soil
4. Effect of Heavy Metal toxicants on the behaviour pattern of earthworm

1. Major Experiments

1. Effect of effluents containing heavy metals on germination of groundnut.
2. Determination of LC50.
3. Effect of different concentrations of any 2 heavy metals on growth of microorganisms
4. Estimation of any toxicant by agar diffusion assay.

PSEVSP304
Industrial Hygiene and Chemical Safety

A. Minor Experiments

1. Preparation of Material Safety Data Sheet for some common chemicals.
2. To neutralize the given sample using NaOH / HCL/ CaCO₃
3. Determination of CO₂ from the atmosphere by volumetric method in a workplace Environment.
4. Estimate Noise Levels and Determine L₁₀, L₅₀, L₉₀ by histogram method.

B. Major Experiments

1. Air sampling of gases (sulphur dioxide, nitrogen dioxide, carbon disulphide, carbon monoxide etc.) and analysis by UV-Visible spectrophotometer.
2. Estimation of sulphur in coal and calculation of release of SO₂ on combustion of per ton of coal.
3. Enlisting the characteristics, advantages and disadvantages of PPE and NRPPE of any industry.
4. Preparation of DMP for nuclear power plant, petrochemical industry, fertilizer plant, hydropower station, chemical industry, thermal power plant, textile mill, metallurgical industry

SEMESTER -IV

PSEVS401

Eco Technology

Unit I:INTRODUCTION TO ECOTECHNOLOGY

15 L (1 Credit)

- Definition, Principles and Concept of Ecotechnology, Why Ecotechnology and Applications of Ecotechnology.
- Appropriate technology for rural environment: Gandhian philosophy: swadeshi movement, concept & definition, characteristic features of appropriate technologies, an account of various technologies developed for rural people- Biogas schemes for rural development, solar cells, solar cooker, solar heaters, smokeless chulas, Biogas stoves, community Biogas plant.

Unit II:Sanitation -PhytosanitationAnd Green Inhibitors

15 L (1 Credit)

- Meaning, concept and importance of SPS, in reference to WTO-SRS Agreement, important phytosanitation technologies-HBPST,TDC,SPS committee-Who and What they do, the ten commandmentsof SPS agreement of WTO.
- Green inhibitors: Factors pertaining to metal samples, Inhibitors in use, Cooling systems, Processing with acid solutions, Corrosion ,Problems in oil industry, Corrosion inhibition in the mining industry, Atmospheric corrosion inhibition mechanisms, Standardized Environmental testing, Hybrid coating & corrosion inhibitors, Environmental green inhibitors, Industrial application of corrosion inhibition.

Unit III: Climate Change Mitigation And Carbon Sequestration

15 L (1 Credit)

- Carbon related definitions C-pool, C-stock, C-Flux, C-sink, C-source, sequestration/uptake.
- A brief understanding of the Clean Development Mechanism (CDM) to combat CC, Developing C market for combating CC, how India can benefit from CDM projects,.
- Development of C-sequestration projects their modalities & procedures- reducing emissions from degradation and deforestation (REDD and REDD+),International efforts in combating global warming & CC.A brief understanding of UNFCCC (Kyotoprotocol)NATCOM, IPCC,CBD,UNCCD,world heritage conventions , UN forum on forests etc.

Unit IV:Restoration Ecology& Remediation Technology

15 L (1 Credit)

- Definitions, aims and objectives, principles, concept & strategies (long tern vs short term), physical chemical & biological restoration, role of ecological principles in restoration, holistic approach in restoration.
- Greenness improvement & planting technologies, bamboo forest maintenance, biotopes, recycled water technology, soil & ground water contamination survey & cleaning technologies.

TEXTS/REFERENCES

1. Faegri, K.vanderpifl (1976). The principles of pollination ecology.3rd Edition pergamon press, NY
2. Burroughs (2007). Climate Change: A multi disciplinary approach, 2nd Edition, Cambridge, New York university press ISBN 9780521690331
3. Cunningham. Principles of Environmental Science.
4. Green Corrosion Inhibitors by V.S.Sastri

SEMESTER -IV

PSEVS402

Environmental Biotechnology and Nanotechnology

Unit I: Environmental Biotechnology

15 L (1 Credit)

- Basic Concept, Brief account of the structure and functions of DNA and RNA, Recombinant DNA Technology, Tools in rDNA Technology.
- Transgenic Plants, Insect Tolerant and Herbicide Tolerant Plants, Environmental Impact of Transgenic Plants, Genetically Modified Organism (GMOs) Impact on the Environment, Molecular Probes in Environmental Monitoring.
- Bioremediation Technology: Land Treatment, Surface Soil Contaminant Remediation: Case Studies, Slurry Bioreactor, Bioremediation of Metals.
- Phytoremediation- Approaches, Technical Considerations, Types of Phytoremediation, Factors influencing Phytoremediation, Uptake and Translocation, Enzymatic Transformation, Detoxification and Tolerance for Heavy Metals.

Unit II: Biotechnology in Protection and Conservation of the Environment 15 L (1 Credit)

- Degradation of Xenobiotic compounds, Microbial degradation of surfactants, Biological Odorization, Biobleaching- *Thiobacillusferrooxidans* in leaching,
- Metal recovery by Microbial Accumulation, Biosensors in Environmental Monitoring and Analysis, Biopolymers, Bioplastics
- Biocomposting; Aerobic composting methods such as Windrow, Static pile and In-vessel methods for composting, Preparation of Biocompost, Particle size, Carbon to Nitrogen ratio, Temperature, Aeration, pH Control, Anaerobic Composting Fermentation/Digestion: Role of Hydrolyzing Microbes, Acetogens and Methanogens, Marketing of Biocompost
- Vermicomposting: Introduction, Biology of Earthworm, Type/ Species of, Preparation of Worm Pit, Bedding Material, Addition of Worms, Sampling, Washing and Sieving Addition of Organic Waste, Harvesting the Final Product.

Unit III: Organic Farming

15 L (1 Credit)

- **Biopesticides:** Introduction, Biological Insecticides, Properties of *Bacillus thuringiensis*, Microbial Pesticides, Entomopathogenic Fungi or Viruses, Entomopathogenic Nematodes Biochemical Pesticides Plant-Incorporated Protectants (PIPs) like GM plants etc, Insect Pheromones and other Semiochemicals, Applications of Biopesticides.
- **Biofertilizers:** Classification, Nitrogen Fixation (Bacterial, with Blue Green Algae, VAM etc.), Symbiotic Nitrogen Fixers *Rhizobium sp.*, Non-symbiotic, Free Living Nitrogen Fixers *Azotobacter*, *Azospirillum* etc. BGA Inoculants *Azolla-Anabaena*, Phosphate Solubilizing Microorganisms (PSM) *Bacillus Pseudomonas*, *Penicillium Aspergillus* etc. Mycorrhiza, Cellulolytic microorganisms and Organic fertilizers.

Unit IV: Environmental Nanotechnology

15 L (1 Credit)

- Nanotechnology and its Applications in Agriculture and Food Industry, Nanotechnology : Materials and Manufacture, Nanotechnology for Renewable Energy,
- Nanotechnology in the Environment, Nanotechnology- Risks for Health and Environment, Benefits for the Environment.
- Nanomaterials-Remediation, Nano Membranes, Nano Fibers, Nano Clays Adsorbents, Zeolites, Nano Catalysts, Carbon Nano tubes,
- Environmental Nano Remediation Technology- Thermal, Physico-Chemical, and Biological Methods, Nano Filtration for the Treatment of Wastes, Removal of Organics, Inorganics and Pathogens, Nanotechnology for Water Purification.

TEXTS/REFERENCES

1. M.H.Fulekar (2010) Bioremediation technology recent advances, springer
2. *Environmental Biotechnology - Theory and Application* – M.H.Fulekar: CRC Press and Science Publisher, USA
3. M.H.Fulekar (2005) Environmental Biotechnology Oxford IBH Publishing cooperation
4. *Bioinformatics – Application in Life & Environmental Sciences* - M.H.Fulekar: Springer Publisher
5. Environmental Biotechnology-Alan Scragg,Oxford University Press.
6. Environmental Biotechnology, A Biosystems Approach, Author(s): Daniel A. Vallero, PhD, ISBN: 978-0-12-375089-1, Copyright © 2010 Elsevier
7. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
8. Environmental Biotechnology: Basic Concepts and Applications . 2006, Indu Shekhar Thakur, I. K. International Pvt Ltd.

9. N.P Cheremisinoff (1996) Biotechnology for Waste and Wastewater Treatment, William Andrew Publishing, New York
10. Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Environmental Microbiology, Academic Press, 2000.

SEMESTER -IV

PSEVS403

Sustainable Management

Unit I: Understanding sustainable development

15 L (1 Credit)

- Definition and dimensions of sustainability, The ecological footprint and carrying capacity
- Global challenges of sustainable development: Our common future report, Agenda 21 and Millennium Development Goals, Earth Charter, domains of sustainability-Economics, ecology, politics and culture.
- National Action Plan on Climate Change.
- National sustainable development strategies in India: Twenty point program of Govt. of India, Key programs introduced to increase agricultural productivity and profitability. Policies and programs relevant to sustainable development in India key legislations relative to sustainable development
- Strategies for promoting sustainable development-International Trade-TRIPS, IPR; finance, technology, Science and education
- Resistances to the concept and some alternative approaches, Important current issues and areas of debate in relation to sustainable development.

Unit II: Business strategies and sustainability

15 L (1 Credit)

- Business and sustainability-Concept of responsible business, CERES (coalition for environmentally responsible economics) principles and blended value.
- Principles of sustainable development in business planning and management
- Triple Bottom Line approach in sustainable business planning and development,
- Green Business profiles- The Body Shop, General Electric, Toyota etc.
- Indicators for sustainability: introduction to Nature's Living Planet Index developed by WWF, Happy Planet Index developed by New Economics Foundation, Gross domestic product, Human development index, Dow Jones sustainability index.

- Sustainability reporting: Corporate social responsibility –Global reporting initiatives guidelines for sustainability reporting

Unit III:Sustainable urban development

15 L (1 Credit)

- Urbanization and its impact on Environment, Rural and Urban planning for sustainable development
- Green city challenges-Ecological footprint, Principles of creating eco cities with two examples.
- Architecture- Eco industrial parks, Urban farming, Green roofs, Green Building-LEED certification, with two examples, walkable Urbanism, Xeriscaping,
- Transportation: improved public transport, car free cities, emphasis on proximity, zero emission transport, Diversity in modes of transportation
- Green city solutions - bicycle city, car-free day campaign ,green belt, compact development, carpooling ,bus rapid transit, parks, greenways and open space, traffic calming

Unit IV:Sustainability in practice

15 L (1 Credit)

- Current environmental Issues in India, Narmada Dam, Tehri, Almetti Dam, waste land & their reclamation, desertification, water crises, wetland conservation.
- Watershed management: Definition, Concepts, principals and classification in watershed management.Rainfall and runoff, water balance approach, water budgeting, topographic surveying, water conservation and harvesting methods – importance and techniques, artificial recharge of groundwater
- NGOs – characteristics and role of NGOs in sustainable development, Principles for NGOs, NGO-Community relations, NGO-Government relations , Some Indian NGOs working for saving environment

TEXTS/REFERENCES

1. Our Common Future, Chapter 2: Towards Sustainable Development: *Report of the World Commission on Environment and Development.*
2. Edwards, Andres R., *The Sustainability Revolution: Portrait of a Paradigm Shift.* New Society Publishers, 2005.
3. Report of the Department for Policy Coordination and Sustainable Development (DPCSD), United Nations Division for Sustainable Development.
4. Sustainable development in India: Stocktaking in the run up to Rio+20: Report prepared by TERI for MoEF,2011.
5. World Resources Institute (1995) "Environmental Indicators: A Systematic Approach to Measuring & Reporting on Environmental Policy Performance in the Context of Sustainable Development", World Resources Institute, Washington, DC.
6. Adger, W.N., Brown, K., Fairbrass, J., Jordan, A., Paavola, J., Rosendo, S., Seyfang, G. (2003) Governance for sustainability: towards a 'thick' analysis of environmental decisionmaking. *Environment and Planning A* 35, 1095 –1110.

7. Connelly, J. and Smith, G. (2003). Politics and the Environment: from theory to practice. Routledge, London.
8. Carter, N. (2001) The politics of the environment. Cambridge University Press: Cambridge
9. Leach, M., Scoones, I., Wynne, B. (2005) Science and Citizens: Globalization and the Challenge of Engagement. Zed books, London.
10. Pearce, D.W., Barbier, E. (2000) Blueprint for a sustainable economy. Earthscan, London.

SEMESTER -IV

PSEVS404

Paper –ENVIRONMENTAL MANAGEMENT

Unit I: Introduction to principles of Environment Management 15L (1 Credit)

Resources and wealth-meaning, types of resources and its exploitation, Wealth-meaning, distinction between wealth and resources, optimum conversion of resources into wealth. Definition, Goals of Environment Management, significance of environmental management, scope of environmental management, Development and environmental linkages, Environmental concerns in India, Actions For Environmental Protection Indian initiatives- National committee on Environmental Planning and Coordination, The Tiwari committee, Department of Environment etc, Ministry of Environment & Forest, Changes in Environmental Management Practices, Introduction Environmental Management Tools

Unit II: Environment Management Systems and Life Cycle Assessment 15L (1 Credit)

International Organization for Standardization (ISO), Plan -Do-Check-Act Cycle, EMS Certification, ISO 14000 series, ISO 14001, Difference between ISO 14000 and ISO 14001 Environmental Policy, Planning, Implementation and Operation, Checking, Management Review, Benefits of ISO 14001 certification, Evolution of Life Cycle Assessment (LCA), Cradle to grave approach. Different applications of LCA.

Procedure for LCA: Defining goal and scope, preparation of life cycle inventory, assessment of environmental impact, Areas for Improvement and Interpretation. Methods to assess impact using methods like ecoindicator-95

Unit III: Environmental Audit and Environmental Economics15L (1 Credit)

Introduction to environmental audit, Types of environmental audits: objectives- based and client-driven types. General audit methodology and audit process: Introduction, the basic steps of an environmental audit program.Element of audit process, audit protocols (why, who, what and how).Waste audits and pollution prevention assessments, Waste minization audit examples. Site assessment and liability audit, Introduction to macro economics, microeconomics, environmental economics, difference between natural resource economics and environmental economics. Valuation of environment impacts: types of economic values, approach, valuation techniques, valuing environmental amenities. Environmental Costs and benefits analysis, examples of cost benefit analysis of technology or process,Introduction to Market based instruments and command control instrument for pollution control.

Unit IV: Environmental Design(ED) and Modeling15L (1 Credit)

Environmental Design: Principles of Environmental Design (ED). Benefits of environmental design, ED of manufactured products, ED considerations in products life stages-DfE concepts, tools for ED of products, Examples of environmental design: Concept of Ecolabel. Cleaner Production Programmes, Leadership in Energy and Environmental Design certification programmes.

Introduction to Environmental Monitoring and Modeling, Definition of model, Need of modeling, water quality models-surface and ground water, Air Quality Models-Dispersion and receptor models

TEXT / REFERENCES

- Vijay Kulkarni and T.V.Ramachandra, 2006. Environment Management, Common wealth of Learning, Canada, Centre for Ecological Sciences, Indian Institute of Science, Karnataka Environment ResearchFoundation.TERI press.
- Environmental Economics for Non-Economist, John Asafu-Adjaye,World scientific publishing Co Pvt Ltd, 1999
- Camborne D F, Environmental Life Cycle Analysis, Lewis Publishers, 1997
- Cattanach,R.E., Hodrieth J.M., Reinke D.P., Sibik L.K., Environmentally Conscious Manufacturing from Design to Production to Labelling and Recycling, National Centre for Manufacturing Sciences (NCMS), Irwin Publications,1995
- Fundamental concepts of Environmental chemistry,2009, G.S. Sodhi, Narosa Publishers
- Environment Management Systems-

<http://www.iso.org/iso/home/standards/management-standards/iso14000.htm>

PSEVSP401

Eco Technology

A. Minor Experiments

1. Determination of Root density
2. Determination of Fertility rejuvenation index
3. Determination of Translocation factor by phytoremediation.
4. Case study on Tehri project, Silent Valley Project , Narmada Dam Project, Biopiracy, Ecodisaster of deforestation

B. Major Experiments

1. Tracing of watershed and their morphological features from toposheets.
2. Interpretation of Aerial photographs/satellite imageries/GIS data.
3. Problems in water budgeting.
4. Designing structures for water conservation and harvesting based on field visits.

PSEVSP402

Environmental Biotechnology and Nanotechnology

Minor Experiments

1. Bioremediation of Heavy Metals by Green Plants in Aquatic/ Soil Environment.
2. Phytoremediation of Heavy Metals by Green Plants in Aquatic/ Soil Environment.
3. Development of Mycorrhizal Soil Using Pot Culture Technique.
4. Development of Compost from Organic Waste.

Major Experiments

1. Estimation of DNA by spectrophotometer
2. Determination of molecular weight of DNA by electrophoresis.
3. Determination of coliforms by Membrane Filter Technique
4. Determination of Streptococcus faecalis.

PSEVSP403

Sustainable Management

Minor Experiments

1. To perform Water/Energy audit in the house/college building /society/laboratory
2. To study sustainability report of major business groups/environment compliance report for a company.
3. Report on Visit to NGO/Biomedical waste management site/hazardous waste Management/Pollution control facility of any industry.
4. Report on Seminar/Conference attended.

Major Experiments

1. Report on study tour to the following places
 - Lakes/rivers/estuary/marine ecosystem.
 - National Park/Sanctuary
 - Mangrove Ecosystem/Open Cast Mining/Agricultural field.
 - Pollution Control Board/Research Institute/Meteorology Department.

PSEVSP404

Environmental Management

Project work : 50 MARKS

Student will submit their independent project work at the end of semester IV. Assessment of the project and internship will be based on the submitted M. Sc. project report, seminar and viva-voice examination.

Report on Project work : 30 MARKS

The Internship/project report submitted by the student and the evaluation report by the externalexaminer.

Project Evaluations:20 MARKS

(Viva-voice + Presentation)

Texts/References:

1. Standard methods for examination of water and waste water , American Public Health Association.
2. A comprehensive laboratory manual for Environmental Sciences and Engineering By P.R. SreemahadevanPillai.New Age International Publishers.
3. Chemical and biological methods for water pollution studies By R.K. Trivedi
4. Handbook of water and waste water analysis By S.K. Maiti.
5. Soil and air analysis by S.K. Maiti.

1. The candidate is expected to submit a journal certified by the head of the department or institution at the time of the practical examination.
2. A candidate will not be allowed to appear for the practical examination unless he or she produces a certified journal or a certificate from the head of the institution or department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate
3. Use of non programmable calculators is allowed both at the theory and the practical examination.