MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVEL-12

PhD Course Structure for our University Departments

(Effective from the academic year 2018-2019 onwards)

Sri Paramakalyani Centre of Excellence in Environmental Science

PhD Programme: Environmental Science

PhD PROGRAMME: ENVIRONMENTAL SCIENCE

S.No	TITLE OF THE SUBJECT
1.	Environmental Pollution and Toxicology
2.	Instrumentation and Methodology for Environmental Analysis
3.	Environmental Chemistry
4.	Waste Recycling and Resource Recovery Technology
5.	Fundamental Chemistry
6.	Environmental Nanoscience
7.	Environmental Microbiology
8.	Pollution Control Engineering and Bioremediation
9.	Solid and Hazardous Waste Management
10.	Introduction to Nanoscience
11.	Synthesis of Nanomaterials
12.	Characterization techniques for Nanomaterials
13.	Methods of Nanofabrication
14.	Nanomedicine
15.	Nanocomposite
16.	Nanobiotechnology
17.	Environmental Pollution Control
18.	Research and Teaching Methodology
19.	Agricultural Entomology and Pest Management
20.	Sustainable Agriculture
21.	Eco Friendly Bioproducts
22.	River Ecosystem Ecology
23.	Restoration Ecology and Management
24.	Biostatistics and Science Writing
25.	Freshwater Ecology
26.	Biological Invasions and Management
27.	Mini Project

Environmental Pollution and Toxicology

Unit I **8hrs**

Introduction – Major Industrial Effluents – Sewage – Characteristics, Fertilizers – Pesticides and other agrochemicals – Heavy metals – Mercury, Cadmium, Chromium, Lead, Aluminum, Arsenic, Copper, Nickel and their toxicity – Ground water contamination – Soil Pollution – Environmental impacts of use and throw plastics - Hospital wastes and their environmental impacts

Unit II **8hrs**

Air pollution – Sources – Oxides of Carbon, Nitrogen, Sulphur, Hydrocarbons – Transport and Diffusion – Effects of air pollutants on life and properties – Measurement of airborne contaminants-Acid rain – Ozone depletion – Global warming and their consequences – Radioactive Pollution – Thermal pollution – Noise pollution – Sources and effects – Fate of air, water and soil pollutants - Episodes of pollution

Unit III **8hrs**

Principles and Methodologies for the quantitative analyses of TOC, chromium, cadmium, arsenic, mercury, copper, lead, nickel and zinc in waste water – Estimation of NOx, CO2, CO, SO2 and SPM in air.

Unit IV **8hrs**

General principles of toxicology - Scope of toxicology - Outlines of toxicological testing methods, cost effective bioassays - Toxicity and Probit Analysis - Bioassays – Mechanism of action of toxicants - Routes of exposure - Routes of entry of xenobiotics - Absorption and Translocation – Biotransformation - Combined action of toxicants - Factors influencing toxicity - Dose effect and Dose response relationship

Unit V **8hrs**

Toxicity – Cytotoxicity, Immunotoxicity, Hepatotoxicity, Molecular toxicity, Neurotoxicity - Carcinogens, mutagens and teratogens. Ecotoxicology and human toxicology, Behaviour of toxicants in the environment – Occupational exposure to industrial toxicants - Bioaccumulation, Biomagnification – Toxic residues - Residual analytical methods - Safety evaluation of toxic chemicals

Reference

1.Josephy, P. D., Mannervik, B., de Montellano, B.O., 1997. Molecular Toxicology. Oxford University Press, UK.

2.Tomlin, C., 2000. The Pesticide Manual. 11th edition,. British Crop Protection Council. Several editions. updated every few (2-4) years.

3.Bryant, R., Bite, M., Hopkins, WL., 1999. Global insecticide directory, 2nd ed. Ed.. Ag. Chem. Inform. Services, Agranova.

4.Krishnan Kannan, K., 1997. Fundamentals of Environmental Pollution, S. Chand Company, New Delhi.

5.Sharma, B. K., Kaur, H., 2000. Environmental Chemistry, Goel Publishing House, Meerut, India.

6.Anderson, K., Scott, R., 1981. Fundamentals of industrial toxicology, Ann. Arbor. Science Publishing Inc. Michigam. USA.

7.Ecobicham, D., 2004. The basis of toxicity testing, CRC press, USA.

8.Prasad, D.N., Kashyap, V., 1999. Introduction to toxicology, S. Chand Company, New Delhi
9.De Matters, F., Smith, L., 1995. Molecular and Cellular Mechanisms of Toxicity CRC Press, USA
10.Dara, S.S., 2000. A text book of environmental chemistry and pollution control. S. Chand Company, New Delhi.
11.Sharma, P. D., 1993. Environmental Biology and Toxicology, Rastogi Publications, New Delhi.
12.A.G.Murugesan and C.Rajakumari, Environmental Science and Biotechnology – Theory and Techniques, MJP Publishers.
13.Nation, J. L., 2008. Insect Physiology and Biochemistry, Second Edition, CRC Press, USA.
14.Josephy, P. D., Mannervik, B., de Montellano, P.O., 1997. Molecular Toxicology, Oxford University Press, UK.
15.Finney, D. J., 1971. Probit Analysis. 3rd edition. Cambridge University Press, UK
16.Subramanian, M.A., 2004. Toxicology: Principals and methods, MJP Publishers.
17.APHA. 1975. Standard methods for the examination of waste water. AWWA, New York.
18.A.K. Gupta. Industrial Safety and Environment. 2013. University Science Press.

Instrumentation and Methodology for Environmental Analysis

Unit- I **8hrs**

Centrifugation: Low speed-high speed-ultra refrigerated centrifuges. Principles and operation methods of weighing devices- Preparation of buffers and stock solutions of media/ reagents- Preparation of normality- ppm- solutions. Microtome-Cryocutting-Sectioning-Staining, Haemocytometer

Unit –II **8hrs**

Chromatographic techniques- TLC- Electrophoresis: Polyacrylamide gel electrophoresis (PAGE) and agarose gel electrophoresis. Biosensors: Definition – components of biosensors- types of biosensors- Enzyme electrodes- Bacterial electrodes- Enzyme immunosensors- Environmental biosensors. Instrumentation techniques: HPLC, SEM, XRD, GC, UV, FTIR, DSC/TGA, TEM, AFM

Unit- III **8hrs**

Scientific research: Methods of scientific research- Preparation of rebview article- editing research paper- collection of literature- references- bibliography and thesis writing

Unit-IV **8hrs**

Principles of pollution analysis: Gravimetric Methods- Volumetric Methods- Solvent Extraction evaporations- Toxic metal pollutants analysis (Chromium, Mercury)- Air pollution analysis- Sampling Methods for Aerosols- Sampling of Gaseous Pollutants-Analysis of aerosols- Analysis of gaseous pollutants (SO2, H2S, NO2-NOX, CO-CO2, ozone and NH3)

Unit-V **8hrs**

Principles of Monitoring Methods- Analysis of Soil Quality- pH, EC, Total Nitrogen-Organic Carbon-C: N ratio – Water Quality- Residual Chlorine- Fluorides. Estimation of Phenols. Pesticide Analysis- Spectroscopic Analysis and GC- Noise Measurement – Sampling of Odors- Measurement of Odor.

References

1.Chatwal, G. and Anand, S. 1989. Instrumentation methods of chemical analysis. Himalayas Publishing House, Delhi.

2.Robinson, J.W. (ed) 1991. Practical Handbook of spectroscopy CRC Press, Boston.

3.Webster, J.C. (ed). 2005. Bioinstrumentation. John Wiley & Sons Inc., Singapore

4.Guruman, N. 2006. Research methodology for Biological Sciences. MJP Publishers, Chennai.

5.Palanichamy, S. Shunmugavelu, M. 2006. Research methods in Biological sciences. Sarojini for Palani paramount Publication. Anna Nagar Palani.

6.Cannel, J.P.1998. Natural products isolation, Humana Press New Jersey.

7.Harbone, J.B. 2003. Phytochemical methods. (5th Edition) Chapman &Hall, London.

8.Keith Wilson, 2000. A practical guide to clinical biochemistry.

9.Murugesan A.G. andRajakumari C. Environmental Science and Biotechnology Theory and Techniques. 2009 (3rd Edition). MJP Publishers.

10.S.M. Khopkar. (2001). Environmental Pollution analysis. New Age International (p) Limited, Publishers

Environmental Chemistry

UNIT I **7hrs**

Introduction to Environmental Science – Water, Air, Earth, Life and Technology – Ecology – Energy and Cycles of Energy – Human impact and Pollution – Atmosphere and Atmospheric chemistry – The Geosphere and Soil – The Biosphere

UNIT II **7hrs**

Overview to Environmental chemical analysis – Classical methods – Spectrophotometric method – Electrochemical methods – Gas Chromatography – Mass spectrometry – Analysis of water samples – Analysis of sulfur dioxide – Analysis of Hydrocarbons

UNIT III **7hrs**

Introduction to water pollution – Nature and types of water pollutants – Elemental pollutants, Heavy metals and Metalloids – Organic pollutants – Pesticides in water – Water treatment and water use – Sewage treatment – Removal calcium and other metals- Water Reuse and recycle

UNIT IV **7hrs**

Particles in the atmosphere – Physical behavior of particles in the atmosphere – The composition of inorganic particles – Toxic metals – Radioactive particles – The composition of organic particles – Effect of particles – Control of particulate emissions

UNIT V **7hrs**

Origin of Hazardous wastes – Transport of Hazardous wastes – Effect of Hazardous wastes – Fates of Hazardous wastes - Hazardous wastes in the Geosphere - Hazardous wastes in Hydrosphere - Hazardous wastes in Atmosphere - Hazardous wastes in Biosphere

References

1.Manahan SE, Environmental Chemistry (6th Ed.), Lewis Publishers, USA

2.Schwarzenbach, Rene P., Phillip M. Gschwend, and Dieter M. Imboden, Environmental Organic Chemistry, John Wiley & Sons, New York, 1993.

3.Simpson, Peter, Basic Concepts in Organic Chemistry—A Programmed Learning Approach, Chapman and Hall, London, 1994.

4.Solomons, T. W. Graham, Organic Chemistry, 6th ed., John Wiley & Sons, New York, 1998.

5.Sorrell, Thomas N., Organic Chemistry, University Science Books, Sausalito, CA, 1999.

6.Timberlake,Karen C., Chemistry: An Introduction to General, Organic, and Biological Chemistry, Benjamin/Cummings, Menlo Park, CA, 1999.

7.Vollhardt, K. Peter C. and Neil E. Schore, Organic Chemistry: Structure and Function, 3rd ed., W.H. Freeman, New York, 1999.

Waste Recycling and Resource Recovery Technology

Objectives:

To impart knowledge on waste recycling and resource recovery from wastes.

UnitI:Introduction

Solid waste – Sources – Domestic, industrial and agriculture sources- Industrial wastes- Mineral wastes – Indentification waste – Minimizing options -Recovery and Recycle- Composting- Vermi composting – Incineration – Energy from waste- Pyrolysis, chemical processing- Legislative measures for garbage disposal.

UnitII: FlyAsh

Introduction- Nature- Direct Replacement of Cement- Waste Land Development- Soil Amendment to grow Crops- Utilization of Flyash In Afforestation, Limitation of Land Application of Fly Ash.

UnitIII:PlasticWaste,IndustrialWaste

Introduction – Amount and types of plastic waste – Recycling of plastic waste-cement manufacture from industrial solid waste – Paper industry waste – Calcium carbide industry waste.

UnitIV:BioFuels&BioEthanol

Bio ethanol production technologies- Bio hydrogen- its application – Methanogenesis from agroindustrial residues- Bio mass – Gasifier based power plants.

UnitV:WasteWater

Introduction reuse- Quality, the basic treatment processes – Benefits of reuse in agriculture – The costs of reuse projects and economic justification – Factors essential for the success of reuse projects- Case study.

Textbook:

1. Agarwal S.K. "Wealth from Waste",Kul Bhushan Nangia, APH Publishing Corporation, New Delhi, 2005

References:

1. Nemerow N.L., "Industrial Water Pollution", Addison – Wesley Publishing Company inc., USA, 1978
2. Wesley Eckenfelder Jr. W, Industrial water pollution control, McGraw Hill book Co, New Delhi, 1989.
3. Mahajan S.P. "Pollution Control in process industries", Tata McGraw Hill Publishing Co Ltd., New Delhi, 1989.

FUNDAMENTAL CHEMISTRY

Unit I Inorganic chemistry –Zero group elements 5 Hrs (3L+2P)

Isolation of inert gases by physical and chemical methods – preparation and properties of xenon tetrafluoride, xenon hexafluoride, xenon oxytetrafluoride – uses of noble gases – clathrates and their uses.

Unit II Organic chemistry – Principles of reactions 6 Hrs (3L+3P)

Heterolytic and hemolytic cleavage – nucleophiles and electrophiles – reaction intermediates – preparation and properties of carbonium ions, carbanions and free radicals – types of reactions – substitution, addition, elimination and polymerization reactions.

Unit III Physical chemistry – Photochemistry 7Hrs (4L+3P)

Definition – composition between thermal and photochemical reactions – Laws of photochemistry-Beer Lambert's law-Grothus Draper law-Einstein's law-Quantum yield-low and high quantum yield-determination of quantum yield-fluorescences, phosphorescence, thermoluminescence, chemiluminescence and bioluminescence – definition with examples – photosensitization.

Unit IV Polymer chemistry 7 Hrs (4L+3P)

Defination-Monomers, Oligomers, Polymers – Classification of polymers – Natural, synthetic, linear, cross linked and network – plastics, elastomers, fibres, homopolymers and Co-polymers. Thermoplastics – Polyethylene, Polypropylene, polystyrene, Polyacrylonitrile, poly vinyl chloride, nylon and polyester – Thermosetting plastics - :Phenol formaldehyde and exposxide resin – Elastomers – Natural rubber and synthetic rubber – Buna N, Buna – S and neoprene.

Unit V Applied chemistry 7 Hrs (4L+3P)

Lubricants – classification - criteria of good lubricating oils – synthetic lubricating oils – poly glycols and poly alkene oxides – greases or semi solid lubricants examples – solid lubricants – graphite. Preparation and uses of shampoo, nail polish, sun screens, tooth powder, tooth paste, boot polish, moth ball, chalk piece.

Suggested List of Exercises:

Books Studies:

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Prentice Hall, 2011.
2. S. H. Pine, Organic Chemistry, Tata McGraw Hill, 5th Edition, 2008.
3. Michael B. Smith, Jerry March, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, John Wiley & Sons, 6th edition, 2007.

Books References:

1. L. Finar, Organic Chemistry, Vol. I & II, 5th Edition, Longman Ltd., New Delhi, 1975.
2. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 4th edition, New Academic Science Publisher.
3. Peter Sykes, Guidebook to Mechanism in Organic Chemistry (6th Edition), Longman Scientific & Technical, 1985
4. K.J. Laidler, Chemical Kinetics, Tata McGraw Hill
5. Gurdeep Raj, Chemical Kinetics, Goel Publishing House.
6. P.W.Atkins, Physical Chemistry
7. W.J.Moore, Physical Chemistry, Longmans
8. A.A.Frost and R.G.Pearson, Kinetics and Mechanism, Wiley Eastern, Pvt. Ltd.
9. F.W. Billmeyer, Text book of Polymer science, Wiley- Interscience
10. Fundamentals of Photochemistry – K.K.Rohatgi – Mukherjee (Revised Edition) New age International publications, Reprint 2002.

Environmental Nanoscience

UNIT 1 **8hrs**

Background to nanotechnology: scientific revolutions – types of nanotechnology and nano machines – atomic structure – molecules & phases – energy – molecular and atomic size – surfaces and dimensional space.

UNIT 2 **8hrs**

Nanomaterials Fabrication: Principles and Methods - Nanomaterials Fabrication-Specificity and Requirements in the fabrication methods of nanoparticles oxide-Semiconductor nanoparticles-metallics-Bimetallics and alloys-carbon based nanomaterials.

UNIT 3 **8hrs**

Membrane Process: Overview of membrane processes-transport principles for membrane processes-Membrane fabrication using nanomaterials-Nanoparticle Membrane reactors-Active membrane systems.

UNIT 4 **8hrs**

Nanocomposites: Introduction-Advantages and Disadvantages of Nano-sized Additions-Application of Nanocompsites-Areas of Application-Clay-based Nanocomposities.

UNIT 5 **8hrs**

Environmental Applications of Nanomaterials: Nanomaterials for Groundwater Remediation –Reactivity, fate and lifetime, Nanoiron reactivity, Reaction products, Intermediates and efficiency, Effects of competing oxidants, Delivery and transport issues, Injection methods and delivery vehicles.

References

1.Nanotechnology: basic science and emerging technologies – Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, BurkhardRaguse, Overseas Press (2005).

2.Amorphous and Nanocrystalline Materials: Preparation, Properties, and Applications, A.Inoue, K.Hashimoto (Eds.,) (2000)

3.Nanocomposite science and technology, PulickelM.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weiheim (2003).

4.Nanobiotechnology: Concepts, Applications and Perspectives, ChristofM.Niemeyer, / ChadA.Mirkin, (eds.), Wiley-VCH, Weinheim, (2004)

5.Bionanotechnology: Lessons from Nature, by: David S. Goodsell, Wiley-Liss. (2004).

6.Nanotechnology - Fundamentals and Applications. Manasikarkare.I.K. International Publishing HousinPvt.Ltd. New Delhi.

Environmental Microbiology

UNIT I: 8hrs

hrsIntroduction – History of microbiology – Scope of microbiology- Concept of Microbial Ecology– Succession and Colonization of Microbes in Environment- Positive and Negative roles of Microbes in Environment- Atmosphere as habitat and medium for microbial dispersal – Air borne diseases – Air sanitation

UNIT II: 8 hrs

Biogeochemical cycles – Carbon, Nitrogen, Sulfur, Phosphorus, Iron and other elements - Microbial Nitrogen fixation – Anabaena, Azospirillumand Rhizobium – Nitrogenase, Hydrogenase

UNIT III: 8 hrs

Microbiology of waste water: Waterborne pathogens – Salmonella, Shigella, Vibrio cholera, Gastroenteritis, Escherichia coli, Hepatitis viruses, Chikungunya, Swine flu and Dengue. Tests for water quality – Microbiological water quality standards - Detection of faecal contamination - Detection of virus – Biological oxygen demand - Eutrophication – Microbial indicators of water pollution-Water purification and recycling process.

UNIT IV: 8 hrs

Microbiology of Soil –- Soil types and their microbes- Microbes in soil fertility- Humus- Microbial degradation of lignin – Tannin – Rhizobacteria- Microbial degradation of pesticides – Microbial interactions with inorganic pollutants – Microbial leaching of metals – Microorganisms in abatement of heavy metal pollution - Microbial composting of biowastes

UNIT V: 8 hrs

Strategies in bioconversion - bioconversion of lignocelluloses into product-Biogas from wastes – Specific methanogenic activity – Microbial production of fuels: Ethanol, Methane and Hydrogen – Microbial production of biopolymers

References

1.Atlas & Bartha, 1981, Microbial Ecology and Fundamental Applications, The Benjamin Kummings Publishing Co

2.Grant and Long, 1981, environmental Microbiology, Blackie and Sons ltd., BishopbridgeGlassgow

3.Ralph Mitchell, 1974, Introduction to Environmental Microbiology, Prentice Hall London

4.Cambell, 1983, Microbial control of pollution, Blackwell Scientific Publication

5.A.K. Chatterji , Introduction to Environmental Biotechnology, Prentice – Hall of India, Newyork

6.A.G. Murugesan and C.Rajakumari, 2005, Environmental Science and Biotechnology – Theory and Techniques, MJP Publishers

7.J.C. Fry et al., 1992. Microbial Control of Pollution, Cambridge University Press

8.K. Vijaya Ramesh, 2003, Environmental Microbiology, MJP Publishers, Chennai. ISBN No – 81-8094-003-9.

9.A.H. Patel. 2016. Industrial Microbiology. Trinity Press. ISBN 978-93-85750-26-7

10.R.C.Dubey and D.K.Maheswari, 1999. A Textbook of Microbiology. S. Chand and Company LTD, New Delhi. ISBN No – 81-219-1803-0.

POLLUTION CONTROL ENGINEERING AND BIOREMEDIATION

UNIT I: **8 hrs**

Concept of pollution control and management – Characteristics of major industrial effluents – primary – secondary and tertiary treatment of effluents – Ion exchange – reverse osmosis – electrodialysis – colour removal from industrial effluents – Sludge treatment and disposal – Modelling of activated sludge process.

UNIT II: **8hrs**

Working principles of the following reactors – Rotating Biological Contactors, Fluidized Bed Reactor, Trickling filter - Expanded Bed Reactor, Contact Digesters, Packed Column Reactors, UASB Reactor – Sequencing batch reactors – High Rate reactors – Microbial removal of nitrogen and phosphorus – Nutrient removal through biomass production – Hospital waste management – Air Pollution Control Strategies: Automotive and industrial emission control, greenhouse gases emission control– biological purification of contaminated air

UNIT III: **8hrs**

Metal microbes interactions – Microbial immobilization and transformation of metals – Genetic aspects of heavy metal resistance – Anaerobic decomposition of organic matter – Pesticide biodegradation – Microbial leaching of metal – Biotechnological applications for pesticide waste disposal – Oil degradation by microbes – Aquatic macrophytes for waste water treatment – Biotechnology in soil pollution abatement

UNIT IV: **8hrs**

Bioremediation General perspectives – Microbes for bioremediation – Bioremediation techniques– Advantages and disadvantages Bioremediation monitoring and case studies– Effluent irrigation in agriculture – phytoremediation: approaches and types, factors influencing phytoremediation – advantages and disadvantages – Microalgal species for aquaculture – Mass cultivation techniques – Harvesting and Drying of Algal Biomass – Bioagumentation for commercial production of algae

UNIT V: **8hrs**

Genetics of microbial bioremediation – Microbial genetic plasticity – Role of plasmids in bioremediation – Evolution barriers for new microbes – Enhancement of novel microbial degradative abilities – Genetics and gene manipulation –Transgenic microbes for treating toxic chemicals – Gene transfer in the environment – GEMS and biosafety – Ethics of microbial biotechnology – application of genetic engineering in bioremediation

References

1. Pradipta Kumar Mohapatra (2007), Text book of Environmental Biotechnology, I.K. International Publishing House Pvt. Ltd
2. Jogdand. S.N. (2003) Environmental Biotechnology, Himalaya Publishing House
3. Chatterji, (2003), Introduction to Environmental Biotechnology, Prentice Hall of India Pvt. Ltd
4. A.G.Murugesan and C.Rajakumari, Environmental Science and Biotechnology – Theory and Techniques, MJP Publishers
5. J.C. Fry et al., 1992. Microbial Control of Pollution, Cambridge University Press
6. C.S.Rao, (1997), Environmental Pollution Control Engineering, New Age International Pvt. Ltd, India
7. Dara.S.S. (2000), Environmental Chemistry and Pollution Control, S. Chand & Co., Pvt. Ltd

8. William C. Blackman, Jr, (1996), Basic Hazardous waste management (Ed.) CRC Press Inc
9. Sharon Mc Eldowney et al, (1993), Pollution Ecology Biotreatment – Longman Scientific & Technical, Harlow, England
10. Herber F. Lund – Industrial Pollution control handbook
11. Mahajan, S.P. Pollution control processing in industries
12. Trivedy, R.K. (1995). Encyclopedia of environmental pollution and control, Vol.2. Enviromedia
13. Jenkins,D & B.H.Olson, Waste water microbiology, Pergamon Press
14. Kaul, Nandy & Trivedy, (1989). Pollution control in Distilleries Enviromedia, India
15. P. Rajendran and P. Gunasekaran (2006) Microbial bioremediation, MJP publishers

Solid and Hazardous Waste Management

Unit 1 **8hrs**

Introduction:Sources and generation of solid waste, their classification and chemical composition; characterizationof municipal solid waste; hazardous waste and biomedical waste.Effect of solid waste disposal on environment: Impact of solid waste on environment, human and plant health; effect of solid waste and industrialeffluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

Unit 2 **8hrs**

Solid waste and Hazardous waste Management: Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques. Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

Unit 3 **8 hrs**

Resource Recovery : R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Unit 4 **8hrs**

Waste- to- energy : Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

Unit 5 **8 hrs**

Integrated waste management: Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.: Life cycle assessment: Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study on LCA of a product.

References

1. Asnani, P. U. 2006. Solid waste management. *India Infrastructure Report 570*.
2. Bagchi, A. 2004. *Design of Landfills and Integrated Solid Waste Management*. John Wiley & Sons.
3. Blackman, W.C. 2001. *Basic Hazardous Waste Management*. CRC Press.
4. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. *Integrated Solid Waste Management: A Life Cycle Inventory*. John Wiley & Sons.
5. US EPA. 1999. *Guide for Industrial Waste Management*. Washington D.C.
6. White, P.R., Franke, M. &Hindle P. 1995. *Integrated Solid waste Management: A Lifecycle Inventory*. Blackie Academic & Professionals.
7. Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. *Improving Municipal Solid waste Management in India.* The World Bank, Washington D.C.

INTRODUCTION TO NANOSCIENCE

UNIT I **8hrs**

Scientific revolution- Atomic structures-Molecular and atomic size-Bohr radius – Emergence of Nanotechnology – Challenges in Nanotechnology - Carbon age–New form of carbon (from Graphene sheet to CNT).

UNIT II **8hrs**

Influence of nucleation rate on the size of the crystals- macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio, top-down and bottom-up approaches-self assembly process-grain boundary volume in nanocrystals-defects in nanocrystals-surface effects on the properties.

UNIT III **8hrs**

Definition of a Nano system - Types of Nanocrystals-One Dimensional (1D)-Two Dimensional (2D) -Three Dimensional (3D) nanostructured materials - Quantum dots - Quantum wire-Core/Shell structures.

UNIT IV **8hrs**

Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization- surface charge density-electric potential at the proximity of solid surface-Van der Waals attraction potential.

UNIT V **8hrs**

Properties of Individual Nanoparticle - Metal Nanoclusters- Semiconducting Nanoparticle-Rare Gas and molecular Clusters- Method of synthesis - RF plasma- Chemical methods-Thermolysis - Pulsed Laser Methods.

References

1. M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, *Nanotechnology: Basic science and Emerging technologies*, Overseas Press India Pvt Ltd, New Delhi, First Edition, 2005.
2. C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), *The chemistry of nanomaterials: Synthesis, properties and applications*, Wiley VCH Verlag Gmbh&Co, Weinheim, 2004.
3. Kenneth J. Klabunde (Eds), *Nanoscale Materials Science*, John Wiley & Sons, InC, 2001.
4. C.S.S.R.Kumar, J.Hormes, C.Leuschner, *Nanofabrication towards biomedical applications*, Wiley –VCH Verlag GmbH & Co, Weinheim, 2004.
5. W. Rainer, *Nano Electronics and information Technology*, Wiley, 2003.
6. K.E.Drexler, *Nano systems*, Wiley, 1992.
7. G.Cao, *Naostructures and Nanomaterials: Synthesis, properties and applications*, Imperical College Press, 2004
8. R. Cantor, P.R.Samuel, "Biophysical Chemistry", W.H., Freeman & Co., 1985.
9. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, and R.Losick. "Molecular Biology of the Gene", 5th ed., San Francisco: Addison-Wesley, 2000.
10. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.
11. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
12. Creighton, E, Thomas, "Proteins: Structures and Molecular Properties", 2nd Ed. New York: W.H. Freeman, 1992.
13. B.Lewin, "Genes IX", International Edition. Sudbury: Jones & Bartlett, 2007.

SYNTHESIS OF NANOMATERIALS

UNIT I **8hrs**

Synthesis of bulk nanostructured materials - Sol Gel processing- Mechanical alloying and milling - Grinding – high energy ball milling-types of balls-WC and ZrO2-materials –ball ratio-limitations- melt quenching and annealing.

UNIT II **8hrs**

Self Assembled Monolayers (SAM) - Vapour Liquid Solid (VLS) approach- Chemical Vapour Deposition (CVD) - Langmuir-Blodgett (LB) films - Spin coating - Electrochemical approaches: Anodic oxidation of alumina films, porous silicon and pulsed electrochemical deposition - Spray pyrolysis - Flame pyrolysis - Thin films - Lithography.

UNIT III **8hrs**

Homogenous Nucleation -diffusion and surface controlled growth process - synthesis of metallic nanoparticles - semiconductor nanoparticles-metal oxide nanoparticles - vapor phase reactions - solid state phase segregation -Heterogenous nucleation - kinetically confined nanoparticles.

UNIT IV **8hrs**

Evaporation-condensation - Vapor- liquid - solid (VLS) - VLS model - Nucleation and growth - surface and bulk diffusion – kinetics – growth of various nanowires –control of size –precursors and catalysts - single- and multi- wall CNT - Si nanowires – density and diameter – doping in nanowires.

UNIT V **8hrs**

Thin films- Environment for thin film deposition (Gas and Plasma) - Introduction to vacuum technology-physical vapour deposition techniques (Reactive sputtering (DC and RF), laser ablation); Epitaxy-different types of Epitaxy - Lattice mismatch - Liquid Phase Epitaxy (LPE) - Molecular Beam Epitaxy (MBE)- Pulsed laser deposition (PLD) - Atomic layer deposition (ALD)

References

1. W. Gaddand, D.Brenner, S.Lysherski and G.J.Infrate (Eds), *Handbook of nanoscience, Engg and Technology*, CRC Press,2002.

2. G.Cao, *Nanostructures and Nanomaterials: Synthesis, properties and applications,* Imperical College Press, 2004.

3. J.George, *Preparation of thin films*, Marcel Dekker, InC., New York, 2005.

4. C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), *The chemistry of nanomaterials: Synthesis, properties and applications*, Wiley VCH Verlag Gmbh&Co, Weinheim, 2004

CHARACTERIZATION TECHNIQUES FOR NANOMATERIALS

UNIT I **8hrs**

X-ray diffraction – powder diffraction–single crystal XRD –thin film analyses – determination of lattice parameters-structure analyses-rocking curve-strain analyses-phase identification-particle size analyses using Debye- Scherer`s formula - X-ray photoelectron spectroscopy (XPS)- Auger electron spectroscopy (AES)- low energy electron diffraction and reflection high energy electron diffraction (LEED, RHEED).

UNIT II **8hrs**

Electron Microsopy (Basic principle only)-Scanning Electron Microscope (SEM) – Field Emission scanning Electron microscope (FESEM)-Atomic force microscopy (AFM), – Transmission Electron Microscopy (TEM)- Scanning Probe Microscopy (SPM)- scanning Tunnelling microscopy (STM), scanning near field optical microscopy (SNOM) .

UNIT III **8hrs**

Infra red spectroscopy (IR) - UV-visible-Absorption and reflection-Raman Spectroscopy – Micro- Raman spectra--Tip enhanced Raman-Surface Enhanced Raman scattering (SERS) – Photoluminescence (PL)– Cathodeluminescence (CL).

UNIT IV **8hrs**

Magnetic measurements using vibrating sample magnetometer (VSM) - magnetic force microscopy (MFM) – SQUID-Electron Paramagnetic Resonance (EPR)-Nuclear Magnetic Resonance (NMR) spectroscopy . Magnetic Resonance Imaging (MRI).

UNIT V **8hrs**

Hall Effect - Quantum Hall effects and its applications –Four –Probe resistivity measurements- LED Characteristics-measurements of band gap - FET characteristics and its applications.

References

1. Ghuzang G.Cao, *Naostructures and Nanomaterials: Synthesis, properties and applications,* Imperical College Press, 2004
2. Zhong Lin Wang, *Hand Book of Nanophase & Nanostructured materials* (Vol. I&II), Springer, 2002.
3. B.D. Cullity, *Elements of X-ray diffraction,* Addison Wesley, 1977
4. B.W.Moot, *Micro-indentation hardness testing,* Butterworths, London , 1956.
5. R.M.Rose, L.A.Shepard and J. Wulff, *The structure and properties of materials*, Wiley Eastern Ltd., 1966.
6. S.M. Sze, *Semiconductor Devices – Physics and Technology*, Wiley, 1985.
7. D. K. Schroder, Semiconductor Material and Device Characterization, John Wiley & Sons, New York, 1998.
8. C. Richard Brundle Charles A. Evans, Jr.Shaun Wilson, *Encyclopedia of Materials Characterization* Butterworth-Heinemann, 1992.

METHODS OF NANOFABRICATION

UNIT I **8hrs**

Introduction to microelectronics fabrication and Moore`s empirical law - Limitations – Si processing methods:Cleaning/etching, oxidation, Gettering, doping, epitaxy- semiconductor device road map –gate dielectrics, poly Si, high k dielectrics.

UNIT II **8hrs**

Necessity of clean a room – different types of clean rooms – maintenance - Importance of Lithography techniques – Photolithography – Electron Beam lithography – Extreme UV lithography – X-ray Lithography – Focused ion beam Lithography (FIB).

UNIT III **8hrs**

Types of etching - Reactive ion etching (RIE) - Wet chemical etching - Isotropic etching – Anisotropic etching- electrochemical etching.

UNIT IV **8hrs**

Self-assembly, self-assembled monolayers, directed assembly, layer-by layer assembly, patterned growth - control of position and diameter - Combinations of top-down and bottom-up techniques: current state of the art - DNA self-assembly-Nanocrystals - Nanowires by catalytic (Au, Ni and Ag) and non-catalytic VLS approach.

UNIT V **8hrs**

Nanoimprint lithography (NIL) –soft polymer photoresistive - moulding /replica - printing with stamp pads - RIE etching - patterned growth - control of position, size and density - Dip-pen lithography - setup - working principle.

References

1. M. Madou, Fundamentals of microfabrication CRC press, 1997.
2. G. Timp, Nanotechnology, AIP press, Springer Verlag, New York , 1999.
3. M.J.Jackson, Micro fabrication and Nanomanufacturing, CRC press.2005
4. G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, 2004
5. W.T.S Huck, Nanoscale assembly : Chemical Techniques (Nanostructure Science and Technology, Springer, 2005.
6. H. Schift et al Fabrication of polymer photonic crystals using nanoimprint lithography, Nanotechnology 16, 261, (2005).
7. R.D.Piner, Dip-pen lithography, Science 283, 661(1999).

NANOMEDICINE

UNIT I **8hrs**

Nanomedicine: Introduction – Basic of Nanobiotechnology in Relation to Nanomedicine – Landmarks in the Evolution of Nanomedicine – Classification of Nanobiotechnologies – Visualization and Manipulation on Nanoscale.

UNIT II **8hrs**

Nanomolecular Diagnostics: Introduction – Nanodiagnostics – Nanoarrays for Molecular Diagnostics – Nanoparticles for Molecular Diagnostics – Nanobarcodes Technology – Nanoparticle-Based Colorimetric DNA Detection Method – Nanobiotechnology for Detection of Proteins – Nanobiosensors – Applications of Nanodiagnostics.

UNIT III **8hrs**

Nanopharmaceuticals: Introduction – Nanobiotechnology for Drug Discovery & Development – Drug Delivery – Nanoparticle based Drug Delivery - Liposomes – Nanospheres – Nanotubes – Future Prospects of Nanobiotechnology based Drug Delivery

UNIT IV **8hrs**

Role of Nanotechnology in Biological Therapies: Introduction – Vaccination – Cell & Gene Therapy – Antisense Therapy – RNA Interference - Nano-Oncology – Nanomicrobiology – Regenerative Medicine & Tissue Engineering - Nanodentistry - Nanobiotechnology & Nutrition.

UNIT V **8hrs**

Miscellaneous Applications of Nanobiotechnology – Nanoimmunology – Nanobiotechnology for Public Health - Role of Nanobiotechnology in Biodefence - Worldwide Development & Commercialization of Nanomedicine – Research & Education in Nanomedicine – Future of Nanomedicine – Ethical, Safety and Regulatory Issues of Nanomedicine.

References

1. The Handbook of Nanomedicine – Kewal K. Jain, Humana Press (Springer) (2008)
2. Bio-Applications of Nanoparticles – Warren C.W. Chan, Lands Bioscience & Springer Science Business Media, LLC (2007)

NANOCOMPOSITE

UNIT I

Introduction of Nanocomposites: Nanocomposites- Definition - Nanocomposites past and present- Nomenclature -Solids -Atomic and molecular solids -Role of statistics in materials - Primary , secondary and tertiary structure - Transitions

UNIT II

Properties and features of nanocomposites: Physics of modulus - Continuum measurements - Yield -Fracture -Rubbery elasticity and viscoelasticity - Composites and nanocomposites - Surface mechanical properties -Diffusion and permeability -Features of nanocomposites - basics of polymer nano compos1tes

UNIT III

Processing of nanocomposites: Viscosity -Types of flow -Viscosity - Experimental viscosity - Non-newtonian Flow -Low-viscosity processing –Solvent processing -Particle behavior -In situ polymerization -Post-Forming -Hazards of solvent Processing -Melt, high -shear, and direct processing

UNIT IV

Characterization of nanocomposites: Introduction to characterization - Experiment design - Sample preparation -Imaging -Structural characterization - Scales in nanocomposites - Texture -Electromagnetic energy -Visualization - Physicochemical analysis -Characterization of physical properties -Identification -\Mechanical -Surface mechanical properties.

UNIT V

Applications of nanocomposites: Nanocomposites -Optical, structural applications - Nanoparticulate systems with organic matrices -Applications - Biodegradable protein nanocomposites -Applications Polypropylene nanocomposites - Application as exterior automatic components -Hybrid nanocomposite materials - Application for corrosion protection

References

1. Thomas E. Twardow ski, Introduction to Nanocomposite Materials -Properties, Processing, Characterization, DesTech Publications, April 2007
2. Boston New york Washing ton, DC. and Woodhead publishing Itd, England, 2006.
3. Parag Diwan and Ashish Bharadwaj. Nanocomposites Pentagon Press
4. Nanocomposite Science and Technology Pulickel M. Ajayan , Linda S. Schadler, Paul V. Braun, 2006, Wiley-VCH

NANOBIOTECHNOLOGY

Objectives:

Understand the bases for Introduction to Nanotechnology

The principle of surface Biology and Analysis of Biomolecular Structure.

UNIT I

Introduction to Nanotechnology – Scientific Revolutions – Types of Nanotechnology and Nanomachines – Nanotechnology Products and Applications – Future Applications of Nanotechnology – Risks of Nanotechnology.

UNIT II

Nanobiotechnology Overview – Nanobiometrics – Introduction – Lipids as nano-bricks and mortar – Biocompatible Inorganic Devices - Cell-Nanostructure Interactions - Structure information-DNA – Nanostructured Systems from Low-Dimensional Building Blocks.

UNIT III

Protein-based Nanostructures – S-Layers – Engineered Nanopores – Microbial Nanoparticle Production – Magnetosomes-Nanoscale Magnetic Iron Minerals in Bacteria – Polymer Nanocontainers – Biomolecular Motors Operating in Engineered Environments – Nanoparticle-Biomaterial Hybrid Systems for Bioelectronic Devices and Circuitry.

UNIT IV

DNA-Protein Nanostructures – DNA-Templated Electronics – Biomimetic Fabrication of DNA-Based Metallic Nanowires and Networks – Mineralization in Nanostructured Biocompartments: Biomimetic Ferritins for High-Density Data Storage - DNA-Gold-Nanoparticle Conjugates.

UNIT V

Surface Biology: Analysis of Biomolecular Structure - Application of Nanoparticle in Biomedical research: Introduction – Nanotechnologies for Cellular and Molecular Imaging – Nanoparticles for Cancer Drug Delivery – Bioconjugated Silica Nanoparticles for Bioanalytical Applications - Impact of Biomedical Nanotechnology – Nanobiomedical Technology: Financial, Legal, Clinical and Societal Challenges to Implememtation

References

1. Nanobiotechnology: Concepts, Applications and Perspectives – Christof M. Niemeyer, Chad A. Mirkin, John Wiley & Sons Inc (2004)
2. Nanofabrication Towards Biomedical Applications – Challa S.S.R. Kumar, Josef Hormes, Carola Leuschner, John Wiley & Sons Inc (2005)
3. Nanotechnology: Basic Science and Emerging Technologies – Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Buckhard Raguse, Chapman & Hall/CRC Press (2002)

Environmental Pollution Control

Unit – I : Air Pollution: Air pollution Control Methods–Particulate control devices – Methods of Controlling Gaseous Emissions – Air quality standards.Noise Pollution: Noise standards, Measurement and control methods – Reducing residential and industrial noise – ISO14000.

Unit –II : Industrial wastewater Management: – Strategies for pollution control – Volume and Strength reduction – Neutralization – Equalization – Proportioning – Common Effluent Treatment Plants – Recirculation of industrial wastes – Effluent standards.

Unit – III : Solid Waste Management: solid waste characteristics – basics of on-site handling and collection – separation and processing – Incineration- Composting-Solid waste disposal methods – fundamentals of Land filling.

Unit – IV : Environmental Sanitation: Environmental Sanitation Methods for Hostels and Hotels, Hospitals, Swimming pools and public bathing places, social gatherings (melas and fares), Schools and Institutions, Rural Sanitation-low cost waste disposal methods.

Unit – V: Hazardous Waste: Characterization – Nuclear waste – Biomedical wastes – Electronic wastes – Chemical wastes – Treatment and management of hazardous waste-Disposal and Control methods.

Text Books

1. Environmental Engineering, by Ruth F. Weiner and Robin Matthews – 4th Edition Elesevier, 2003.
2. Environmental Science and Engineering by J.G. Henry and G.W. Heinke – Pearson Education.
3. Environmental Engineering by Mackenzie L Davis & David A Cornwell. McGraw Hill Publishing.

Research and Teaching Methodology

Objective:
The main aim of this study is to understand the scope, depth and the overall direction of the research and teaching methods.

UNIT I **(12hrs)**
Significance of Life Science Research – Types of Research – Formation of Research Problem –Formulation of Hypothesis – Sources of Data – Methods of Data Collection – Sampling design: Random and Non-random.

UNIT II **(12hrs)**
Meaning of Research - Objectives of Research - Types of Research - Research Approaches Significance of Research - Research and Scientific Methods - Criteria of Good Research - Funding agencies- Choosing the Research Problem- Layout of the Research Report – Types – Precautions in writing Research Reports – Footnotes Bibliography- bibliographic software

UNIT-III **(12hrs)**
Statistical analysis: Tests of Hypothesis- Parametric and Non-Parametric test:'t' and 'f' Test ANOVA $-\chi^2$ Test-statistical software including SAS, SPSS, sigma and origin

UNIT-IV **(10hrs)**
Basic Correlation: Definition, Meaning- Correlation types: Simple, Partial and Multiple Correlation - Regression: Meaning - Linear Regression- Difference between Correlation and Regression.

UNIT-V **(14hrs)**
Methodology of teaching**:**Teaching- Objective of teaching, Phase of teaching- Teaching methods: Lecture method, Discussion method, Discovery learning, Inquiry, Problem solving method, Project method Seminar, Integrating ICT in teaching: Individualized instruction , Ways for effective presentation with power point –Documentation – Evaluation: Formative, summative, & Continuous and comprehensive evaluation- Later adolescent Psychology: Meaning, Physical, Cognitive, Emotional, Social and Moral development- Teaching Later Adolescents.

References:

1. Sampath, K., Pannerselvam, A. & Santhanam, S. (1984). Introduction to education and technology. (2nd reviseded.). New Delhi: Starting publishers.
2. Sharma, S.R. (2003). Effective classroom teaching modern methods, tools and techniques. Jaipur:Mangal:Deep.
3. Vedanayagam, E.G. (1989). Teaching Knowledge for college teachers. New york :Sterling Publishers.
4. Berg, B. L., Lune, H., 2004. Qualitative research methods for the social sciences, Pearson Boston.
5. Kothari, C.R., 2004. Research Methodology Methods and Techniques, New Age International

6. Merriam, S. B., 1998. Qualitative Research and Case Study Applications in Education. Revised and Expanded from" Case Study Research in Education.", Jossey-Bass Publishers, Sansome St, San Francisco, CA.
7. Bogdan, R.C., Biklen, S. K., 1998. Qualitative research in education. An introduction to theory and methods, Allyn & Bacon, A Viacom Company, MA 02194.
8. Davis, M., 1997. Scientific Papers and Presentations‖ San Diego: Academic Press.
9. Isaac, S., Michael, W., 1971.Handbook in research and evaluation, (2nd ed.), San Diego, USA.
10. McDonald, J. H., 2009. Handbook of biological statistics, Vol. 2, Baltimore, Sparky House Publishing. MD, USA.
11. Gomez, K.A., Gomez, A.A., 1984. Statistical procedures for agricultural research, John Wiley & Sons.
12. Townend, J., 2012. Practical statistics for environmental and biological scientists, John Wiley & Sons.

Agricultural Entomology and Pest Management

Pests and diseases are one of the most important factors affecting crop production. Proper management is critical in order to avoid damages, meet regulatory standards, protect the environment and decrease pesticide resistance. This course focuses on pest and disease management in vegetables, greenhouse crops and flowers. However, the principles that are discussed in this course are relevant also for many other crops.

Objectives

1. To learn about agriculturally important pests.
2. To learn the different methods to avoid occurrence of pests.
3. To study the principles of biological control and pesticides, their properties and how to wisely use them.

UNIT I

Introduction to Insects; Insect Classification and Agricultural Pests; General anatomy of insects: Digestive system, Respiratory system, Circulatory system, Reproductive systems of male and female, Excretory system, Nervous system, Endocrine system. Economic importance of insects: Harmful, beneficial and productive insects.

UNIT II

Insect Behaviour and Reproduction: Mechanoreception – Mechanical stimuli, detection and processing; Thermoreception; Chemoreception; Semiochemicals; Vision/light reception-Reproduction.

UNIT III

Pest management - Sampling and monitoring arthropods - Methods of sampling and monitoring, Sampling plan – components & types; Insecticides – Types and formulation; Classification of insecticides on the basis of their chemical nature, mode of entry and mode of action. Application of insecticides; Problems associated with using insecticides - Toxicity to humans and wildlife, Resistance to insecticides.

UNIT IV

Integrated pest management – Concepts and principles; Components of IPM – Ecological aspects of pest management, Host plant resistance and biological components of IPM – Host plant resistance, biological control predators, parasitoids, microbes (fungi, bacteria, virus), entomopathogenic nematodes. Pest management through botanicals, behavioural modification and radiation technology.

UNIT V

Spray application techniques - Contact pesticides, Systemic insecticides and Translaminar insecticides, spray application, types nozzle selection, spray pressure and sprayer capacity. Biotechnology approaches and IPM case studies - Biotechnology approaches in IPM; IPM case studies - field crops and pulses (Paddy), Commercial crops (Cotton and sugarcane), vegetable (Tomato) and fruits (Mango).

Text books:

1. Richards, O.W., Davies,R. G., 1977. Imms' general textbook of entomology. Volume 2: classification and biology, Springer, pp. 388.
2. Whitten, M.J., 1992. Pest management in 2000: what we might learn from the twentieth century In: Kadir, A.A.S.A. (Ed.), Pest Management and the Environment in 2000. C.A.B.I., Wallingford, pp. 9-44.
3. Hall, F. R., Menn, J. J., 1998. Biopesticides: Use and Delivery (Methods in Biotechnology), Humana Press, 1st Edition, pp 640.
4. Pedigo, L. P., Rice, M. E., 2006. Entomology and Pest Management, 5th edn. Upper Saddle River, N], USA.
5. Harris, J., Dent, D., 2001.Priorities in Biopesticide Research and Development in Developing Countries (Biopesticides), CABI Publ.
7. Burgess, H.D., 1981. Microbial control of pest and diseases, Academic press, New York.
8. Hunter-Fujita, F. R., Entwistle, P. F., Evans, H. F., Crook, N.E., 1998. Insect Viruses and Pest Management, John Wiley, New York, pp. 620.
9. Ramakrishna Ayyar,T.,1940 Handbook of economic Entomology for South India, Government Press, Madras [Chennai], pp. 528.

Sustainable Agriculture

Sustainable agriculture is farming in sustainable ways (meeting society's food and textile needs in the present without compromising the ability of future generations to meet their own needs) based on an understanding of ecosystem services, the study of relationships between organisms and their environment.

Objectives

1. To achieve environmental health by meeting current needs without sacrificing future needs.
2. To attain economic profitability by sustainable use of energy sources along with renewable energy production and consumption
3. To adopt labour practices along with social and economic equity.

Unit I **12 hours**

Fundamentals of Agronomy - Importance of agriculture, Agricultural classification of crops, Soil and climatic requirements, varieties, cultural practices, special systems of cultivation, harvesting and processing of major crops, Soil productivity and fertility. - Crop nutrition - nutrients -classification - Nutrient sources - organic manures -fertilizers – biofertilizers; Irrigation - methods - drip and sprinkle irrigation systems. Water management of different crops - rice, banana and vegetables.

Unit II **12 hours**

Plant Breeding and Seed technology - Morphology and systematics of crop plants - General features - morphology of roots, stem, leaves, flowers, fruits and seeds .Introduction to field crops - Classification of field crops. Principles of plant breeding - Modes of reproduction, Sexual, Asexual, Apromixis and their classification; Modes of pollination, genetic consequences, differences between self and cross pollinated crops; Methods of breeding. Seed Technology - definition-structure of a seed-seed development process, Definition, Characters of good quality seed, Factors affecting seed quality - ecological influences , packing practices, harvest and post-harvest handling, Genetic and agronomic principles of seed production, Seed testing procedures for quality assessment- Physical, Purity, germination and viability test.

Unit III **12 hours**

Fundamentals of organic farming - Conventional, sustainable, and alternate agriculture-Alternate agricultural systems- biodynamic farming, natural farming, organic farming, permaculture, homa farming, and other formslimitations- Modernization of agriculture and its relation to sustainability. -Natural resource management as a part of sustainable resource management -crop production practices; Organic agriculture - Organic farming and food security-Principles of organic farming. Tools and practices of organic farming: Planned crop rotation, Green manures and cover crops, Manuring and composting, multiple cropping.Intercropping in relation to maintenance of soil productivity Farming System Approach for Sustainable Crop Production.

Unit IV **12 hours**

Farming System Approach for Sustainable Crop Production - crop production, different cropping systems; Cropping pattern - Multiple cropping and various forms- advantages and disadvantages- Intercropping- ecological basis of intercropping systems- types; Crop planning, crop calendar and cropping scheme preparation-factors affecting cropping schemes. Plant interactions- Allelopathy, Competition; Farming systems- components- Livestock-poultry- aquaculture- apiculture- sericulture. Incorporation of components of Integrated farming system in homestead farming. Integrated farming system (IFS) models for uplands and low lands for sustainable and organic agriculture- Evaluation of farming systems.

Unit V **12 hours**

Government Policies and Programmes related to agriculture – National Agricultural Policy in brief; Agricultural policies regarding land and labour; Agricultural policies regarding seeds - National Seeds Policy -varietal development and plant variety protection - seed production - quality assurance - seed distribution and marketing - infrastructure facilities - transgenic plant varieties - import of seeds and planting material - export of seeds -promotion of domestic seed industry Agricultural policies regarding fertilizers - Fertilizer pricing policy - payment of subsidy. Agricultural policies regarding plant protection chemicals - pesticide production and consumption in India - protection of consumers from adverse impacts of pesticides. Agricultural policies regarding irrigation, machinery, technology.

Text Books:

1. Balasubramaniyan, P and Palaniappan, S.P. 2001. Principles and Practices of Agronomy
2. AgroBios(India)Ltd., Jodhpur.
3. Cox, G.W and Atkins, M.D. 1979. Agricultural Ecology : An Analysis of World Food
4. Production Systems. W.H. Freeman and Company, San Francisco
5. De, G.C.1989.Fundamentals of Agronomy. Oxford & IBH Publishing Co., New Delhi.
6. Havlin, J. L., Beaton, J. D., Tisdale, S.L., and Nelsothn, W.L. 2006. Soil Fertility and
7. Fertilizers: An Introduction to Nutrient Management (7 ed.). Pearson Education, Delhi.
8. Chalam, G.V., J. Venkateswarlu. 1966. Agricultural Botany in India-Vol. 1. Asia pulishing house, Bombay, New Delhi
9. Daniel Sundararaj, D and G. Thulasidas, 1993. Botany of field crops. Macmillan India Ltd., New Delhi.
10. Palaniappan, S.P and Anandurai, K. 1999. Organic Farming- Theory and Practice, Scientific Pub., Jodhpur.
11. Government of India. Five year Plan Documents.
12. Government of India.Economic Survey. Published by Planning Commission (various issues)
13. Government of India.Economic Review. Published by State Planning Board (various issues).

Eco friendly Bioproducts

It is essential to develop alternative technologies to prevent any further damage health and the environment. Speeding their implementation can benefit our environment and truly protect the planet. Explore the goals of green technology, introducing sustainable living, develop renewable energy and reduce waste.

Objective:

1. To provide knowledge on biofertilizer
2. To develop students technical skills on bio fertilizer production

Unit I General Biofertilizers 12 Hours

Bacterial, fungal and algal biofertilizers; mycorrhiza -types-endo, ectomycorrhiza and orchidaceous mycorrhiza, Problems and prospects of biofertilizers. Rhizobium- Physiology, Rhizobium interactions, mass cultivation

Unit II Production of Biofertilizers 12 hours

Largescale production of biofertilizers, Blue green algae, VAM fungi- Field application of biofertilizers - method of application; Chlorella biofertilizer-growth parameters-Mushroom cultivation.

Unit III Bacterial Biofertilizers 12 hours

Cyanobacteria as biofertilizers – Azolla- Bacterial biofertilizers - Mass production of Azospirillum, Azotobacter and Phosphobacteria; N_2 fixation - Phosphate solubilization and mobilization.

Unit IV Biopesticides 12 hours

Definition, kinds and commerce of biopesticide, Bacillus thuringiensis, insect viruses and entomopathogenic fungi – its characters, physiology, mechanism of action and application of bioinsectides - neem and related natural products.

Unit V Vermicompost Technology 12 hours

Introduction to vermiculture, biology, economic important, their value in maintenance of soil structure, production of organic fertilizers by vermiculture- Earthworm farming, Extraction (harvest), vermicomposting- vermiwash collection, composition and use harvest and processing.

Suggested List of Exercises:

Books Studies:

1. Altman, A., 1997. Agricultural biotechnology, CRC Press.
2. Ariëns, E.J., Van Rensen J., Welling, W., 1988. Stereo selectivity of pesticides. Biological and chemical problems. Chemicals in agriculture. Volume 1, Elsevier Science Publishers, The Netherland.
3. Blackburn, R.S., 2009. Sustainable textiles: Life cycle and environmental impact. Elsevier Science Publishers, The Netherland.
4. Board, N., 2004. The complete technology book on vermiculture and vermicompost CRC Press.
5. Costanza, R., Norton, B.G., Haskell, B. D., 1992. Ecosystem health: new goals for environmental management, Island Press.USA.
6. Kannaiyan, S. 2002.Biotechnology of Biofertilizer, Narosa Publishing House, New Delhi.

Book References:

1. Franklin R.H., Julius, J.M. 1999.Biopesticides - Use and Delivery. Humana Press Inc, USA.
2. Purohit, S.S. 2003. Agricultural Biotechnology, Agrobios, India.
3. Nutman, P.S. 1976. Symbiotic nitrogen fixation in plants, Cambridge Univ. Press, London.
4. Cavaco-Paulo, A., Gubitz, G., 2003. Textile processing with enzymes Elsevier Science Publishers, The Netherland.
5. Chouhan, N., Kumar, A., Sharma, A., Ameta, R., 2013. Eco-Friendly Products. Green Chemistry: Past, Present, and Future: CRC Press.
6. Croft, B.A., 1990. Arthropod biological control agents and pesticides. John Wiley and Sons Inc., UK.
7. Entwistle, P.F., Cory, J., Bailey, M., Higgs, S., 1993. Bacillus thuringiensis: an environmental biopesticide: theory and practice, John Wiley and Sons Inc. UK.eprnt), CBS Publishers and Distributers, New Delhi.
7. Yadav, A.K., Motsara M.R and Raychaudhuri S., 2001 Recent Advances in Biofertilizer Technology, SPURT publication, New Delhi.

River Ecosystem Ecology

Preamble: The goals for this course are to gain an understanding of: 1) major physical and biological features of streams and rivers, 2) the range of diversity of running waters around the world, 3) fundamental processes producing patterns of riverine structure and function, and 4) critical issues associated with the conservation and management of streams and their biota.

Objective:

The main aim of the course is to teach the Stream/River ecology.

To provide scientific knowledge on Stream/River management.

Unit 1

Introduction – Stream order – Stream flow – Hydrology- Flow alteration- Environmental Flow- Fluvial Geomorphology – Discharge – Channel Morphology.

Unit 11

Stream water chemistry – Nutrient dynamics – Nutrient pollutions –Scaling of Sediment dynamics in the River Environment– Sediment Management - Influence of chemical factors on stream / river biota.

Unit 111

Stream / River ecological theories – River continuum concept – importance of connectivity in stream / Riverine Ecology- River Fragmentation- Biogeochemistry of NPC (nitrogen, phosphorus, carbon) – Organic matter budgets.

Unit 1V

Biotic interactions – Terrestrial aquatic linkage. Primary producer – Heterotrophic energy – Source in stream/river – Trophic relationships – Drift composition and periodicity – Functional basis of drift – Riparian vegetation.

Unit V

Stream/River management – River modifications – Dams and impoundments – Alien species – Climate change – Recovery and restoration of running waters.

Reference Books:

1. Nancy D. Gordon, Thomas A. McMahon, Brian L. Finlayson, Christopher J. Gippel, Rory J. Nathan. Stream Hydrology: An introduction for Ecologists.
2. Barbara A. Hauser. Drinking Water Chemistry: A Laboratory Manual.
3. Richard F. Hauer, Gary Lamberti. Methods in Stream Ecology: Volume 1: Ecosystem Structure.
4. Walter K. Dodds and Matt R. Whiles. Freshwater Ecology: Concepts and Environmental Applications of Limnology.
5. David J. Allan. Stream Ecology: The Structure and Function of Running Waters.
6. Philip J. Boon, Paul J. Raveen. River Conservation and Management.
7. Gary J. Brierley and Kirstie A. Fryirs (2005) Geomorphology and River Management: Applications of the River Styles Framework. Blackwell Publishing, Oxford, UK, 398pp.
8. Kathleen Weathers, David Strayer, Gene Likens. Fundamental of Ecosystem Science.
9. Vannote et al . The River Continum Concept.
10. Allan, J. David, Castillo, Maria M. Stream Ecology: Structure and function of running waters.

RESTORATION ECOLOGY AND MANAGEMENT

Preamble: The primary goal of this course is to develop critical thinking skills in the application of ecological principles to restoration.

Objective:

1.To understand the ecological concepts relevant for restoring ecosystems and critically think about the scientific/logistic challenges of applying these concepts into a restoration plan.

2. Students will describe the role of key ecological concepts in restoration

Unit I

Restoration Ecology - Definition, principles, concepts and strategies.(long term vs. short term); physical, chemical and biological restoration; role of ecological principles in restoration, role of pioneer species in restoration and holistic approach in restoration.

Unit II

Restoration of natural resources; restoration of river corridor, water resources and mine spoils. Approaches to Flood Plain Mana4ement, Concepts and Programs related to Restoration and Management of Lakes, Rivers and streams, Riverine = Riparian ecosystem and Wetlands, Fluvial restoration.

Unit III

Planning and evaluating aquatic ecosystem restoration — Project planning, Purpose of evaluation, Selecting assessment criteria and synthesizing data. Introduction to watershed, concept and significance. Physical and hydrological characteristics of watershed. Drain — line treatment; Area treatment — Goals, features and watershed as unit of sustainable development.

Unit IV

Integrated Aquatic Ecosystem Restoration- Introduction, Institutional barriers to Integrated Aquatic Restoration, Importance of Integrated restoration to wildlife, Appropriate scale for restoration, Use of Historical records in reconstructing watersheds. Impact of human activities on water resources, climate change threats to water quality, Shifts in freshwater ecosystems

Unit V

National restoration goals, Policy and Program. redesigning for restoration Integrated Water Resource Management (IWRM),. Role of. public participation, government agencies and NGOs in conservation and restoration; environmental education and its role in conservation and restoration. Finish Biotic restoration Landscape ecology and restoration Finish monitoring and adaptive management

Reference Book

1. John CairnS Jr., 1992. Restoration of Aquatic Ecosystems - Science, Technology and Public Policy. National Academy Press. Washington D.C.

2. Adamus, P.R., Clairain, E. J., Smith R.D., Young R. E., 1987. Wetland Evaluation Technuique (WET). Vol II. Methodology Operational Draft. U.S. Army cors of Engineers waterways Experiment Station, Vicksburg, Miss.

3. Barker, LA and E. B. Swain, 1989. Review of lake management in Minne-sota. Lake Reservoir Manage. 5:1-10.

4.Young, T. P. 2000. Restoration ecology and conservation biology. Biological Conservation 92: 73.83.
5. Hobbs, R. J. and Harris, J. A 2001. Restoration ecology: repairing the Earth's ecosystems in the new millennium. Restoration Ecology 9: 239-246.
6. Van Diggelen et al. 2001. Ecological restoration: state of the art or state of the science? Restoration Ecology 9: 115-118.
7. Ehrenfeld, J. G. 2000. Defining the limits of restoration: the need for realistic goals. Restoration Ecology 8: 2-9.
8. McClanahan, T. R. and Wolfe, ft W. 1993. Accelerating forest succession in a fragmented landscape: the role of birds and perches. Conservation Biology 7: 279-288.
9. Palmer et al. 1997. Ecological theory and community restoration ecology. Restoration Ecology 5: 291-300.
10.Cairns, J.Jr., and T. V. Crawford, eds. 1991. Integrated Environmental Management. Lewis Publishers, Chelsea, Mich. 214 pp.

Biostatistics and Science writing

Course overview:

Biostatistics is essential to analyse biological variations by the interpretation of results obtained from various research studies. This course would help in acquiring knowledge on the statistical tools relevant for the study. Science communication is a rapidly expanding area and meaningful engagement between scientists and the public requires effective communication. Contents of this course would enable research scholars to get started with science writing and effective communication

Objectives:

to understand the basic concepts and utility of common statistical techniques for biological data.
to stress on the importance and appropriateness of statistical methods, their assumptions, validity and interpretation.
to understand the methods of communicating science research to the community.
to use writing for the purposes of reflection, action and participation in academic inquiry.

Unit I **6 Hrs**

Introduction to Biostatistics - population, sample, variable, parameter, primary and secondary data, screening and representation of data, frequency distribution, tabulation, bar diagram, histograms, pie diagram.

Unit II **10 hrs**

Mean, median, mode, quartiles and percentiles, variance, standard deviation, coefficient of variation; Probability and distributions- definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability.

Unit III **10 hrs**

Correlation and Regression analysis: Correlations and regressions-: Relation between two variables, scatter diagram, definition of correlations, curve fitting, principles of least squares, Two regression lines, Karl Pearson's coefficient of correlation, Rank correlation, chi-square test for independence, P-value of the statistic, confidence limits, one way analysis of variance.

Unit IV **6 hrs**

Introduction to concepts research communication - popular science writing genres, Components of research article – various types and styles of writing - opinion – correspondence – Research communication – research article – review article.

Unit V **5 hrs**

Report writing scholarly and popular media - disciplinary relevance - effective drafting techniques. – Peer review process - Plagarism - publication ethics – copyright and use of publication - Creative Commons

Text Book/Reading material

1. Gurumani, N. 2010 An introduction to Biostatistics. MJP Publishers. Chennai. 376 pp.
2. Rao, P.S.S S and J. Richard 2012 Introduction to Biostatistics and Research Methods (Fifth Edition) PHI Learning Private Limited. 322 pp.
3. Banerjee, K. P. 2007 Introduction to Biostatistics. S Chand publishers, New Delhi.
4. Ramakrishnan, P. 2015 Biostatistics Saras publication, 416 pp.

Reference

1. Pagano M. and Gauvreau, K, 2000 Principles of Biostatistics, Duxbury Press, USA.
2. Turabian, K. L. 2007 A Manual for Writers of Research Papers, Theses, and Dissertations 7th edition. University of Chicago Press. 470 pp.

Freshwater Ecology

Course Overview This course will develop the principles of aquatic ecology, with a focus on their application to freshwater ecosystems (streams, rivers, wetlands, and lakes). This course aims at providing a comprehensive understanding of all the major element cycles, patterns of energy flow through ecosystems, and the links between ecosystem structure and function so that we can critically evaluate how complex processes (climate change, watershed urbanization) may directly or indirectly impact aquatic ecosystems.

Objectives:

To understand the interaction of biotic and abiotic factors in aquatic systems.

To have an overview of the role of hydrological cycle and importance of aquatic systems.

To critically evaluate the complexity of ecosystem processes (nutrient distribution, impact of climatic change) in aquatic ecosystems

To impart knowledge on various threats and conservation strategies.

Unit I **10 Hrs**

Introduction to Aquatic ecology – Hydrological cycle - Properties of Water –- Stratification and Mixing Classification – biotic and abiotic components. Biotic integrity.

Unit II **8 Hrs**

Energy and Trophic Dynamics - Primary production in streams, rivers, and lakes - Energy transfer – modification of organic matter - Stream metabolism

Unit III **10 Hrs**

Various Freshwater bodies – streams, rivers, lakes Swamps and marshes: Physicochemical conditions. Nutrient cycling. Biotic components. Origin and characteristics of river. Functions. Biological productivity. watershed and water drainage.

Unit IV **9 Hrs**

Major threats to freshwater systems - Impact of dams and fragmentation on river ecology. River continuum concept. Pollution and eutrophication. Climate change implications on freshwater systems. Habitat quality and Biomonitoring potential

Unit V **7 Hrs**

Conservation and Management of aquatic ecosystems – role of government and agencies – Restoration ecology - Ecological concepts of restoration ecology - Barriers to effective management

Text Book/Reading material

1. Dey. S and B. Nasrin 2014 Ecology of Aquatic systems. Scientific International (Pvt.) Ltd.
2. Munshi J. D., and J. Datta 2015 Fundamentals of Limnology. Astral Publisher.
3. Agarwal. S.C., 1999 Limnology 4th edition CBS Publishers.

Reference

1. Allan, J.D. and Castillo, M.M. 2009. Stream Ecology (Second Ed.). Springer, Netherlands.
2. Keddy, P.A. 2000. Wetland Ecology. Principles and Conservation. Cambridge University Press, Cambridge.
3. Dodds. W and W. M. Whiles 2010 Freshwater Ecology 2nd Edition Concepts and Environmental Applications of Limnology. Academic Press. 829 Pp.
4. Closs, G., Downes, B and A. Boulton 2004 Freshwater Ecology: A Scientific Introduction EPZ Edition
5. Falk, D. A., Palmer, M. A. et al. 2006. Foundations of Restoration Ecology. Island Press, Washington, DC.
6. Frid C and M Dobson 2013 Ecology of Aquatic Management Second Edition. Oxford Unviersity Press 352 pages

Biological Invasions and Management

Course Overview

Invasive species are among the world's worst threats to biodiversity and is likely to cause economic and environmental damage. This course aims to provide an overall understanding of the impact of invasive species and its management. The important aspect of this course is to extend the learning to help in protecting the species and ecosystems from the impact of invasive species.

Objectives

To learn the basic concepts of invasive species and their impacts

To understand the patterns of invasion and traits of successful invasive species

To develop concepts based on the information available from various invasion models

To design and develop management measures to control exotic invasive species

Unit I **8 Hrs**

Biological invasions – invasive species: impact, overview of the problem and modes of exotics spread both historically and currently, political impacts.

Unit II **6 Hrs**

Accidental introductions - Aquatic and terrestrial environments - Human mediated spread and other intentional introductions - Epidemics and epizootics

Unit III **8 Hrs**

Characteristics of successful invasive species - Community and ecosystem - structure and function - Disruption of normal ecosystem function by exotics

Unit IV **8 Hrs**

Patterns and dynamics of spread of invasive species – overview of invasion models – Case studies – Biosecurity failures - Feral Cat Management in Tasmania – African cat fish in India.

Unit V **10 Hrs**

Invasive species management – organizations – IUCN – Invasive Species Specialist Group (ISSG) – National biodiversity authority (NBA) - methods of invasive species control – awareness and strategies

References:

1. Shigesada N and K. Kawasaki, 1997, Biological Invasions: Theory and Practice , Oxford University Press, Oxford.

2. Simberloff D 2013 Invasive Species: What Everyone Needs to Know. Oxford University Press,. 352 pp

3. Lockwood, Julie L., Martha F. Hoopes and Michael P. Marchetti. 2007. Invasion Ecology. Malden, MA: Blackwell Publishing.

4. Mooney, Harold A. and Richard J. Hobbs. 2000. Invasive Species in a Changing World. Washington: Island Press.