



M.Sc. Environmental Science Course Structure under CBCS

(For the candidates admitted from the academic year 2016-2017 onwards)

Updated on 17.10.2018

Sem	Course	Course Title	Ins. Hrs / Week	Credit	Exam Hrs	Marks		Total
						Int.	Ext.	
I	Core Course – I (CC)	Principles of Ecology and Environmental Science	6	4	3	25	75	100
	Core Course – II (CC)	Environmental Chemistry and Toxicology	6	4	3	25	75	100
	Core Course – III (CC)	Environmental Microbiology and Biotechnology	5	4	3	25	75	100
	Core Course – IV (CC)	Climate Change and Current Issues	5	4	3	25	75	100
	Core Practical – I (CP)	Environmental Chemistry, Microbiology and Biotechnology (P)	8	4	3	40	60	100
	TOTAL			30	20			
II	Core Course – V (CC)	Environmental Pollution Studies	6	5	3	25	75	100
	Core Course – VI (CC)	Environmental Geology, Geography and Remote Sensing	6	5	3	25	75	100
	Core Practical – II (CP)	Environmental Geology and Geography and Remote Sensing (P)	8	4	3	40	60	100
	Elective Course – I (EC)	Biodiversity and Conservation	5	5	3	25	75	100
	Elective Course – II (EC)	Environmental Ethics, Law and Policy	5	5	3	25	75	100
	TOTAL			30	24			
III	Core Course – VII (CC)	Waste Management and Remediation	6	5	3	25	75	100
	Core Course – VIII (CC)	Energy and Green Technology	6	5	3	25	75	100
	Core Practical – III (CP)	Energy and Remediation (P)	8	4	3	40	60	100
	Elective Course – III (EC)	Natural Resource Management	5	5	3	25	75	100
	Elective Course – IV (EC)	Statistical and Computer Applications in Environmental Studies	5	5	3	25	75	100
	Total			30	24			
IV	Core Course – IX (CC)	Environmental Analytical Methods	5	5	3	25	75	100
	Core Course – X (CC)	Environmental Impact Assessment and Environmental Audit	5	5	3	25	75	100
	Core Practical - IV (CP)	Environmental Analytical Methods (P)	8	4	3	40	60	100
	Elective Course – V (EC)	Industrial Pollution and Safety Management	5	4	3	25	75	100
	Project		7	4	-	-	-	100
	TOTAL			30	22			
GRAND TOTAL			120	90				2000

Note:

Project - 100 Marks
Dissertation - 80 Marks
Viva Voice - 20 Marks

Core Papers - 10
Core Practical - 4
Elective Papers - 5
Project - 1

Note:

1. Theory	Internal	25 marks	External	75 marks
2. Practical	”	40 marks	”	60 marks

3. Separate passing minimum is prescribed for Internal and External

- a) The passing minimum for CIA shall be 40% out of 25 marks (i.e. 10 marks)
- b) The passing minimum for University Examinations shall be 40% out of 75 marks (i.e. 30 marks)
- c) The passing minimum not less than 50% in the aggregate.

CORE COURSE I

PRINCIPLES OF ECOLOGY AND ENVIRONMENTAL SCIENCE

OBJECTIVES

1. To study the ecological factors, structure and function of ecosystem.
2. To study about biodiversity and natural resources in the Biosphere.
3. To understand the causes, effects and control measures of pollution.

UNIT I

Definition, principle, branches and scope of ecology. Ecological factor: Abiotic –Physical and chemical factors: Soil, air, water, temperature, pH, humidity, radiation, wind, pressure, precipitation. Biotic – Limiting factors – Species interaction: Commensalism, amensalism, mutualism, competition, parasitism, prey-predator relationship. Basic components of an ecosystem – structure and functional aspects of an ECO System, Tropic structure – Ecological Niche – Ecological dominance –stability diversity rule.

UNIT II

Population: definition, characteristics, population density, natality, mortality, age distribution, growth patterns, population fluctuation, population equilibrium, biotic potentials, population dispersion and regulation of population. Ecological age pyramid. Ecological succession types, process, climax and significance of succession. Food chain –types of food chain with examples, food web, energy flow, ecological pyramid of biomass.

UNIT III

Definition, concept, structure and function of an ecosystem: producers, consumer and decomposers. Primary and secondary productivity. Ecosystem types: Terrestrial – forest, mountain, deserts and grassland. Aquatic – Freshwater (lentic and lotic) and marine (Estuary, mangroves, corals, deep sea).

UNIT IV

Definition, concept and types of biodiversity. Introduction to taxonomy. Biogeographical classification in India. Values of biodiversity. Status of biodiversity – Global, national and local status. Hot-spots of biodiversity. Endangered and threatened species. Strategies for biodiversity conservation – Insitu and Exsitu conservation, Cryopreservation, Gene banks, Gene pool and species conservation. National parks and sanctuaries. Common flora and fauna in India. Bioprospecting.

UNIT V

Definition, principle and scope of Environmental science. Earth, man and Environment interactions. Geographical classification and zones. Significance of Atmosphere, lithosphere and Hydrosphere. Biosphere – global distribution of plant biomes, spatial distribution of animals – zoogeographic realms. Environmental pollution: definition types (Air, water and soil). Biogeochemical Cycles – Availability and rate of cycling of nutrients – gaseous and Sedimentay cycle.

REFERENCES

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2. Asthana, DK and Meera Asthana, (2014). *A Textbook of Environmental Studies*. S. Chand Publication, New Delhi
3. Begon M, Townsend CR & Harper JL, (2006). *Ecology: from individuals to ecosystems*
4. Daniel chiras, (2001). *Environmental Science*, 6th Edition. Jones and Bartket publishers
5. Jørgensen SE and Johnson I, (1981). *Principles of Environmental Science and Technology*. By Copenhagen, Denmark
6. Ranveer Kumar, BS Singh and MP Singh, (2012). *Walter pollution and Environment*. Enkay Publishing House
7. Sharma PD, (2003). *Ecology and Environment*. Rastogi Publication, Meerut
8. Shormila Mukherji, (2004). *Fragile Environment*, Manak publication Pvt. Ltd. New Delhi
9. Singh JS, Singh SP and SR Gupta, (2008). *Ecology, Environmental and Resource conservation*. Anamaya Publishers, India
10. Smith R and Smith RM, (2000). *Ecology and Field Biology*. (6th ed.). Prentice Hall
11. Subramanian V, (2002). *A Text Book on Environmental Science*. Narosa Publishing House. New Delhi
12. Suresh K. Dhameja, (2003). *Environmental Science and Engineering*, S.K.Kataria & Sons Publishers and Distributors, New Delhi

CORE COURSE II

ENVIRONMENTAL CHEMISTRY AND TOXICOLOGY

OBJECTIVES

1. To understand the sources, distribution, transport, chemodynamics and fate of chemicals/pollutants in the ecosystems.
2. To acquire broad knowledge of Environmental Chemistry including development of methods for ultra-trace analysis of pollutants in air, water, soil and biological matrices.
3. To describe important chemical reactions in the lithosphere, hydrosphere and atmosphere, including smog formation, ozone chemistry, acid rain chemistry, etc.

UNIT I : Fundamentals of environmental chemistry

Stoichiometry, Gibb's energy, chemical potential, chemical equilibria, acid-base reactions, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, radionuclides.

UNIT II : Chemical composition of air

classification of elements, chemical speciation. Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reactions in the atmosphere. Oxygen and ozone chemistry. Chemistry of air pollutants. photochemical smog and acid rain.

UNIT III : Water chemistry

Physico-Chemical parameters of water, concept of DO, BOD, COD, sedimentation, coagulation, filtration, Redox potential, hydrological cycle, sampling techniques.

UNIT IV : Soil chemistry

Structure of lithosphere, nature of soil - physical properties of soil - soil water - soil air - soil temperature - mechanical composition- structure and texture. Chemical properties of soil: Minerals of soil - colloids in soil; ion exchange reactions in soil. Soil fertility and evaluation - organic matter in soil and their transformation - soil pH.

UNIT V : Environmental toxicology and toxicogenomics

Introduction to toxicology, toxicity evaluation methods-LD₅₀, LC₅₀, etc. Toxic chemicals in the environment -Teratogens, mutagens and carcinogens. Pollutant uptake, biotransformation, accumulation, detoxification and elimination by organisms. Toxicant effects - molecular effects and biomarkers, sublethal, acute and chronic effects. Impact of toxic chemicals on enzymes and hormones - Biochemical effects of arsenic, lead, mercury,

pesticides, PCBs, flame retardants, Environmental toxicology of nanoparticles/materials.

REFERENCES

1. Banerji SK, (2002). Environmental chemistry. Prentice-Hall of India, New Delhi
2. Bhatia SC, (2002). Environmental chemistry. CBS publishers and Distributors, New Delhi
3. Chatwal A, (1999). Instrumental methods of chemical analysis. Himalaya publishing House, Mumbai
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5. De AK, (1990). Environmental Chemistry. Wiley Eastern Ltd., New Delhi
6. Johnson DO, Netteville JT, Wood JC and James M, (1973). Chemistry and the Environment W.B. Saunders Co., Philadelphia
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8. Sindhu PS, (2002). Environmental chemistry. New age international publishers, New Delhi
9. Sodhi CS, (2000). Fundamental concepts of environmental chemistry. Narosa Publishing house, New Delhi
10. Manahan SE, (2009). Environmental Chemistry. CRC Press
11. Baird and Cann, (2012). Environmental Chemistry. W. H. Freeman
12. vanLoon and Duffy, (2011). Environmental Chemistry: A Global Perspective. OUP Oxford
13. Crosby. (1998). Environmental Toxicology and Chemistry. Oxford University Press USA
14. Wright and Welbourn, (2002). Environmental toxicology. Cambridge University Press
15. Newman and Clements, (2008). Ecotoxicology: a comprehensive treatment. CRC Press

CORE COURSE III

ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

OBJECTIVES

1. To provide the students with an opportunity to learn about the fundamentals of microbes and environment interactions.
2. To make the students to understand the biotechnological aspects of microbes in biodegradation and environmental remediation.

UNIT I : Introduction to microbiology and biotechnology

Structure and reproduction of microbes in general - Bacteria, Fungi, Virus, and Actinomycetes - Sterilization and microbial culture methods - Preparation of culture media - isolation and identification of microorganisms by biochemical and molecular methods - Microbial growth kinetics - Molecular methods - Nucleic acids isolation - Restriction enzymes - PCR.

UNIT II : Aquatic microbiology

Microbiology of water - Bacteriological analysis in Water - Water pollution - Eutrophication - Waterborne diseases - Sewage microbiology - Sewage treatment - Activated sludge process.

UNIT III : Soil microbiology

Soil Microbial Community - Microbial interactions - Biogeochemical cycles - Carbon cycle - Nitrogen cycle - Biological Nitrogen fixation, ammonification, nitrification and denitrification - Phosphorus cycle - Sulphur cycle - Role of bacteria and fungi in soil fertility.

UNIT IV : Environmental application of microorganisms

Biological wastewater treatment - Effluent treatment - Anaerobic digestion and biogas production - Biodegradation, Biotransformation, Mineralization, Bioremediation of Environmental Pollutants - organic pollutants and heavy metals remediation - Bio-mining.

UNIT V : Biotechnological products of microbes

Biodegradation and Bioconversion lignocellulose to fuels - Microbial Fuels Bioethanol, Biobutanol production, Biohydrogen production - Biodeterioration - Bio-fertilizers - Bio-pesticides, Microbial enzyme - cellulases, hemicellulases - ligninases, laccases, amylases, xylanase.

REFERENCES

1. Thakur IS, (2012). Environmental Biotechnology: Basic Concepts and Applications (2nd Second Edition). I. K. International Publishing Housing, New Delhi
2. Singh DP, Singh SK and DP Dwivedi, (2005). Environmental Microbiology and Biotechnology. New Age International (P) Limited , Publishers
3. Alexander N Glazer and Hiroshi Nikaido, (2007). Microbial Biotechnology: Fundamentals of Applied Microbiology (2nd Edition)
4. Ian L Pepper, Charles P Gerba and Terry J Gentry, (2015). Environmental Microbiology (Third edition), (Eds.) C.P. Gerba, T.J. Gentry, Academic Press

WEB RESOURCES

1. https://en.wikipedia.org/wiki/Microbial_ecology
2. <http://www.environmentalscience.org/environmental-microbiology-gis>
3. http://www.greenpeace.org/australia/PageFiles/434214/GM_Fact%20Sheet_Health_%20and_Env_Impacts.pdf
4. <http://enhs.umn.edu/current/5103/gm/harmful.html>
5. <http://igmoris.nic.in/>
6. www.wastewatertreatment.co.in/index.php
7. www.microbialfuelcell.org
8. www.pollutionissues.com/A-Bo/Bioremediation.html
9. www.bioreactors.net
10. <http://www.cpeo.org/techtree/ttdescript/biorec.htm>
11. <http://www.personal.psu.edu/jel5/biofilms/>
12. www.rdp.cme.msu.edu

CORE COURSE IV

CLIMATE CHANGE AND CURRENT ISSUES

OBJECTIVESS

1. To understand the structure and composition of the Earth.
2. To describe the climatology pattern, changes and its effect on earth.
3. To discuss the climate change impact and its mitigation.

UNIT I

Overview of the structure and composition of the atmosphere; earth and sun relations - rotation, revolution and seasons. Atmosphere, Hydrosphere, Lithosphere, Biosphere and their linkage, Earth's geological history and development and evolution of the atmosphere; Gaiya Hypothesis. Element of climate, climate controls. Species and temporal patterns of climate parameters.

UNIT II

Meteorology fundamental – Energy, radiation, temperature and heat; pressure, pressure belts, wind and atmospheric circulation; atmospheric moisture humidity, condensation, formation of precipitation, dew, fog and clouds; atmospheric stability, adiabatic process; scales of meteorology; application of micro-meteorology to vegetated surfaces, urban areas; atmospheric stability diagrams, turbulences, diffusion. Wind roses, Topographic effects, Pollutant climatology

UNIT III

Atmosphere and climate. Basic atmosphere properties, climate controls. Climate classifications and variability. Atmospheric climate - global scale, regional scale, local scale. Oceans: General circulation patterns. Air-Sea interaction. Tropical systems– equatorial trough, ITCZ, jet streams, vortices; Indian monsoon.

UNIT IV

Global Energy balance: Source, transfer, distribution. Energy balance of the atmosphere. Wind, stability and turbulence; El Niño, southern oscillations cyclones. Natural climate changes: Records of climate change (glacial cycles, ocean sediments, corals, tree rings). Climatic considerations in industrial locations and city planning. Oceans and variation in climate.

UNIT V

Human impact on climate-causes and consequences of Global warming – Global and regional trends in greenhouse gas emissions –Sea level rise; role of oceans and forests as carbon sinks, Ozone hole. Impacts of climate changes- Effects on organisms including humans; effects on disease;

Extinction risk for temperature –sensitive species; UV effects climate change and policy: Montreal protocol; Kyoto Protocol; carbon trading. Physiography, spatial and temporal patterns of climatic parameters - temperature, rainfall and its variability in India with special reference to NE monsoon, general circulation.

REFERENCES

1. Barry RG, (2003). Atmosphere, weather and climate. Routledge Press, UK
2. Burrough WS, (2007). Climate change; A multidisciplinary Approach, CUP
3. Critchfield Howard J, (1998). General climatology, prentice Hall India Pvt .Ltd., New Delhi.
4. Critchfield HJ, (2002). General Climatology, PHI.
5. Das Monsoon PK, NBT 17.
6. David D Houghton, (2002). Introduction to climate change: Lecture notes for meteorologist, World Meteorologist Organization.
7. Donald Ahrens C. Meteorology Today – An introduction to weather, climate and the environment Brooks/Cole Thompson Learning.
8. Firor J and Jacobsen JE, (2002). The crowded green house: population, climate changes and creating a sustainable world. Yale University press.
9. Gorden, (1998). Dynamic Meteorology - A basic course, Arnold,
10. Harvery D, (2000). Climate and Global climate changes. Prentice Hall.
11. Menon, P.A. Our Weather, NBT.
12. Natalia Trofimenko, (2011). Climate change: current issues
13. Oliver J.E. and Hidore J.J. Climatology and atmospheric science.

WEB RESOURCES

1. <http://nca2014.globalchange.gov> .
2. http://rhg.com/wpcontent/uploads/2014/06/RHG_AmericanClimateProspectus_June2014_LowRes1.pdf.
3. http://www.unc.edu/~jjwest/ClimateCourse-Syllabus_2015.pdf
5. www.hmmtreasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.
6. www.aip.org/history/climate.
7. www.realclimate.org.
8. www.globalchange.gov/engage/process-products/sap-summary

CORE PRACTICAL I

ENVIRONMENTAL CHEMISTRY, MICROBIOLOGY AND BIOTECHNOLOGY (P)

OBJECTIVES

1. To provide practical knowledge on basic environmental chemistry.
2. To develop experimental skills of the students in handling microbes.
3. To develop experimental skills of the students in production of microbial products for environmental applications.

PRACTICAL

1. Determination acidity, alkalinity, pH and conductivity.
2. Estimation of total solids (TS), total dissolved solids (TDS) and total suspended solids (TSS)
3. Preparation of culture media and isolation of microorganisms from soils, mine contaminated area bacterial growth kinetics.
4. Isolation of bacterial DNA and gel electrophoresis.
5. PCR amplification of 16S rRNA gene, sequencing and identification of Bacteria.
6. Enumeration bacteria from water and wastewater - total coliform and total fecal coliform.
7. Estimation of Ammonium and Phosphorus content of wastewater.
8. Biodegradation of environmental pollutant by bacteria – phenol degradation.
9. Microbiological treatment of industrial (dye or paper) effluent and determination of COD.
10. Production fungal biocontrol agent for pathogen control.
11. Production and quantification of enzyme activity.

CORE COURSE V

ENVIRONMENTAL POLLUTION STUDIES

OBJECTIVES

1. Define pollution and describe the sources, types and effects of major pollution.
2. Appreciate why access to sewage treatment and clean water are important to people in developing countries.
3. Examine the topic of pollution, its possible solutions, and the government agencies that are responsible to deal with environmental issues.
4. Enable students to understand environmental problems, looking at causal linkages between pollution sources, exposure pathways and impacts to environmental quality and human health.

UNIT I : Air Pollution

Structure of the atmosphere, Types of air pollutants, primary and secondary particulate and gaseous contaminants, their sources and impact on vegetation, animals and human beings. Photochemical smog, Bhopal gas disaster. Acid rain formation its effects on environment. Community air pollution survey. Meteorological factors in air pollution survey. Meteorological factors in air pollution, wind, Atmospheric stability, plume behaviour. Air pollution monitoring, principles of sampling and analysis of particulate and gaseous contaminants.

UNIT II : Water Pollution

Sources and types of water pollution. Classification of water pollutants - Oxygen demanding wastes, pathogens, plant nutrients, synthetic organic compounds, inorganic chemicals and mineral substances. Thermal pollution - sources and effects, an episode of thermal pollution. Sewage - nature of sewage.

UNIT III : Land Pollution

Sources, types and nature of solid wastes, effects of solid wastes, solid industrial wastes, defecation and its effects, fertilizer pollution, types of fertilizers, field run off-effects. Pesticides pollution, history, types - effects of biocides, Other forms of environmental degradation, monoculture and its impacts, Dam water development projects and its impacts.

UNIT IV : Radioactive Pollution, Noise pollution and Marine pollution

Radiation - types and units-sources natural and man-made. Effects of radioactive pollution, atomic explosions and episode. Noise pollution: Sources, types, characteristics of sound, noise, intensity annoyance, impacts of noise pollution. Marine pollution: Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system. Impact of marine pollution. Oil pollution - sources and effects, an episode of oil pollution. - coastal management

UNIT V : Environmental Pollution and Management

Applications of Advance technologies on Pollution Management - Environmental impact assessment and monitoring – cleaner production technology, waste minimization techniques – bioremediation technology, Remote Sensing and GIS technology. Green technology, Alternative energy, waste to energy conversion technology, International Organization for standardization (ISO) - Role of NGOs, Public participation. Enforcement or implantation environmental protection acts.

REFERENCES

1. Abbasi SA, (1998). Environmental pollution and its control, Cogent international, Pondicherry
2. Asthana K and Asthana M, (2003). Environment. Chand and Co. Ltd., New Delhi
3. Bhatia HS, (1998). Environmental pollution and its control, Glogotia publications (P) Limited, Delhi
4. Dara SS, (2002). A text book of environmental chemistry and pollution control, Chand and Co. Ltd., New Delhi
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8. Kumaraswamy K, Alagappamoses A and Vasanthi, (2004). Environmental Studies. National offset printers, Tanjavur
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10. Murty JVS, (1994). Watershed Management in India. Wiley Eastern Ltd., New Delhi
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13. Sharma BK and H Kaur, (1994). Air Pollution. Goel Publishing House, Meerut.
14. Sharma BK and H Kaur, (1994). Soil and Noise Pollution. Goel Publishing House. Meerut.
15. Sharma BK and H Kaur, (1995). Environmental Chemistry. Goel Publishing House, Meerut.
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18. Trivedy RK and PK Goel, (1995). An introduction to air pollution. Enviromedia, Karad
19. Kannan K, (1991). Fundamentals of Environmental Pollution. S chand Co, New Delhi
20. Best GA, (1999). Environmental Pollution Studies. Liverpool University Press
21. Daniels RJR, and Krishnaswamy J, (2014). Environmental Studies. Wiley India Private Limited
22. VK Sharma, (2011). Environmental Pollution: A Brief Study. Delhi: Neha Publishers & Distributors

CORE COURSE VI

ENVIRONMENTAL GEOLOGY, GEOGRAPHY AND REMOTE SENSING

OBJECTIVES

1. To introduce the fundamental process and dynamics that place in various components of the Geosphere.
2. To understand the structure of the earth, its formation and composition.
3. To throw light on rock cycle inclusive weathering, soil formation and land forms.
4. To understand the basics of Sedimentology including formation chemistry and transport.
5. To develop an understanding on geochronology, tectonic and ocean crust

UNIT I : Introduction to geosphere components

Fundamentals of Atmosphere (Troposphere, Mesosphere, Stratosphere, Exosphere), Hydrosphere, Lithosphere, Pedosphere and their interaction, material balance principle, Thermodynamics princ and entropy.

UNIT II : Geology and its perspective

Earth in the solar system: origin, size, shape, mass, density, rotational and revolution parameters. Formation of core, mantle, crust, and elemental abundance in each constituent. Convection in the earth's core and production of its magnetic field. Mineral: physical properties (form, colour, lusture, strak, cleavage, fracture, hardness, specific gravity) and chemical composition. Silicate structure and their classification.

UNIT III : Rock Cycle and weathering

Types of rocks and their composition, controlling factors and products of weathering. Soil formation, soil profile and soil types. Important erosional and depositional landforms produced by running water: waterfalls, rapids, meanders, oxbow lakes, floodplains, levees, alluvial fans, stream terraces and deltas. Youth, mature and old stages of river systems. Stream patterns.

UNIT IV : Radioactivity and age of the earth

Radio isotope dating methods and geochronology, Elementary ideas of various geotectonic units namely shield, craton, platform, orogenic belt, mid-oceanic ridge, ocean island arc, deep sea trenches and their examples. Elementary ideas about seafloor spreading, plate tectonics, and continental drift.

UNIT V : Remote Sensing and GIS

Remote Sensing and GIS – Definition, Principles and Concept of Remote Sensing, Types, Components of GIS, Concept. Sensors – Satellite Remote Sensing Sensors. Data Processing – Digital Image Processing, Visual

Interpretation. GIS – GIS Softwares, Spatial Database Creation, Integration, Analysis. Application of Remote Sensing and GIS for Environmental Studies – Land Use/Land Cover Changes, Forest Management, Natural Resource Management, Pollution Mapping and Biodiversity Assessment.

REFERENCES

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2. Edward A. Keller (2011) Environmental Geology (9th Edition) 9th Edition, Prentice Hall, Inc. A Pearson Company
3. Tom L. McKnight (2005) Physical Geography A Landscape Appreciation, 8th Edition, ISBN#: 0-13-145302-5, Prentice Hall, Inc. A Pearson Company
4. Bettinger, Wing and Wing, (2004). Geographic Information Systems: Applications in Forestry and Natural Resources Management, McGraw Hill, NY
5. Kang-tsung Chang, (2003). Introduction to Geographic Information Systems, Tata McGraw Hill Edition, New Delhi
6. IA Mirsal, (2004). Soil Pollution, Springer Publications
7. Lillesand and Kiefer, (2004). Remote Sensing and Image Interpretation, John Wiley and Sons, NJ, USA
8. Vardiman L , Snelling A, Chaffin. F (2000) Radioisotopes and Age of Earth, Creation Research Society, Missouri, USA.
<https://www.icr.org/i/pdf/research/rate-all.pdf>
9. Lillie's T.M. and Kiefer R.W (2003) Remote Sensing and Image Interpretation, John Wiley and Sons.
10. Burrough P.H and Mc Donnell (1998) Principles of Geographical Information System, Oxford University Press.

CORE PRACTICAL II

ENVIRONMENTAL GEOLOGY, GEOGRAPHY AND REMOTE SENSING (P)

OBJECTIVES

1. To experimentally understand the basic structure of rocks and their mineral composition
2. To read the toposheet and identify topographical features for further environmental analysis
3. To process maps and analyze environmental data using GIS softwares
4. To visualize the satellite imageries and interpret geographical, geological and ecological features using ERDASS software.

1. Structure of geology and geophysical method
2. Identification of rock types
3. Introduction of toposheet /Basic Mapping and Creation of a database
4. Georeferencing of toposheet and Projection and transformation of Raster data (toposheet)
5. Basic of Digitization, Data editing and topology creation
6. Data analysis and output map generation
7. Study of satellite Imagery in different bands and visual interpretation
8. Identification of feature on satellite imagery
9. Georeferencing of image using Erdas Imagine
10. Demonstration of GPS (Global position system)

ELECTIVE COURSE I

BIODIVERSITY AND CONSERVATION

OBJECTIVES

1. To maintain essential ecological processes and life supporting systems.
2. To preserve the diversity of species or the range of genetic material found in the worlds organisms.
3. To make sustainable utilization of species and ecosystems.

UNIT I : Biodiversity – Concept and Definition

Scope and Constraints of Biodiversity Science, Composition and Scales of Biodiversity: Genetic Diversity, Species/ Organismal Diversity, Ecological/ Ecosystem Diversity, Landscape/ Pattern Diversity, Agrobiodiversity, Biocultural Diversity and Urban Biodiversity.

UNIT II : Values of biodiversity

Instrumental/Utilitarian value and their categories, Direct use value; Indirect/ Non-consumptive use value, Introduction to Ecological Economics; Monetizing the value of Biodiversity; Intrinsic Value; Ethical and aesthetic values, Anthropocentrism, Biocentrism, Ecocentrism and Religions; Intellectual Value; Deep Ecology.

UNIT III : Threats to biodiversity

Habitat Destruction, Fragmentation, Transformation, Degradation and Loss: Causes, Patterns and consequences on the Biodiversity of Major Land and Aquatic Systems Invasive Species' pathways, biological impacts on terrestrial and aquatic systems. Extinction: Types of Extinctions, Processes responsible for Species Extinction, Current and Future Extinction Rates, IUCN Threatened Categories, Sixth Extinction/Biological Crisis.

UNIT IV : Introduction to conservation biology

The history and distinctions of conservation Biology, Emergence of Global Conservation (Developing and Developed Nations) strategies

In response to expanding anthropogenic demands, In response to global climate changes, Multidimensional aspects of conservation biology-*in situ*, *ex situ*, Biogeographic classification.

UNIT V : Conservation challenges in the twenty first century:

Urbanisation; Creating knowledge society, Conflict management and decision making, Management of introduced species.

Evaluation of priorities for conservation of habitats and species

Selection criteria for protection of species – species quality, IUCN Guidelines for Red List categories and criteria (version 7.0), Red List of Indian Flora and Fauna, Selection criteria for protection of habitats – hotspots, Conservation indices.

REFERENCES

1. Groom MJ, Meffe GR and CR Carroll, (2006). Principles of Conservation Biology. Sinauer Associates, Inc., USA
2. Krishnamurthy KV, (2003). Textbook of Biodiversity. Science Publication
3. Primack R, (2014). Essentials of Conservation Biology. Sinauer Associates, Inc., USA
4. Hamblen C and SM Cannly, (2013). Conservation. Cambridge University Press.
5. Van Dyke F, (2008). Conservation Biology Foundations, Concepts, Applications 2nd Edition, Springer

ELECTIVE COURSE – II (EC)
ENVIRONMENTAL ETHICS, LAW AND POLICY

OBJECTIVES

1. To learn the basic concepts of constitutional frame work of India with emphasis to Environmental protection
2. To understand the pollution control laws in India with respect air, water soil, wildlife and biodiversity
3. To develop and understanding about the powers of Government and Judiciary in Environmental Protection

UNIT I

Environment and Constitution of India – Environmental Legislature Machinery – Constitutional Status of Environment – Duty to Protect Environment – Role of Public Interest Litigation in Environmental Protection – Constitutional Justification – Ethics - Concepts - Ethical theories - consequential theory - deontological theory - virtue ethics - situation ethics - feminist ethics.

UNIT II

Laws on Water Pollution Control – Powers of Central and State Pollution Control Boards – Prevention and Control of Water Pollution – Judicial Restraint Order – Closure or Stoppage of Water and Electricity Supply – Citizen Suit Provision – Power of Central Government to Supersede the Central Board – Power of State Government to Supersede the State Board.

UNIT III

Laws on Air Pollution Control – Powers and Functions of Boards – Air Pollution Control Areas – Prohibition of Emissions of Air Pollutants – Judicial Restraint Order – Citizen Suit Provision – Offences and Penalties.

UNIT IV

Legal Protection of Forests and Wild Life – The Forest Act 1927 – Constitutional Status – The Forest (Conservation) Act 1980 Application of Act to Union Territories – Hunting of Wild Animals – Sanctuaries or National Parks – Prohibition of Trade or Commerce in Wild Animals, Animal Articles – Offences and Penalties. Biodiversity Act and Rules.

UNIT V

Environment (Protection) Act 1986 – Powers of Central Government – Legal Regulation of Hazardous Substances – Hazardous Wastes (Management and Handling) Rules 1989 – The Natural Environment Tribunal Act 1995 – Legal Measures to Control Noise Pollution. EIA 1994 and 2006.

REFERENCES

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5. Tiwar AK (2006) Environmental law in India, Deep & Deep Publishing, New, Delhi

CORE COURSE VII

WASTE MANAGEMENT AND REMEDIATION

OBJECTIVES

1. To provide information about various types wastes and waste characteristics.
2. To introduce about the waste management practices - collection and treatment of various types of wastes.
3. To impart knowledge on waste remediation and recycling processes.

UNIT I : Introduction to waste and pollution

Wastes - Introduction, sources, collection, characteristics, composition, types of wastes – Global scenario of wastes - wastes generation per capita - Wastes collection, storage, segregation – disposal methods - sanitary land fillings.

UNIT II : Municipal Solid wastes management

MSW – Sources, types, collection, transportation and disposal – Waste segregation, resource recovery, recovery of recyclable and non-recyclable wastes – reuse and recycling of MSW – Disposal – Incineration, pyrolysis, composting, aerobic and anaerobic digestion. Biomedical wastes – source, types, disposal principles.

UNIT III : Hazardous Waste Management

Introduction, characteristics, sources – Types of hazardous wastes (industrial, hospital, domestic) – Handling of hazardous solid wastes – segregation and recovery – Disposal of hazardous wastes – Radioactive hazardous wastes – source, types, control, management and remediation.

UNIT IV : Plastic and E-wastes

Plastic wastes - Sources, Facts and figures of plastic wastes in national and international level, environmental effects and control measures – E-wastes – sources, types, recovery, reuse – E-wastes pollutant chemicals - E-wastes Environmental impacts.

Unit V : Remediation of Pollutants

Bioremediation - Description – Biostimulation, Gaseous nutrient stimulation organic liquid stimulation – Bio-augmentation – Limitations and Concerns – Biofertilizer technology – Bio composting techniques.

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4. Rakesh Johri, (2008). E-waste implications, regulations & Management in India and Current global best practices, TERI Press, New Delhi
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6. Bhide and Sundaresan, (2000). Solid Waste Management in Developing Countries – Indian National Scientific Documentation Center, New Delhi
7. CPHEEO, (2010). Technical EIA Guidance Manual for Common Municipal Solid Waste Management Facilities
8. CPHEEO, (2000). Manual on Solid Waste Management
9. Hester RE and RM Harrison, (2009) Electronic Waste Management, Design Analysis & Application, RSC Publishing, UK

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2. <http://www3.epa.gov/epawaste/nonhaz/municipal/>
3. <http://www.cpeo.org/techtree/ttdescript/pyrols.htm>
4. www.satavic.org/vermicomposting.htm
5. <http://web.mit.edu/urbanupgrading/urbanenvironment/sectors/solid-wastelandfills.html>
6. www.cement.org/waste/wt_apps_radioactive.asp
7. www.ipma.co.in/recycle.asp
8. www.algae.info
9. <http://www.epa.vic.gov.au/business-and-industry/lower-your-impact/~media/Files/bus/EREP/docs/EREP-waste-management-seminar.pdf>
10. http://www.tn.gov.in/dtp/publications/SWM/SWM_161to184.pdf
11. <http://energy.gov/em/services/waste-management>
12. <https://www.unesco-ihe.org/online-course-solid-waste-management>
13. <http://www.bostonelectronicwaste.com/go-green/what-is-ewaste>
14. <http://www.ces.iisc.ernet.in/energy/paper/ewaste/ewaste.html>
15. http://ec.europa.eu/environment/waste/plastic_waste.htm

CORE COURSE VIII

ENERGY AND GREEN TECHNOLOGY

OBJECTIVES

1. To study the energy and its effects.
2. To understand the concepts of green technology composite on environment.
3. To study ecological economics and green energy management.

UNIT I

Types of energy: oil, natural gas, coal, solar, wind, their merits and demerits, (effect of price controls, cost benefit) and environmental perspectives - Renewable and non-renewable energy - The McCKelvey classification of energy resources. Commercial and non-commercial energy economic issues

UNIT II

New Energy Materials: Carbon nano-tubes (CNTs) and multiwall carbon nanotubes (MWCNTs) methods of production, properties and its utility in energy devices. Recent advances in new energy materials, concepts of Green Composites: Low Energy Approaches to Water Management. Management of Solid Wastes and Sewage. Urban Environment and Green Buildings.

UNIT III

Approaches from ecological economics; indicators of sustainability; ecosystem services and their sustainable use; bio-diversity; Indian perspective; alternate theories. environmental reporting and ISO 14001; climate change business and ISO 14064; green financing; financial initiative by UNEP; green techniques and methods, green energy management.

UNIT IV

Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends –process/product innovation; Eco/green technologies for addressing the problems of water, energy, health, agriculture and biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agro ecology and other appropriate green technologies); design for sustainability (4Ds).

UNIT V

The inseparable linkages of life supporting systems, biodiversity and ecosystem services and their implications for sustainable development; future energy Systems- clean/green energy technologies; International agreements/conventions on energy and sustainability - United Nations Framework Convention on Climate Change (UNFCCC).

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9. Parry C Field, (2001). Natural Resource Economics, Mcraw Hill. Chapters 10 & 11
10. Wilson, R. & Jones, W. J., Energy, Ecology and the Environment, Academic Press Inc.

CORE PRACTICAL – III

ENERGY AND REMEDIATION (P)

OBJECTIVES

1. To provide the practical knowledge on green energy and its benefits.
2. To develop the experimental skills of the students in utilizing wastes for better management.

1. New energy materials
2. Microbial fuel cells
3. Solar battery
4. Solar cooker
5. Solar lantern/light
6. Waste segregation survey for better management at local level
7. E-wastes survey at institution level
8. Waste to wealth through vermicomposting
9. Biofertilizers
10. Biocomposting techniques
11. Phytoremediation
12. Microbial remediation

ELECTIVE COURSE III

NATURAL RESOURCE MANAGEMENT

OBJECTIVES

This course will provide the students with the knowledge of natural resources, their types and their availability. The students will understand the environmental impact of overuse of these resources. The students will learn the importance of management of these resources and how to manage them.

UNIT I

Introduction to Natural Resource (Renewable & Non –renewable Resources) Bases: Concept of resource, classification of natural resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. Concern on Productivity issues. Ecological, social and economic dimension of resource management.

UNIT II

Forest resources: forest vegetation, status and distribution, major forest types and their characteristics. Timber extraction, mining, dams and their effects on forest and tribal people, deforestation and forest management. Developing and developed world strategies for forestry. Land resources: Dry land, land use classification, land -degradation, man induced landslides, soil erosion and desertification. Landscape impact analysis, wetland ecology and management. Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Water ecology and management. Food resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity.

UNIT III

Marine resources: Production, status, dependence on fish resource, unsustainable harvesting, issues and challenges for resource supply, new prospects. Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources. Resource Management Paradigms. Resource conflicts: Resource extraction, access and control system. Approaches in Resource Management: Ecological approach; economic approach; Poverty and implications in Resource Management in developing countries .

UNIT IV

Management of Common International Resources: Ocean, climate, International fisheries and management commissions; Biological classification of India: Endangered and endemic species of India: Antarctica:

the evolution of an international resource management regime. Environmental Scenario in India, National Forest policy act in 1998.

UNIT V

Case Studies: Resource management in mountain ecosystem, Dry-land ecosystem, Management of marine and coastal resources, shifting cultivation, Mangrove ecosystem and their management

REFERENCES

1. Agarwal KC, (2001). Environmental Biology, Nidhi Publication Ltd. Bikaner
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11. Odum EP, (1971). Fundamentals of Ecology. W.B. Saunders Co. USA, 574p
12. Townsend C, Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science

ELECTIVE COURSE IV

STATISTICAL AND COMPUTER APPLICATIONS IN ENVIRONMENTAL STUDIES

OBJECTIVES

1. To study the basics of statistics and information technology,
2. To understand the statistical and computer application in Environmental Studies.
3. To learn applications of computer, hard ware and software.

UNIT I

Introduction to Statistics: scope, limitations of statistics, statistical method and experimental method. Collection of data, sampling, classification and tabulation of data. Diagrammatic & graphic presentation of data. Information technology: Information Types, needs, data processing, computer network and Internet. Computer application in Environmental Studies.

UNIT II

Descriptive statistics – Introduction, measure of central location, mean, mode, median, measure of shapes. Properties of mean, measure of spread, variance and standard deviation, co-efficient of variation. Sampling theories and Hypothesis testing, techniques and experimental designs. Testing hypothesis: Significance level and χ^2 test, t and F test.

UNIT III

Correlation, regression and ANOVA: Analysis of variance: One way and two way ANOVA, MONOVA, Regressions: Defining the fit, Correlation, polynomial regression, multiple regression, P-Value.

UNIT IV

Introduction: History of Computer; character and organization – types and generation of computer. Hard ware and Software: Types of memory; primary (RAM, ROM, PROM, EPROM, EEPROM) and secondary (Floppy, hard disc, eband DVD), video terminal, OMR, OCR, Printers and scanners Operating system- Introduction; DOS: UNIX, Linux, M.S. Office.

UNIT V

Environmental Statistics & Computer Application - Tabulation of data. Graphical presentation of data; line graph, bar chart, cumulative bar chart, percentage bar, chart, pie chart and three dimensional graphs. Frequency analysis; Univariate and bivariate frequency tables. Calculation of mean, median and mode. Calculation of modal frequency; grouping table and analysis table. Testing and hypothesis; application of t' test. ANOVA:

application and problems. Calculation of correlation and regression. Data sheet and data management. Simple statistical work using Excel spread sheet.

REFERENCES

1. Bryan FJ, Manly, (2008). Statistics for Environmental Science and Management, Second Edition, ISBN 9781420061475.
2. Ford ED, (2000). Scientific methods for Ecological Research. Cambridge University Press, Cambridge
3. John Schuenemeyer, Larry Drew, (2011). Statistics for Earth and Environmental Scientists.
4. Rosner B, (1986), Fundamentals of Biostatistics, Duxbury Press, Boston
5. Snedecor W and G Cochran, (1967). Statistical Methods. Oxford and IBH Publishing Co. Calcutta
6. Zar JH, (1984). Biostatistical Analysis. Prentice-hall, Inc Englewood Cliff, New Jersey

CORE COURSE IX

ENVIRONMENTAL ANALYTICAL METHODS

OBJECTIVES

1. To explain fundamental principles for environmental analytical methods (titration, spectrophotometry, spectroscopy, chromatography, electro-chemistry, etc.)
2. To develop both the analytical toolsets and mindset for quantitative research.
3. To develop ability to acquire suitable analytical techniques for analyzing a specific compounds in an environmental matrix.

UNIT I : Microscopy

Introduction to microscopy. Principles and applications of light, phase contrast, fluorescence, confocal, atomic force, scanning and transmission electron microscopy (SEM & TEM) -. Cytophotometry, fixation and staining.

UNIT II : Biomolecular Separation Techniques

Centrifugation - Differential and Ultracentrifugation. Chromatography - Principles and applications of gel filtration, and Column Chromatography ion-exchange, Size exclusion and affinity chromatography. Paper and Thin Layer Chromatography, High Pressure Liquid Chromatography (HPLC).

UNIT III : Bioanalytical Techniques

Titrimetry, Gravimetry, Colourimetry, Flame Photometry. Spectrophotometers – Fluorescence, Visible, UV and IR. NMR spectroscopy. AAS, ICPOES, ICPMS, Amino Acid analyzer, HPLC, GC, GC-MS, LC-MS, SELDI-TOF-MS, MALDI-TOF-MS and Bio-Sensors. Application of X-ray - fluorescence and diffraction.

UNIT IV : Molecular Techniques

Electrophoresis - PAGE, PFGE, SDS-PAGE, Agarose gel, Immunoelectrophoresis, 2D electrophoresis - Gel documentation. Principle and applications of PCR, RT-PCR, RFLP, RAPD, AFLP and DNA fingerprinting. Principle and applications of DNA sequencing - Automated DNA sequencing, Gene silencing and Knock out- Microarray technique.

UNIT V : Blotting and Tracer Techniques

Principles and techniques of Southern, Northern and Western blotting techniques and Hybridization. Principles and applications of radioactive isotopes, Autoradiography and Scintillation counter, Geiger Muller counter.

REFERENCES

1. Avinash Upadhyay, Kakoli Upadhyay and Nirmalend Nath, (2009). Biophysical Chemistry: Principles & Techniques, Himalaya Publishing House
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16. Skoog DA, West DM, Holler FJ, and Crouch SR, (2013). Fundamentals of Analytical Chemistry (Cengage Learning)

CORE COURSE X

ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL AUDIT

OBJECTIVES

1. To understand about development projects and their impacts on Environment
2. To learn about the EIA practice in India and the legal framework in environmental clearance
3. To know about the EIA process and various steps involved in baseline studies, methods in assessment of environmental impacts and environmental management plan
4. To understand about environmental audit and the methods to carry out audit process

UNIT I : Introduction to Environment and Development

Development Projects - Impacts on Environment -Long-term Impacts - Short-term Impacts – Reversible and Irreversible Impact - Sustainable Development – Role of EIA in Sustainable Development – Aim of EIA - EIA inputs to project planning - Benefits of EIA

UNIT II : EIA Basics

Concept of EIA, Evolution of EIA, EIA practice in India, **EIA Notifications 1992, 1994, 1997 2009 of MoEF&CC, Coastal Regulation Zone Notifications**, Project Screening in EIA, Defining and Examining Scope, OBJECTIVESs and Alternatives in EIA Projects, Project Planning and processes, Baseline information, Impact prediction, decision making.

UNIT III

Types of EIA, Rapid EIA, Comprehensive EIA, Strategic EIA, Data Collection, Ecological Impacts, Environmental Impacts (Air, water, Land Noise), Socioeconomic and cultural Impacts, Health impacts, Prediction of Impacts; Methodologies, Cost Benefit analysis, Environmental Management Plan (EMP). Preparing and Writing of Environmental Impact Statements (EIS), Computer aided techniques, Reviewing EIA/EIS, Use of EIA in Public participation and decision making,

UNIT IV : Introduction ISO14000 and Environmental Audit

ISO 14000 Organizational Standards -Environmental Management Systems (EMS) - Environmental Auditing (EA) - Environmental Performance Evaluation (EPE) – EMS overview: Environmental Policy Development – Plan, do, check act. Environmental Audit program development and management - EMS Audit program design - type and scope of audits - Program administration

UNIT V : Audit Process

Pre-audit activities - On-site activities - Post site activities - Report and followup -Case Study Analysis - Audit Assessment. Auditor qualification, Auditing standards - Evaluating information - Internal reporting and communicating -External reporting and communicating

REFERENCES

1. AK Shrivastava, (2003). Environmental Impact Assessment, APH Publishing Corporation, New Delhi
2. SA Abbasi and DS Arya, (2004). Environmental Impact Assessment, Discovery Publishing House New Delhi
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4. Edited Maria Rosario, (2000). Perspectives on Strategic Environmental Assessment, Lewis Publishers, USA

CORE PRACTICAL IV

ENVIRONMENTAL ANALYTICAL METHODS (P)

OBJECTIVES

1. Demonstrate insight into how to tackle practical analytical chemical problems
2. Demonstrate understanding of the basic theory and relevant parameters in analytical chemistry
3. Apply methods of instrumental chemical analysis to natural materials and (eco)systems
4. Demonstrate awareness of the limitations of the various methods
5. Report about experimental chemical analytical results and draw correct conclusions

PRACTICAL

1. Paper Chromatography
2. Thin-layer Chromatography
3. Gas Chromatography
4. Cell fractionation
5. Isolation of DNA from liver tissue
6. Electrophoresis
7. Isolation and estimation of chlorophyll by UV-spectrophotometry
8. Sample extraction methods: Liquid-liquid extraction (LLE), Solid phase extraction (SPE), Ultrasound assisted extraction (UAE), soxhlet extraction
9. Determination of pesticides in water samples using liquid liquid extraction

REFERENCES

1. Edited Helmut Gunzler and Alex Williams, (2001). Handbook of Analytical Techniques WILEY Germany
2. Roger N. Reeve, (2002). Introduction to Environmental Analysis. John Wiley & Sons Ltd.

ELECTIVE COURSE V

INDUSTRIAL POLLUTION AND SAFETY MANAGEMENT

OBJECTIVES

1. Examine the relationship between work activities and their effect on the environment
2. Identify the main sources of man-made pollutants and examine their typical patterns of emission and distribution
3. Consider the technical and scientific control measures available to mitigate the impact of industrial emissions and discharges into the environment
4. Understand the different types of wastes generated in an industry, their effects on living and non-living things
5. Understand environmental regulatory legislations and standards and climate changes

UNIT I : Tanneries and Distillery

Production of leather, vegetable tanning and chrome tanning processes. Sources and characteristics of wastes. Effect of tannery effluent and other wastes on receiving bodies and treatment methods of the wastes. Sugar mills and Distilleries - their manufacturing processes, sources and characteristics of their wastes. On receiving bodies, Treatment of their wastes and disposal.

UNIT II : Paper and Pulp, and textile industries

Manufacturing processes, sources and characteristics of wastes. Effect of wastes. Treatment processes of the wastes. Textile mills - manufacturing processes, sources and characteristics of wastes. Effects of the wastes on receiving bodies. Treatment of the wastes.

UNIT III : Cement and energy Industries

Manufacturing process, sources of pollution and wastes. Effect of wastes. Control technique of pollution. Oil refineries and thermal power plants-processes involved. Sources of pollution characteristics of pollutants and their effects. Pollution control techniques.

UNIT IV : Fertilizer and pharmaceutical Industries

Manufacturing processes, sources and characteristics of wastes and their effects. Treatment processes pharmaceutical plants: manufacturing processes sources and characteristics of wastes and their effects. Treatment of wastes.

Unit V : Safety Management and Industrial Acts

Industrial safety- Causes of accident, Accident reporting system, Accident prevention, Disaster planning, Safety committee. Hazards control- Elimination, Control, Isolation, Substitution, Personal protective equipment, medical first aid- management of medical emergencies.

Labour laws: factories act 1948, Mines act 1952, ESI act 1948- Health organizations: NIOH,AIIHPH, NHO,WTO.OSHA standards.

REFERENCES

1. Austin GT, Shreves, (1977). Chemical processes in industries. McGraw Hill Book Co., New York
2. Khudesia VP, (1986). Industrial pollution control. Pragati Prakasham, Meerut
3. Mahajan SP, (1986). Pollution Control in process industries. Tata McGraw Hill Co. Ltd., New Delhi
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12. Paul A Erickson, (1996). Practical Guide to Occupational Health and Safety, Academic Press, USA
13. Sell NJ, (1992). Industrial Pollution Control: Issues and Techniques, John Wiley & Sons
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