M.Sc. Semester-III
Paper -I
(Physico-chemical and Biological Treatment of Water and Waste Water)

Unit I:

Introduction to Water Treatment : Water scarcity , need of water treatment. Various steps involved in water treatment.

Methods of Water Treatment : Theory, working principle & operation of various methods involved in water treatment – Coagulation & Flocculation, Sedimentation, Flocculation, Filtration, Disinfection, adsorption, fluoridation.

Water Treatment Plant - Operations of various units involved in water treatment –Intake Well, Jack Well, Coarse & Fine Screen, Aeration unit, Clarifier, Chemical dosing system, Filters. Distribution pipeline, Mass Balancing Reservoir, Elevated Service Reservoirs

Unit 2 :

Introduction to Wastewater Treatment : Classification of waste water -Domestic and Industrial. Characteristics of waste water – sewage & various industrial sectors. Need of waste water treatment. Methods of waste water treatment – physical treatment, physico-chemical treatment, biological treatment , tertiary treatment.

Physical & Chemical Treatment of waste water: Theory & design principle of Screen, Grit Chamber, Oil & Grease Trap, Pre-Sedimentation, Pre-aeration, and Equalization tank, clarifiers, flash mixer, clariflocculators. Theory of coagulation, flocculation, precipitation & filtration. Dosing chemicals used in waste water treatment, specific roles of dosing chemicals. Sand Filters and Activated Carbon Filters

Introduction to Basic Drawings : Introduction to basic drawings of waste water treatment – Process Flow Diagram, Layout, Hydraulic Profile, Piping & Instrumentation drawing. Process Flow Diagram for sewage treatment plant and Industrial waste water from Brewery, Starch and Dairy units

Unit – 3 :

Biological Treatment of waste water: Introduction to Biological treatment. Types of biological treatment. Application & Performance efficiency.

Anaerobic Treatment: Basic Principles of Anaerobic Treatment, Structure, Properties and Function of Biofilm, Types of Anaerobic Reactors and Processes – Thermophilic & Mesophilic reactors, Design principle and operation of Anaerobic Digesters - Media Based Digesters, Upflow Anaerobic Sludge Blanket (UASB) digesters, Continuous Stirred Tank Reactors(CSTR), advantages and disadvantages, application as per inlet waste water characteristics, Methane production and reuse.

Aerobic Treatment : Basic Principles of Aerobic Treatment, Design principle and operation of various technologies of aerobic treatment – Activated Sludge Process, Aerated lagoon, Trickling Filters, Rotating Biological Contractor, Aerobic Bio towers. Advantages and disadvantages of each aerobic treatment.

Unit – 4 :

Operation & Maintenance of Wastewater Treatment Plant: Objectives of Operation of Wastewater Treatment Plant Units, Maintenance Procedures for various units & equipment such as Screens, Grit Chamber, Skimming Tanks, Primary clarifiers, Clariflocculators, Anaerobic Digesters, aeration tanks, secondary clarifiers, filters. Responsibilities of waste water treatment Plant Incharge

Sludge Handling System : Sources of sludge generation in waste water treatment. Design principle and Operation of various sludge handling units – Sludge Thickener, Decanters, Filter Press, Screw Press, Sludge Drying Beds.

Commissioning of Wastewater Treatment Plant : Role of Commissioning Incharge, Seeding of anaerobic digesters and aeration tank. Development of micro organisms, sources, routine monitoring and analysis, Micro and Macro Nutrient, Utility of Bio-cultures.

Books for Reference

01. Wastewater Treatment for Pollution Control *by Soli J. Arceivala, Tata McGraw Hill Publishing Company, New Delhi*
02. **Water Supply & Sanitary Engineering** by *R. C. Rangwala and S. C. Rangwala, Charotal Publishing House, Anand.*
03. **Wastewater Treatment** by *M. N. Rao, A. K. Datta, IBH Publishing Company, New Delhi.*
04. **Water Pollution** *by V. P. Kudesia, Pragati Prakashan, Meerut*.
06. Waste Water Engineering *by Metcalf and Eddy, Tata McGraw Hill Publishing Company, New Delhi.*
07. Waste Water Treatment- *Concept & Design Approach by G.L. Karia & R.A. Christian, Prentice Hall of India Press*.
09. Introduction to Environmental Engineering : *Mackenzie L. Davis & David A. Cornwell (Mc-Grew Hill Publishing Company, New Delhi)*

Semester-III
Paper-II
Advanced Water and Waste Water Treatment

Unit-I:

Introduction to Advanced Water Treatment: History of emergence of advance water treatment in India. Necessity and advantages.

Advancement in Water Treatment: Design and operation of various advanced water treatment process - Ion exchange, electro-dialysis, Reverse Osmosis, Ultra filtration, Modern Desalination plants. Design & operation of packaged drinking water and mineral water plants.

Reverse Osmosis: Membrane technology in water treatment, types of membranes, advancement in Reverse Osmosis Technology for drinking water. Maintenance and efficiency of an RO system.

Unit-II:

Introduction to Advanced Waste Water Treatment: History of emergence of advance waste water treatment in India. Necessity and advantages.

Advancement in Waste Water Treatment: Design and Operation of various advanced wate water treatment technologies- Dissolved Air Floatation Unit (DAF), High-Rate Solid Contact Clarifier (HRSCC), Membrane Bio Reactor (MBR Membrane Bio Reactor (MBR), Moving Bed Biofilm Reactor (MBBR).

Advanced Primary Treatment required prior to Reverse Osmosis: Need to pre-treatment before RO. Design and operation of Pre-Treatments – Removal of emulsified oil, Silica, Hardness, Heavy Metals. Process Flow Diagram highlighting various treatment process

Unit III:

Zero Liquid Discharge (ZLD): Introduction to Zero Liquid Discharge (ZLD). Emergence of ZLD in Indian scenario. Present Status. Need and advantages of ZLD. Indian & Global Scenario.

Treatment Process involved in ZLD: Design of ZLD system with Process Flow Diagram for Breweryand Starch unit. Reverse Osmosis, Nano Filtration, Multi Effect Evaporator, Agitated Thin Film Dryer (ATFD). Upgradation of existing waste water treatment plant as per discharge norms. Role of Statutory Bodies in decision making and implementing of ZLD system.

Common Effluent Treatment Plant (CETP): Introduction, advantages and disadvantages. Indian scenario. Case Studies of CETPs.

Unit-IV:

Automation in Waste Water Treatment: Importance of Automation, advantages and disadvantages. SCADA based operation of waste water treatment plant. Online pH correction system. Application of Logics. Advanced Motor Control (MCC) Panel. Variable Frequency Drive. Level Sensors, Online monitoring system.

Cost Economics of Advanced Technologies: Capital Expenditure (CAPEX) , Operating expenditure (OPEX). Power Consumption - Connected Load, Operational Load & Consumed Load.

Safety Advancement: Importance of safety, Hazard and Operability Analysis (HAZOP), Safety procedure during construction and erection. Personal Protective Equipment.

Books for Reference:

1. Waste Water Engineering: Metcalf and Eddy, Tata McGraw Hill Publishing Company, New Delhi.
2. Introduction to Environmental Engineering: Mackenzie L. Davis & David A. Cornwell, McGrew Hill Publishing Company, New Delhi.
3. Basic Water Treatment:George Smethurst (Scientific Publishers, Jodhpur).
4. Wastewater Treatment for Pollution Control by Soli J. Arceivala, Tata McGraw Hill Publishing Company, New Delhi.
5. Water Supply & Sanitary Engineering by R. C. Rangwala and S. C. Rangwala, Charotal Publishing House, Anand.
6. Wastewater Treatment by M. N. Rao, A. K. Datta, IBH Publishing Company, New Delhi.
7. Waste Water Treatment- Concept & Design Approach by G.L. Karia & R.A. Christian, Prentice Hall of India Press.
8. Introduction to Environmental Engineering: Mackenzie L. Davis & David A. Cornwell (Mc-Grew Hill Publishing Company, New Delhi)

Semester-III
Paper-III
Disaster Management

Unit I:

Disaster Management: Meaning, Nature, Importance, Dimension and scope of Disaster Management, Disaster Management Cycle, National Disaster Management frame work, financial arrangement for Disaster Management, International strategy for Disaster reduction.

Natural Disasters: Meaning and nature of natural disaster, their types, causes and effects, Hydrological disasters (Flood, Flash flood, Drought and Cloud burst), Geological disasters (Earthquake, Volcanic eruption, Landslides, Avalanches, Tsunami and Mud flow).

Man-made Disaster: Meaning and nature of man-made disaster, their types, causes and effects,Chemical, Biological, Radiological and Nuclear disaster, Fire (Building fire, coal fire, forest fire and oil fire), Accidents (Road, rail, air and sea accidents).

Unit II:

Warning and Communication System: Early warning system, Community early warning system, Core Components of People centered early warning system, Emergency Communication System, Wireless Communication, Bluetooth Wireless Technology HAM Radio, GPS Application in Emergency Communication.

GIS and Remote Sensing: Definition, Principle, fundamentals and Scope of Remote Sensing, Geographical Information System (GIS)-Definition Concept of Space and Time Domains of spatial information system, components of GIS (Hardware, Software, Data, People and Process)

Applications of GIS and Remote Sensing: Role of Remote Sensing and GIS in Disaster Management and Warning system, Methods of Collecting relevant information- Libraries, Internet, Survey, observation, Mass media, Role of Information from disaster affected community.

Unit III:

Risk Assessment: Risk concept, Elements of risk, Acceptable risk, Requirement in risk assessment, Role of Science and Technology in Disaster Risk Reduction, Strategies of risk reduction.

Process of Risk Assessment: Risk Analysis techniques, Process of risk assessment, Analytical system for risk assessment, Natural hazard/risk assessment, understanding climate risk, Decision making for risk reduction, Problems in risk assessment.

Vulnerability: Observation and perception, vulnerability identification, vulnerability types and dimensions, Vulnerability (social & economic factor). Physical and social infrastructure for vulnerability reduction, Hazard resistant design and construction, systematic management and strategic planning for vulnerability reduction.

Unit IV:

Disaster preparedness: Concept and significance, Disaster preparedness measures, Institutional mechanism for disaster preparedness, Policy and programme of disaster preparedness.

Disaster preparedness Plan: Concept and significance, Community based Disaster preparedness plan. Prediction, Early warning and safety measures of disaster, Role of Government, NGOs and Information technology in Disaster preparedness.

Disaster Response: Essential components of disaster response, Disaster Response Plan (Communication, Participation and Activation of Emergency preparedness Plan), Search, Rescue, Evacuation and Logistic management, Relief and Recovery, Rehabilitation and Reconstruction.

Books for References:

1. Textbook of Environmental Studies by Benny Joseph, McGrew-Hill Publishing Company Limited.
2. Disaster Management by Mukesh Dhunna, Vayu Education of India, New Delhi, 2009 First edition.
3. Introduction to Environmental Science by G. Tyler Miller, Jr. Scott Spoolman, Cengage Learning Publication.
4. Environmental Science by S.C. Santra, New Central Book agency Pvt. Ltd. Kolkata, India.
5. Environmental Management by H.P. Behera and M.S. Khan, Himalaya Publication
6. Disaster Management Programmes And Policies by Siddhartha Gautam K Leelakrisha Rao, Publication - Vista International.
7. Introduction To Disaster Management, by B.C.Bose 46 ,Rajat Publishers
8. Global Disaster Management, by Arun Kumar, SBS Publishers
9. Handbook Of Disaster Management (2 Vol.set), Author:ReepunjayaSingh, ABD Publishers
10. Handbook of Disaster Management William L. Waugh 2005
11. Disaster Management: Text and Case Studies D.B.N. Murthy Jain Book Agency 2000
12. Disaster Management and Risk Reduction: Role of Environmental Knowledge Anil K. Gupta, Sreeja S. Nair, Florian Bemmerlein Lux and Sandhya Chatterji Jain Book Agency, 2013
13. Disaster Management and Preparedness Nidhi Gaubha Dhawan CBS Publishers
14. Dr. Mrinalini Pandey Disaster Management Wiley India Pvt. Ltd.
15. Tushar Bhattacharya Disaster Science and Management McGraw Hill Education (India) Pvt. Ltd

Semester-III

Paper-IV: (Elective-I)

(Environmental Conservation and Sustainable Development)

Unit-I:

Introduction of Environmental Conservation: Definition, concept and perspective, Eco-designing, Ecotechnology approaches, Eco-technology for social welfare and sustainable development, Eco-technology for rural development-Agrochemicals, Synthetic organic chemicals conversion, Factors causing molecular recalcitrance.

Biopesticides: Concept, Types of Biopesticides, Biopesticides- Pest Control, Formulation and Regulation of Biopesticides, Stabilization, Mode of Action, Advantages and Disadvantages of Microbial Insecticides, Biochemical Pest Control Agents, Applications of Biopesticides.

Biofertilizers: Biofertilizer Perspective, Biofertilizers-Types, Rhizobium, Azospirillum, Azobacter, Phosphate Solubilizing Microorganisms, Mycorrhiza, Blue Green Algae, Azolla, Compost, Biofertilizer- Potential Use, Biological Nitrogen Fixation.

Unit-II:

Environmental Conservation in Clean Bio-process: History, concept, planning and strategies for urban and rural sustainability. Bioprocesses for cleaner production, sustainable development and economic

Application of Bio-process: Dairy industry production, processes and development, Sericulture Technology, Aquaculture, Honey bee farming, organic farming, Agro eco-farming.

Eco-farming: Perspectives, Food sovereignty regarding rural livelihood, smarter food production and yield, Eco engineering technology. Green Building, Bio-sanitizer Ecotechnology, Odourless self-flushing bio toilets.

Unit III

Eco-Technological Restoration: Restoration of degraded eco system using ecological approach Concept and importance of SPS (Sanitary and Phyto-sanitary), WTO-SPS agreement, sanitation and Phyto-sanitation technology: HBPST, TDC, SPS. Environmental green inhibitor.

Ecosystem Conservation:, Conservation strategies: “In-situ” and “Ex-situ” conservation, Waste land India – Biospheres, National Parks and Wildlife anctuaries, Wild life Conservation projects: Crocodile Conservation, GOI-UNDP Sea Turtle Project. Building resilience, Ecological resilience.

Water resource management: Rainwater harvesting, Water conservation practices (ancient and modern); watershed management.

Unit-IV

Sustainable Development: Principles and Scope of sustainability, Strategies for promoting sustainable development and consumption, Current issues and areas of debate in relation to sustainable development, Carrying capacity-based planning processes.

Sustainable Development Control and Model: Environmental sustainability, Energy security, Water security, Food security and social security.

Sustainable Energy Resources: Renewable energy for sustainable development. Natural Resources and Sustainable Development. International efforts for Conservation of Resources.

Books of Reference:

1. Barry Dalal Clayton and Stephen Bass, Sustainable Development Strategies- A Resource Book", Earthscan Publications Ltd, London, 2002.
2. Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide, Green Leaf Publishing, 2006.
3. Primack, Richard B., and Anna Sher (2016). Introduction To Conservation Biology. Sinauer Associates, Incorporated, Publishers.
4. UNEP, , Towards a Green Economy: Pathways to Sustainable Development and
5. Poverty Eradication, www.unep.org/greeneconomy, ISBN: 978-92-807-3143-9, 2011.
6. World Bank "Inclusive Green Growth – The pathway to Sustainable Development, World Bank- Washington DC, 201
7. Singh J S, Singh S P and Gupta S R (2014); Ecology, Environmental Science and Conservation. 4th Edition. S. Chand and Company Pvt. Ltd.

Semester-III
Paper-IV: (Elective-II)
(Atmospheric Science)

Unit-I:

Fundamentals of Atmospheric Science: Composition, change in atmospheric composition, structure and evolution of atmosphere, stratospheric ozone formation, segments of environment, modern views regarding the structure of the atmosphere.

Atmospheric Radiation: Solar spectrum, Earth radiation balance, ions and radicals in the atmosphere. Temperature inversion and lapse rate.

Application of Atmospheric Radiation: Atmospheric radiation and earth's climate, energy balance, gradients.

Unit-II:

Climatology: Definition and scope, aims and objectives of climatology, Insolation-factors affecting the distribution of insolation. Atmospheric depletion of solar radiation, process of heat energy transfer- radiation, conduction and convection.

Hydrological Cycle: Process and importance, evaporation, condensation, forms of condensation (Dew, frost, fog and mist).Precipitation – formation and types, precipitation measurement.

Cloud Physics: Clouds, drops and snowflakes, formation of cloud drop, Koehler theory, Curvature Effect, Kelvin Effect. Cloud formation, classification of clouds and role of clouds in weather forecasting.

Unit-III:

Meteorology: Definition and scope, aims and objectives of meteorology. Primary meteorological parameters and their measurement—temperature, wind direction and wind speed. Secondary meteorological parameters and their measurement— humidity, relative humidity, absolute humidity, pressure and solar radiation. collection and analysis of wind data, wind roses, plotting of wind roses and pollution roses. effects of meteorological parameters on air pollution.

Air Masses and Fronts: Air masses, source, region, classification, frontal weather- types of fronts, mid latitude cyclones and polar –Front theory, cyclonic and anti-cyclonic formation, divergence and convergence, severe weather and societal consequences – Thunderstorms, Lightning, Tornadoes, Hurricanes.

Meteorology and Pollution: Co-relation of meteorology and pollution, Delhi SMOG– meteorological impact, SMOG threat to other cities of India, SMOG towers – operations and effectiveness, need to change in policy to combat urban SMOG. Case Studies.

Unit-IV:

Ocean Science: Physical characteristics of the ocean: ocean basins, temperature, salinity, density and oxygen characteristics, vertical profile of temperature and salinity in the major oceans.

Water Mass Characteristics: Formation and classification of water mass. T-S diagram, mixing processes in the oceans, upwelling and downwelling processes, oceanic heat, salt and momentum budgets, thermohaline circulation and the oceanic conveyor belt.

Geostrophic Flow in Ocean - Ocean currents, equatorial current systems; wind driven ocean circulation, wind driven coastal currents. Ocean waves and their generation and propagation; wave spectrum, storm surges and tsunamis, tides and tide generating forces, El-nino, La-nino and Southern Oscillation (ENSO)

Books for Reference:

1. General Meteorology: H. R. Byers, Tata McGraw Hill Publications, New Delhi
2. Climatology: Fundamentals and Applications: Mater J.R.
3. Climatology: Selected Applications: Henry D. Foth
4. Introduction to Weather and Climate: Trewartha
5. The Atmosphere: An Introduction to Meteorology: Fedrik K.Lutgen,E.J.Tarbuck
6. General Meteorology: H. R. Byers(Tata McGrew –Hill Publications, NewDelhi)
7. Meteorology: Dr.S.R.Gadekar, Agromate Publishers, Nagpur 2000
8. Environmental Analysis: M.M.Saxena, Agrobotanical Publisher,Bikaner1994
9. Climatology: D.S.Lal, Shraddha Pustak BhavanAlahabad,2001
10. Atmosphere, Weather and Climate: K. Sidddhartha, Kisalaya PublicationPvt. Ltd2000
11. The Great SMOG of India: Siddharth Singh, Penguin Viking Publication Fundamental of Atmospheric Science :John A Dutton, Penn State College of Earth and Mineral Sciences.

Semester-III

Practical-V

(Physico- Chemical Treatment and Biological Process in Waste Water Treatment)

1. Determination of Sludge Volume Index (SVI) and Sludge Density Index (SDI) of sludge samples.
2. Estimation of Nitrogen by Kjeldahl's methods waste water.
3. Estimation of Phosphate in sludge for fertilities values.
4. Estimation of Sulphate in sludge for fertilities values.
5. Estimation of Chemical Oxygen Demands (COD) of waste water.
6. Estimation of Biochemical Oxygen Demands (BOD) of waste water.
7. Determination of percent organic matter of sludge.
8. Estimation of fixed solids, organic matter of sludge drying bed's sludge cake.
9. Estimation of suspended, dissolved, total, volatiles solids in sewage.
10. Determination of Chloride in wastewater samples by Argentometric method.
11. Estimation of calorific value of sludge by Bomb calorimeter.
12. Draw Schematic Lay-out of wastewater treatment plant.
13. Estimation of sulphide in waste water.
14. Determination of wind velocity and direction by Anemometer.
15. Determination of relative humidity by psychrometer.
16. Study of sewage treatment plant with respect to:
    a) Flow measurement.
    b) Design of screen, grit chamber, aeration tank, anaerobic digesters, settling units and filtration unit.

Visit to:

- Sewage Treatment Plant
- Industrial Waste Water Treatment Plant

Case Studies:

- Submission of case Study of Sewage Treatment Plant & Industrial Waste Water Treatment Plant.

Distribution of Marks

Practical SEE (PU)	-	50 marks
Practical CIE (PI)	-	50 marks
Research Project SEE	-	50 marks
Research Project CIE	-	50 marks

Total Marks	-	200 marks

M.Sc. Semester-IV
Paper-I
(Advanced Pollution Control Technologies)

Unit-I:

Air Pollutants and Pollution Sources: Main sources of air pollution, air pollution effects on Man, Animals, Plants, Microbes and Materials, Diseases caused by air pollution, Air pollution Index, Types and uses, Air pollution episodes, Photochemical Reactions.

Air Sampling and Monitoring: Criteria, Selection of Sampling Locations, Analytical and Instrumental Techniques Used in Estimation of Atmospheric Pollutants (Particulate Matter and Gases), Stack Sampling, Considerations Sampling, Point Selection for Circular and Rectangular Ducts.

Method for Air Pollution Measurement: Sulphur dioxide, carbon monoxide, Oxide of Nitrogen, photochemical oxidant, Hydrocarbons, particulate matter, Volatile Organic Carbon, ozone, Dust Fall Jar, High Volume Sampler.

Unit-II:

Techniques for air pollution control: Characterization the air stream, Control devices for particulate matter, Principle, Working and Design of Scrubbers, Electrostatic Precipitator, Fabric Filters, Cyclones Collector, Gravity Settling Chamber.

Control of Gaseous Pollutants: Condensation, Refrigeration, Cryogenics, Absorption, Adsorption, Filtration, Impingement Separator, Flue Gas Desulfurization, NO_2 removal, Fugitive Emissions, Environmental quality standards (NAAQ).

Advance Technologies for emission control: Hydrocarbon adsorbersystems, Diesel emission control technology, Plasma technology, Catalytic converters, Biological Oxidation.

Unit-III:

Noise Pollution and Sources: Basic Properties of Sound, Sound Pressure and Intensity Levels, Equivalent Sound Pressure Levels (leq), Noise Pollution Levels (npl), Sound Exposure Levels (sel) Measurement of Noise, Decibel Scale, Sources of Noise Pollution, Physiological and Psychological effects of Noise Pollution.

Techniques for Noise Pollution Control: Criteria, Equipment used for Noise Measurement, Noise Pollution Control in Industries, Noise Control and Abatement Measures, Hearing protection device (HPD), Sound Absorbing Materials, Acoustic Silencers, Mufflers, Barriers, Vibrations and Impact Isolation.

Standards for Noise Pollution: Hearing conservation program, Legal status and country specific regulations, Permissible exposure Limits, Standards Prescribed for Noise in Indian Context. Role of Green Belts. Noise sources regulated by EPA,Land use planning

Unit- IV:

Basic Concept of Soil Pollution and Solid waste Pollution: Major reasons of soil contamination, Effects of soil pollution on plants and humans, Categories of solid waste,Characteristics (Physical, chemical, biological), , Solid Waste Collection, Segregation, Storage and Transport, Criteria for selection of waste processing technology, Solid waste generation and associated environmental risks, Effects of Solid Waste.

Soil pollution control Technologies: Process of desertification, Soil remediation method (Excavation and removal), Chemical oxidation, Soil washing, Thermal desorption, Bioremediation, Phytoremediation, Nano-bioremediation, Biofertilizer, case study of soil remediation strategies.

Techniques for Solid Waste Pollution Control: Aerobic Composting, Recycling, Landfilling, Waste-to-Energy, Vermi-composting, Hazardous Waste Treatment, Source Reduction, Bio-methanation/Bio-waste derived fuel, Incineration, Plasma pyrolysis, Pelletization /Production of Refuse Derived Fuel (RDF), Swachha Bharat Mission, Swachha Survekshan, PPP (Public Private Partnership) Models in Waste Management.

Books for Reference:

1. Air Pollution and its Control: Sumit Malhotra (Pointer publishers, Jaipur).
2. Air Pollution: M. N. Rao (Tata McGraw – Hill publishing company, New Delhi)
3. Air Pollution: B. K. Sharma, H. Kaur (Krishna prakashan Media, Meerut).
4. Fundamentals of Air Pollution: Richard W. Bowbel, Donald L. Fox, D. Bruce Tunner, and A. C. Stern (Academic Press, California).
5. Air Pollution control Engineering: Noel De Nevers (Mc Graw – Hill international, New York).
6. Air Pollution: S. K. Agarawal (A. P. H. Publishing Corporation, New Delhi).
7. Air Pollution: V. P. Kudesia (Pragati Prakashan, Meerut)
8. Noise Pollution and Control Strategy: S.P. Singal, Narosa Publishing House, New Delhi.
9. Noise Pollution: B. K. Sharma, H. Kaur, Goel Publishing House, Meerut, 1994.
10. Solid waste pollution: Dr. Aradhana Salpekar, Jnanada Prakashan, New Delhi, 2008
11. Principals of Soil Science: M. M. Rai, McMillon Publication.
12. Soil pollution & Soil organisms :P. C. Mishra
13. Fundamentals of Soil Science: Henry D. Foth, John Wiley & Sons, New York, 1984
14. Municipal solid Waste Management Manual (Part II), CPHEEO, Ministry of Urban Development, Swachh Bharat Mission, Govt. Of India.

Semester-IV
Paper-II
Environmental Geo-science

Unit I:

Spectrum of Environmental Geoscience Introduction to Geology and its scope, Earth and solar system: origin, size, shape, mass, density and its atmosphere. A brief account of various theories regarding the origin and age of the Earth.

Internal Structure of Earth Brief idea of interior of earth and its composition. Earth magnetic field Weathering and erosion: factors, types and their effects.

Environmental Geology Basic principles of environmental geology, Ecological perspective - Atmosphere, hydrosphere, asthenosphere, biosphere and lithosphere, their interaction and related problems. Earth's energy balance, Biogeochemical cycles.

Unit II:

Concept of minerals and rocks Formation of igneous and metamorphic rocks. Controls on formation of landforms - tectonic including plate tectonic and climatic. Concept of steady state and equilibrium, Weathering including weathering reactions, Erosion, Transportation and deposition of sediments.

Soil Formation Soil forming minerals and process of soil formation, Identification and characterization of clay minerals, Soil physical and chemical properties, soil types and climate control on soil formation, Cation exchange capacity and mineralogical controls.

Natural resource and its management Mineral exploration, Elementary idea of geological, geochemical and geophysical prospecting. Elementary idea of mining and environmental considerations for mining, Resource Management: Energy resources (Conventional and non-conventional), watershed management, management of water resources, land use planning,land reclamation.

Unit III:

Natural hazards – Meaning and nature of natural hazards, their types causes and effects, Types: Volcanoes, Earthquakes, landslides, floods, cloud burst, drought, Avalanches, Tsunamis, remedial measures.

Man's influence on Earth: Pollution, Urbanization, industrialization, air pollution and public health. Water pollution, Coastal environment, Engineering constructions like dams, highways and reservoirs, deforestation.

Medical Geosciences: Human use of trace elements and health. Essential, non-essential, toxic metals, and their level of exposure. Migration of elements through food chain. Impact of toxic elements to human health. Possible effects of imbalance of some trace elements.

Unit IV:

Structural Geology: Introduction to Structural Geology; contours, topographic and geological maps; Elementary idea of bed, dip and strike; Elementary idea of types of deformation; Folds: nomenclature and types of folds. Faults: nomenclature, geometrical and genetic classifications, normal, thrust and slip faults. Definition, kinds and significance of joints and unconformity.

Hydrology: Definition of hydrogeology, Hydrological cycle. Hydrological parameters - Precipitation, evaporation, transpiration and infiltration. Origin of groundwater; Vertical distribution of groundwater. Types of aquifers; Water bearing properties of rocks - Porosity and Permeability; specific yield, specific retention. Groundwater provinces of India.

Geo-dynamics: Earth as a dynamic system, Elementary idea of continental drift, sea-floor spreading and mid-oceanic ridges. Paleomagnetism and its application. Plate Tectonics: the concept, plate margins, orogeny, deep sea trenches, island arcs and volcanic arcs.

Books for Reference:

1. Keller, E. A. (2012). Introduction to environmental geology. Upper Saddle River, NJ, Prentice Hall.
2. Skinner, B. J., and Porter, S. C. 1995. The Blue Planet, An Introduction to Earth System Science, John Wiley & Sons, Inc.
3. Carla Montgomery (2019) Environmental Geology (11th Edition) McGraw-Hill.
4. Valdiya K.S, 2013. Environmental Geology, Tata McGraw-Hill Education
5. Valdiya K.S, 2004. Coping with Natural Hazards: Indian Context, Orient Longmann.
6. A.N. Strahler and A.H.Strahler, 1973, Environmental Geo-science, Wiley.
7. International Edition, Valdiya, K.S.1987, Environmental Geology, Indian context, Tata Mc Graw Hill.
8. Edward Keller, A. Charles E, Environmental Geology, Merrill Pub. Co., A.Bell & Howell Co., London, 4th Edition.
9. Upendra Kumar Sinha, 1986, Ganga-Pollution & Health Hazard. Inter-India Publication, New Delhi.

Semester-IV
Paper-III
Remote Sensing, GIS and Computer Application

Unit-I: Fundamentals of Remote Sensing:
Remote Sensing: Types (thermal and microwave), basic concept, scope, data (In-Situ and Remotely sensed data), principle and process of remote sensing.

Electromagnetic Spectrum: Characterization, interactions with atmosphere and target, principles and geometry of scanners and CCD arrays, Spectral reflectance of earth surface (soil, vegetation and water).

Principles and basic concepts of scanning: Across-track and along-track multispectral scanning, principles of thermal scanning, geometric and radiometric correction, temperature mapping,

Unit-II:

Rensor Resolutions: Types (Spatial, spectral, radiometric and temporal), Image referencing system (path, row and orbital calendar), unmanned aerial vehicle based remote sensing.

Image classification: Supervised classification, unsupervised classification, hybrid classification, output stage, post-classification smoothing and classification accuracy assessment.

Fundamentals of Image interpretation: Types of imagery, elements of interpretation, techniques of visual interpretation, principles of multispectral data analysis, imaging by scanning and non-scanning technique.

Unit III:

Geographic Information System (GIS): Basic principles, concept, components and terminologies, functions and advantages of GIS, Raster and vector data structure, Vector representation (point, line, area and TIN),

Global Positioning System (GPS): Basic principles, GPS positioning techniques, GPS procedures, Role of GPS in GIS and Remote Sensing, AGPS and DGPS and its application.

Introduction to Cartography: Classification of maps, Visual variables, generalization, symbolization, map design, map layout and map projection.

Unit-IV:

Application of Remote Sensing and GIS:

Artificial Intelligence (AI): Use of AI in satellite imagery, sensor data, and historical climate records to assess climate risks, AI-powered systems to optimize energy consumption in buildings, factories, and transportation systems.

Forest resources and water resources mapping: Forest resources – Forest type mapping, forest density mapping, change analysis and matrix analysis; **water resources –** mapping surface water body, flood and inundation mapping.

Agriculture and disaster mapping: **Agriculture** – crop area and yield estimation, damage detection, plant disease detection and land cover mapping: **Disaster mapping** – forest fire, fire frequency mapping fire trend analysis

Books for References:

1. Lillesand, T.M. and Kiefer, R.W., 1987. Remote sensing and Image Interpretation, John Wiley.
2. Jensen, J. R. Introductory digital image processing a Remote Sensing Perspective, Prentice Hall series in Geographic Information Science.
3. Schowengerdt, R. A., 2007. Remote Sensing: Models and Methods for Image Processing, Academic Press.
4. Campbell, J.B., 1996. Introduction to Remote Sensing, Taylor & Francis, London.
5. Cracknell, P. and Hayes, L. Introduction to Remote Sensing.
6. Jensen, J.R., 2003. Remote Sensing of the Environment an Earth Resource Perspective, Pearson Education, Delhi.
7. Joseph, G., 2003. Fundamentals of Remote Sensing, University Press.
8. Gupta, R. P., 2005. Remote Sensing Geology, Springer.
9. Van-der-Meer, F., De Jong, S., 2006. Imaging spectrometry: Basic Principles and Prospective Applications (The Netherlands: Springer Publishers), 451p.
10. Rencz, A.N., 2008. Remote Sensing for the Earth Sciences, Manual of Remote Sensing, 3, ASPRS, 703p.
11. De-Jong, Steven, M., Van der Meer, F.D., 2004. Remote Sensing Image Analysis: Including the Spatial Domain: Including the Spatial Domain, 5, Springer, 359p.
12. Claudia, K., Stefan, D., 2014. Quantitative Remote Sensing in Thermal Infrared, 11, Springer, 281p.
13. Joseph, G. (2005). *Fundamentals of Remote Sensing*. Universities Press (India) Pvt. Ltd, Hyderabad, India.
14. Lillesand, T. M., Ralph, K. W. & Chipman, J. (2008). *Remote Sensing and Image Interpretation* (6th ed.), John Wiley.
15. Sabins, F. F. (1996). *Remote Sensing Principles and Interpretation*. Waveland Pr. Inc.
16. Campbell, J. B. (2002). *Introduction to Remote Sensing*. Guilford Press.Remote Sensing III Edition: American Society of Photogrammtery and Remote Sensing
17. Jensen, J. R. (2000). *Remote Sensing of the Environment*: *An Earth Resource Perspective*. New Jersey: Prentice Hall.

Semester-IV
Paper-IV: (Elective-I)
Biomedical and Hazardous Waste Management

Unit I: Bio-medical Waste (BMW) and its Management.

Introduction to Biomedical Waste: Definition, sources, classification and categories of biomedical waste, colour coding for segregation of medical waste (yellow, red, blue or white and black). Problems associated with Biomedical Waste (BMW), Universal Coding System

Steps of Bio-medical Waste Management: Reduction. Segregation, collection and storage, transportation, Treatment and Disposal, Labelling of Biomedical Waste, Salient Features of Bio-medical Waste Management Rules, 2016 and (Amendment) Rules,2018.

Treatment and Disposal Methods of Bio-medical Waste: Disinfection, Autoclaving, Microwaving, Hydroclaving, Incineration, Encapsulation, Deep burial, Inertization and Plasma pyrolysis. Remediation technique (Physical, chemical, thermal and bioremediation).

Unit II: Hazardous Waste and its Management

Hazardous Waste: Definition, sources and F, K, P and U-List), Characteristics of Hazardous waste (corrosivity, ignitability, reactivity and toxicity), classification of hazardous waste, Effect of Hazardous waste on human health and environment.

Hazardous Waste Management: Storage, collection and transportation of hazardous waste, hazardous waste storage guidelines and hazardous waste label, responsibilities of the hazardous waste transporter, steps involved in hazardous waste management.

Role of Treatment, Storage, Disposal Facility (TSDF): Waste Characterization (Comprehensive Analysis, Fingerprint Analysis), 7-copy Manifest, TREM Card, Requirement for establishment of TSDF of hazardous waste, documents required and procedure for the establishment of TSDF, benefits of TSDF.

Unit III: Treatment and Disposal of Hazardous Waste:

Physico-Chemical Treatment: Physical treatment (Filtration, sedimentation, centrifugation, floatation), Chemical treatment (neutralization, precipitation, oxidation, reduction, ion-exchange and electrolysis), Biological treatment (bioremediation), solidification and stabilization method.

Thermal Treatment: Types of thermal treatment: Incineration (types and process of incineration, advantages and disadvantages), pyrolysis, gasification and plasma gasification.

Disposal methods: Secured landfills **(**criteria for site selection, components, landfill design and benefits), Landfill closure and underground disposal.

Unit IV: Other HazardousWaste and its Management:

Landfill leachate Management: Composition of leachate, components of leachate collection system, Leachate treatment: **Physical** (adsorption and membrane technology), **Chemical** (coagulation and precipitation, chemical oxidation and ammonia stripping).

E-Waste Management: Sources, classification, collection, segregation of E-Waste, Treatment and disposal methods (Landfilling, incineration, recycling and reuse), effects of E-waste on Environment and human health, E-Waste Management, E-waste (Management) Rules, 2022.

Plastic Waste Management: Sources and Types/category plastic waste, environmental issues on disposal of plastic waste, Plastic Waste Management (conventional and non-conventional technology), Adoption of "Circular Economy', Plastic Waste (Management) Rules, 2016.

Books for Reference:

1. **Solid Waste Pollution: Dr**. Aradhana Salpekar, Jnanada Prakashan, New Delhi, 2008.
2. **Environmental Pollution Control Engineering:** C. S. Rao, New Age International, Mumbai, 2003.
3. **Environmental Engineering: Davis** & Cornwell, McGraw – Hill Publications, New York, 1998.
4. **Basic Environmental Technology:** Jerry A. Nathanson, Prentice Hall of India Ltd. New Delhi, 2004.
5. **Municipal Solid Waste Management Manual (Part II)**, CPHEEO, Ministry of Urban Development, Swachh Bharat Mission, Govt. of India.
6. **Handbook on Chemicals Hazardous Waste Management Handling in India** – A Ministry of Environment, Forests and Climate Change Manual.
7. **Training Manual on Biomedical Waste Management for Doctors, Nurses, Nodal Officers and Waste Managers** - A Ministry of Environment, Forests and Climate Change, Government of India Manual.
8. **Sustainable Urban Plastic Waste Management**– NITI Aayog & UNDP Manual**.**
9. **Plastic Waste Management (Issues, Solutions & Case Studies)** – A Handbook by Ministry of Housing and Urban Affairs, Government of India

Semester-IV
Paper-IV (Elective-II)
Climate Change and Its consequences

Unit-I:

Fundamentals of Climate Change: Introduction to climate change. Climate & weather, Greenhouse gases, source and effect, human contribution to climate change, Global scientific opinion, diminishing carbon sink, carbon sequestration.

Climate Change Impact: Observed changes in the climate since the industrial revolution, Future trends and impacts of climate change on surface temperature, precipitation, ocean pH, sea-level and Arctic sea-ice extent.

Economics of Climate Change: Effect of climate change in global and Indian economy, climate damages, mitigation cost, National & international climate change finance.

Unit-II:

International Scenario: Overview of international legal and policy framework to address climate change, brief history of International climate change negotiations, United Nations Framework Convention on Climate Change (UNFCCC) and its key provisions, Organizational structure and different party groups under the convention.

Basic Group Countries: Formation of basic Group- back ground and way forward, concerns of BASIC countries, Gains and losses of Kyoto Protocol.

Paris Agreement- Aims and objectives, associated bodies, Key commitments by Parties, Key issues under negotiation, India's commitment in Paris agreement and status so far, Case studies of meetings of Conference of Parties (COP),SDG's and India's take on meeting the SDG's.

Unit-III:
Climate Change Adaptation: Basic concept of climate change adaptation, measuring vulnerability, adaptation solutions and planned response.

Consequences of Climate Change: Consequences on key sectors, adaptation measures for various vulnerable sectors, linkages between climate change adaptation and development, important international adaptation initiatives and programmes.

Climate Change Mitigations: Aims and objectives, Political context to greenhouse gas emissions, integration of mitigation into development planning, international mechanisms for planning and implementing mitigation actions, Computer modelling for future projections, India's policy structure related to GHG mitigations.

Unit-IV: Planning Process of Climate Change: Introduction to climate change planning, the role of national & sectoral institutions. Methodology for preparing a low-emission climate resilient development strategy, international initiatives to support climate change planning, key emitters, strategies to bring down emissions, mitigation targets per country.

National Action Plan on Climate Change (NAPCC): Aims and objectives, principles, national solar mission, mission on sustainable habitat, sustaining the Himalayan eco-system,

water mission, managing climate change agenda, current carbon dioxide emission status, Introductions of labelling program for appliances.

Clean Air Initiatives: Non-attainment cities of India, Air Quality Index, GHG mitigation in power generation, supercritical technologies, integrated gasification combined cycle (IGCC), natural gas-based power plants, efficient transmission and distribution, Majhi Vasundhara Abhiyan.

Books for Reference:

1. Atlas of Our Changing Environment – United Nations Environment Programme-2005
2. Earth: Making a Life on a Tough New Planet -Bill McKibben-2010.
3. Our Choice: A Plan to Solve the Climate Crisis-Al Gore-2009.
4. Surviving the Century: Facing Climate Chaos and Other Global Challenges-Herbert Girardet-2007.
5. Climate Code Red: The Case for Emergency Action-David Spratt and Philip Sutton-2008.
6. Climate Change: Meeting the Challenge – K R Gupta – 2010
7. The Climate Solution: India's Climate Change Crisis and What We Can Do About It-Mridula Ramesh – 2018
8. The Great Derangement: Climate Change and the Unthinkable-Amitav Ghosh – 2018
9. Climate Change in India: Sulagna Chattopadhyay – 2013.
10. National Action Plan on Climate Change, Govt of India.
11. Climate Changed: A Personal Journey Through the Science-Philippe Squarzoni-2014

Distribution of Marks

Research Project SEE	- 100 marks
Research Project CIE	- 100 marks

Total Marks	- 200 marks