Department of Environmental Science and Chemistry

Theme: Education with innovation at every level of the degree courses.

The curriculum is designed for offering major and minor degrees befitting the international and particularly the national demand for socioeconomic development, maintaining pollution free healthy environment.

The courses are arranged for offering both major and minor degrees. The courses are grouped as fundamental, ancillary, core and advanced courses which are compulsory for all students. Students have to complete minimum 141 credits successfully to get the Major degree in Environmental science and Chemistry. If some one can not complete the required 141 credits, then a minor degree will be awarded if he/she successfully completes a minimum 129 credits.

In addition, students who will take extra 9.0 credits (any three advanced courses from any specialized group) of major courses will be awarded a second major on respective specialized group. Optional advanced courses for the second major can be completed at any semester of the 4th year. The detail of the course distribution is outlined below:

1st year 1st semester

Course No	Course Title	Type	Hours/week	Credit
ENV 111	Introduction to Environmental Science	Foundation	3	3.0
ENV 113	Fundamentals of Chemistry	Foundation	3	3.0
ENV 115	Fundamentals of Biological Sciences	Foundation	3	3.0
ENG 101	English Language	Ancillary	3	3.0
	Total:		12	12.0

1st year 2nd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 121	Environmental Ecology	Core	3	3.0
ENV 123	Basic Physical Chemistry	Foundation	3	3.0
GED 101	Bangladesh Studies	Ancillary	3	3.0
ENV 120	Basic Lab and Field work in Environmental Science-I	Field work	-	2.0
	Total		11	11.0

1st year 3rd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 131	Basic Inorganic Chemistry	Foundation	3	3.0
ENV 133	Environmental Data Handling and Statistics	Ancillary	3	3.0
ENV 135	Environmental Chemistry	Foundation	3	3.0
ENV 138L	Basic Analytical Chemistry Lab	Core-Lab	4	1.5
ENV 100	Seminar and Oral	Viva	-	1.0
	Total		13	11.5

Total Credit completed after 1st year = 12.0+11.0+11.5= 34.5

2nd year 1st semester

Course No	Course Title	Type	Hours/week	Credit
ENV 211	Basic Organic Chemistry	Foundation	3	3.0
ENV 213	Fundamentals of Earth Sciences and Geomorphology	Core	3	3.0
ENV 215	Environmental Physics	Ancillary	3	3.0
MAT 201	Mathematics 1 (Analytical Geometry)	Ancillary	3	3.0
	Total		12	12.0

2nd year 2nd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 221	Analytical Chemistry for Environmental Science	Core	3	3.0
ENV 223	Environmental Organic Chemistry	Core	3	3.0
CSE 201	Computer Programming (Introduction to Computer Language)	Ancillary	2	2.0
CSE 202	Computer Programming Lab (Introduction to Computer Language Lab)	Ancillary	3	2.0
ENV 224L	Environmental Chemistry Lab	Core-Lab	4	1.5
ENV 220	Field work in Environmental Science-II	Field work	-	1.0
	Total		13	12.5

2nd year 3rd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 231	Hydrology and Fundamentals of Aquatic Chemistry	Core	3	3.0
ENV 235	Environmental Economics	Ancillary	3	3.0
ENV 236L	Industrial Chemistry Lab	Core-Lab	4	1.5
MAT 202	Mathematics 2 (Calculus)	Ancillary	3	3.0
ENV 200	Seminar and Oral	Viva	-	1.0
	Total:		13	11.5

Total Credit completed after 2nd year = 34.5+12.0+12.5+11.5= 70.5

3rd year 1st semester

Course No	Course Title	Type	Hours/week	Credit
ENV 311	Chromatographic Methods	Core	3	3.0
ENV 313	Industrial Pollution and Mitigation	Core	3	3.0
ENV 315	Environmental Impact Assessment and Management	Core	3	3.0
ENV 317	Environmental Geography	Core	3	3.0
	Total		12	12.0

3rd year 2nd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 321	Spectroscopic Techniques	Core	3	3.0
ENV 323	Environmental Pollution & its Remediation	Core	3	3.0
ENV 325	Natural Resources and Biodiversity Conservation	Core	3	3.0
ENV 326L	Chromatographic and Spectroscopic Analysis of Environmental Samples Lab.	Core	4	1.5
ENV 320	Field Visit			1.0
	Total:		13	11.5

3rd year 3rd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 331	Environmental Microbiology and Biotechnology	Core	3	3.0
ENV 333	Sustainable Materials and Green Chemistry	Core	3	3.0
ENV 335	Waste Management	Core	3	3.0
ENV 338L	Environmental Pollution and Mitigation Lab	Core	4	1.5
ENV 300	Seminar and oral	Viva		1.0
	Total:			11.5

Total Credit completed after 3rd year =70.5 +12.0+11.5+11.5= 105.5

4th year 1st semester

Course No	Course Title	Type	Hours/week	Credit
EN 411	Current Environmental Issues and Bangladesh Perspectives	Core	3	3.0
ENV 413	Remote Sensing and GIS in Environmental Monitoring	Core	3	3.0
ENV 415	Environmental Toxicology	Core	3	3.0
ENV 417	Computer Modeling for Environmental Studies	Core	2	2.0
	Total:		11	11.0

4th year 2nd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 421	Environmental Law, Ethics and Policy	Core	3	3.0
ENV 423	Agricultural Waste Management	Core	3	3.0
ENV 425	Instrumentation in Environmental Studies	Core	3	3.0
ENV 428L	Environmental Biology Lab.	Core-Lab	4	1.5
ENV 440	In Plant Training (at TICI)		-	1.0
	Total:		15	11.5

4th year 3rd semester

Course No	Course Title	Type	Hours/week	Credit
ENV 431	Meteorology and Climatic Change	Core	3	3.0
ENV 433	Disaster Management	Core	3	3.0
ENV 435	Chemistry and the Technological Backlash	Core	3	3.0
ENV 400	Seminar and Oral	Viva	-	1.0
ENV 430	Project / Internship	Practical	5	3.0
	Total:		14	13.0

Total Credit completed after 4th year = 105.5+11.0+11.5+13.0= 141.0

Optional courses (Students have to chose any 3 courses from any group for the second major degree.)

Course No	***Optional Courses for Major in Environment and Agriculture***	Type	Hours/week	Credit
ENV 4311	Aquaculture	Opl. Core	3	3.0
ENV 4312	Environmental Botany	Opl. Core	3	3.0
ENV 4313	Sustainable Agricultural and Rural Land Management *	Opl. Core	3	3.0
ENV 4314	Agricultural Resource; Planning and Management	Opl. Core	3	3.0
ENV 4315	Groundwater Hydrology and Contamination	Opl. Core	3	3.0
ENV 4316	Agrochemicals-Impact and Bio-Alternatives	Opl. Core	3	3.0
ENV 4324	Food Hygiene, Health and Safety	Opl. Core	3	3.0
ENV 4342	Food Microbiology and Biotechnology	Opl. Core		
		Total	9	9.0
	Optional Courses for Major in Environment and Health			
ENV 4321	Biological Pollution and Mitigation	Opl. Core	3	3.0
ENV 4322	Environmental Sanitation	Opl. Core	3	2.0
ENV 4323	Environmental Safety, Health and Management*	Opl. Core	3	3.0
ENV 4324	Food Hygiene, Health and Safety	Opl. Core	3	3.0
ENV 4316	Agrochemicals-Impact and Bio-Alternatives	Opl. Core	3	3.0
		Total	9	9.0
	Optional Courses for Major in Environment and Energy			
ENV 4331	Energy, Environment and Sustainable Development: Bangladesh Perspective *	Opl. Core	3	3.0
ENV 4332	The Alternative and Sustainable Sources of Energy	Opl. Core	3	3.0
ENV 4333	Global Energy Scenario and Energy Security of Bangladesh	Opl. Core	3	3.0
ENV 4314	Agricultural Resource; Planning and Management	Opl. Core	3	3.0
ENV 4343	Industrial Microbiology And Biotechnology	Opl. Core	3	3.0
	Total:		9	9.0
	Optional Courses for Major in Environment and Biotechnology			
ENV 4341	Biochemistry and Molecular Biology *	Opl. Core	3	3.0
ENV 4342	Food Microbiology and Biotechnology	Opl. Core	3	3.0
ENV 4343	Industrial Microbiology And Biotechnology	Opl. Core	3	3.0
ENV 4344	Recombinant DNA Technology & Genomics			
ENV 4345	Nanobiotechnology	Opl. Core	3	3.0
ENV 4346	Biosafety, Bioethics & IPR Issues	Opl. Core	3	3.0
	Total:		9	9.0

* Compulsory for the corresponding major

Total Credit completed with a second major 141.0 + 9.0 = 150.0

Detailed Syllabus

ENV 111: INTRODUCTION TO ENVIRONMENTAL SCIENCE
3.0 Credit, 3 hours/ week

1. Environmental Chemistry: Concepts and Scope of Environmental chemistry, Nomenclature, Environmental segments, The natural cycles of the Environment.
2. Chemistry of Atmosphere: Composition of the atmosphere, Atmosphere structure, Evolution of the atmosphere, Earth's radiation balance, Particles, ions and radicals in the atmosphere, chemical and photochemical reactions in the atmosphere, Oxygen and Ozone chemistry, Sulphur dioxide, Nitrogen oxide, Organic compounds, Green House Effect., Ozone hole, Human activities in meteorology.
3. Energy: History, different forms of energy, sources, conversion and storage. Renewable and non-renewable energy. **Hydro Energy:** Potential resources, Common features and Socio- economic issues of Hydro power installations. **Fossil Base Energy:** Fossil fuel types, Combustion kinetics and environmental impact, Clean combustion technologies. **Biomass Energy:** Definitions, Chemical and Physical properties, Thermal conversion to heat and electricity, Resources and production, Socio- economic and environment impacts. **Solar energy:** Potential & production, solar cells, Solar thermal energy power generation. **Wind Energy:** Potential and production.
4. Environmental Ecology: Concept, definition, branches and scope of ecology, autecology, synecology, habitat and ecological niche, habitat ecology – aquatic and terrestrial.
5. Environmental protection, Global warming, Environmental changes, etc.

Recommended Books and References:

1. Odum, E. P., Saunders Com, W. B., Fundamentals of Ecology, 3rd Edition
2. Edward, J., Kormondy, Concepts of Ecology- Prentice-Hall of India Pvt. Ltd., New Delhi
3. Clerke, Elements of Ecology, John Wiley & Son
4. Andrew R. W., Jackson & Julie M. Jackson, Environmental Science – The Natural Environment and Human Impact, Addison Wesley Longman Limited
5. Santra, S. C., Environmental Science, 2nd Edition, New Central Book Agency Ltd, Kolkata, India
6. Flowler, John M., Energy and the Environment, 2nd Edition, McGraw Hill, New York

ENV 113 FUNDAMENTALS OF CHEMISTRY
3.0 Credits, 3 hours/week

1. The States of Aggregation of Matter: Gaseous, liquid and solid; The Gaseous States. The gas laws, kinetic theory of gases, molecular diffusion and effusion, deviations from ideal gas behaviour, the van der Waals equation of state, abnormal vapor density, association and dissociation, degree of dissociation.
2. The Liquid State: Liquefaction of gases, the critical state, determination of critical constants, the principle of corresponding state, attainment of low temperature, vapour pressure of liquid, surface tension.
3. The Solid State: Properties of solids, crystalline and amorphous solids, the crystal system.
4. The Structure of Atoms: Rutherford's nuclear theory, Bohr's model of the atoms. Hund's rule, Pauli exclusion principle, Aufbau principle, electronic configuration of atoms, electron probability distribution, shapes of orbital.
5. The Modern Periodic Table: Some periodic properties of the elements: effective nuclear charge, metallic behaviour, atomic size, ionization energy, electron affinity and electronegativity, classification of elements.
6. Concepts of Chemical Bonds: Introductory concept on ionic, covalent and coordination bonds, hydrogen bond, metallic bond, van der Waals forces.

Recommended Books and References:

1. Haque, M. M., Nawab, M. A., Principles of Physical Chemistry
2. Glasstone, S., Lewis, D., Elements of Physical Chemistry, McMillan & Co. Ltd.
3. Ebbing, D. D., General Chemistry
4. Haider, S. Z., Introduction to Modern Inorganic Chemistry
5. Cotton and Wilkinson, Basic Inorganic Chemistry, 4th Edn.

ENV 115 FUNDAMENTALS OF BIOLOGICAL SCIENCES
3.0 Credits, 3 hour/week

1. Introduction: The structure and function of a living organism in the natural environment; components and ecological inter-relationships; Origin and evolution of life; Evolution in the plant and animal kingdom.
2. Environment- Organisms Interactions: Ecological concepts-Environment, Limiting Factors, Habitat and Niche; Kinds of Organism Interactions; Community and Ecosystem.
3. Classification: Groups of plants and their modern classification systems; Principles and kinds of classification. Outline of Whittaker's system of classification. Monera-Protista; Eukaryotic and Prokaryotic Concept.
4. Taxonomy: Principles of nomenclature; author citation, principle of priority and conserved name, Herbarium: Definition, field and herbarium techniques; major herbaria of the world; Bangladesh National herbarium, preservation of funa.
5. Major groups of bacteria and virus: Gram negative and Gram positive bacteria; Growth of bacteria; Mycoplasma; Bacteriaophage and its multiplication; Economic and Ecological Importance of bacteria and virus.
6. Fungi: General characters and classification of fungi; Salient features and life cycle. Economic and ecological importance of fungi.
7. Algae: General characters and classification (up to class) of Algae: The general characters, economic and ecological importance of some Algae.

Recommended Books and References:

1. Pelezar, M. J., Chan. E. C. S., Krieg, N. R., Microbiology- Concepts and Applications. McGaw-Hill Inc.
2. Alexopoulos, C. J., Mims, C. W., Blackwell, M., Introductory Mycology, 4th edn., John Wiley and Sons Inc. New York
3. Ashrafuzzaman, H. A., Text book of plant pathology, Bangladesh Agricultural Research Council
4. Sharma, O. P., Text Book of Fungi, Tata McGraw-Hill publishing Company Ltd., New Delhi
5. Prescott. G. W., The Algae: A review, Bishen Sing Mahendra pal Singh and Otto Koettz Science Publishers
6. Pandev, B. P.; Algae, S., Chand and Company Reprint
7. Porter, C. L., Taxonomy of Flowering Plants Eurasia Publishing House, New Delhi, India, 1969
8. Jones, B. S., Luschinger, A. E., Plant Systematics McGraw Hill Book Co. New Delhi, India, 1979

ENG 101: ENGLISH LANGUAGE

3.0 Credits, 3 hours/week

Problems with: a) Main Verbs; b) Tense; c) Modals and modal-related patterns; d) Causatives; e) Conditionals; f) Subjective; g) Infinitives; h) Have+ participle; i) Auxiliary verbs; j) Pronouns; relative pronouns, nouns and adjectives, nouns function as adjective and other parts of speech; k)determiners; l) comparatives; m) prepositions; n) and prepositional idioms; n) point of view for syntactical pattern; o) agreement of verbs; p) introductory verbal modifiers; q) Sentence and clauses; r) Word choice-vocabulary –antonyms, homonym, homograph, homophone; s) Wh. questions; t) punctuation: full stop, comma, colon, semi colon, apostrophe, capital letter, hyphen, question marks, title, etc.; u) proof reading. One reading comprehension, One paragraph.

Recommended Books and References:

1. Baron's TOEFL
2. Standard Grammar book of Class teacher's choice

ENV 121 ENVIRONMENTAL ECOLOGY
3.0 Credits, 3 hours/week

1. Environmental Ecology: Concept, definition, branches and scope of ecology, autecology, synecology, habitat and ecological niche, habitat ecology – aquatic and terrestrial.
2. Ecosystem: Concept and Principles of ecosystem, Different types of ecosystems, Ecological tools, and techniques, Statistical application in ecology, Energy and energy flow in ecosystem, Pattern of flow energy through the ecosystem and food chains**.**
3. Biogeochemical cycles of ecosystems: Carbon cycle, nitrogen cycle, sulphur cycle, phosphate cycle. Abiotic and biotic component of ecosystem, Phytosociology, Population ecology, Food chains, food webs and ecological pyramids.
4. Population ecology: Definition and characters of population, population density, mortality, age distribution, biotic potential of population, population dispersal

Recommended Books and References:

1. Odum, E. P., Saunders Com, W.B., Fundamentals of Ecology, 3rd Edn.
2. Agarwal, K. M., Sikdar, P. K, Deb. S. C., A. Textbook of Environment- MacMillan India Ltd.
3. Edward, J. Kormondy, Concepts of Ecology- Prentice-Hall of India Pvt. Ltd., New Delhi
4. Richard, T. Wright., Pearson Environmental Science. Prentice Hall
5. Clerke, Elements of Ecology, John Wiley & Son

ENV 123 BASIC PHYSICAL CHEMISTRY
3.0 Credits, 3 hours/week

1. Introduction to Thermodynamics: The basic concepts; Systems and surroundings, State and state functions, Equilibrium states and reversibility, Energy, Heat and work. The First Law: Statement and formulation, Derivation of expression for expansion work and its application, Heat capacity. Relation between *Cp* and *Cv*, Joul-Thomson effect and inversion temperature.
2. **Thermochemistry:** Extent of reaction, Standard states, Standard enthalpy changes, enthalpy of ionization, neutralization, reaction, vaporization, Laws of Thermo chemistry. Measurement of enthalpy changes, Enthalpies of formation, Temperature dependence of enthalpies of reaction; Application of First law to different processes of ideal and real gases.
3. The Liquid State: Molecular interpretation, Measurement of vapor pressure and it's variation with temperature; Vaporization, Evaporation & boiling temperature of a liquid & liquid mixture; Surface tension and viscosity, Ideal and non ideal solution, solubility and it's variation with temperature and pressure, Henry's law and Roult's law, Nernst distribution law, Colligative properties and their applications.
4. The Solid State: Molecular interpretation, Crystalline and amorphous solids, Crystal lattice and lattice energy, Unit cell, Elementary idea on Crystal Systems, Solubility of ionic solids and salvation energy.
5. Fundamentals of Chemical Equilibrium: Concept of equilibrium, Equilibrium law equilibrium constant, Relation between K_p, K_c and K_x, Le Chatelier's principle, effect of temperature, pressure, concentration and inert gas on K, application of K.
6. Chemical Kinetics: Rate of reaction and measurement, rate constant and order of a reaction, Differential rate equation, Half life of a reaction.
7. Electrochemistry: Scope, conductors and non-conductors, electronic and electrolytic conductors, conductance measurement, molar and equivalent conductance, ionic migration, transport number, electrolysis laws, electrochemical cells, electrode potentials, electrolysis, different electrochemical cells, lead storage battery
8. Surface Chemistry and Colloids: Adsorption: Different types of adsorption isotherms. Theories of Langmuir and other adsorption isotherm for gas-solid system. Surfactants, surface films. Classification and general properties of colloids. Properties of gels, Uses of colloids and emulsions.

Recommended Books and References:

1. Chang Raymond, General Chemistry
2. Atkins, P. W. Elements of Physical Chemistry
3. Moore, Physical Chemistry

GED 101 BANGLADESH STUDIES
3.0 Credits, 3 hour/ week

1. Fundamental concepts: State, power, sovereignty, law, liberty, government, institution, nationality, constitution, democracy, dictatorship, unity and federal government, society and politics, war of liberation, nature of leadership, political process, constitutional framework of public administration, public service commission, ministry, secretariat, bureaucracy and local government.
2. **Economy of Bangladesh**: Socio-economic indicators of Bangladesh-GDP, Savings and Investment-Prices, wages and employment-agriculture-industry-power & Energy-transport & Communication-Human Resource Development-Poverty Alleviation-Population-economic planning.

Recommended Books and References:
1. Banglapedia
2. Economic Review of Bangladesh

ENV 120 BASIC LAB & FIELD WORK IN ENVIRONMENTAL SCIENCE-1
2.0 Credits

ENV 131 BASIC INORGANIC CHEMISTRY
3.0 Credits, 3 Hours/ Week

1. Introduction: Some preliminaries, history and review of the chemistry of early period.
2. Chemical Bonding and Shapes of Molecules: Different theories of chemical bonding: preliminary treatment of the valence bond theory and the molecular orbital theory, hybridization, electron pair repulsion (VSEPR) theory for shapes of simple molecules.
3. Acids and bases: Modern concepts of acids and bases, strength of acids and bases, leveling effect, super acids, hard and soft acids and bases, thermodynamic acidity parameters. Periodic trends in aqua acid strength, Chemistry of oxide, hydroxides and superoxides.
4. **Oxidation and reduction reaction:** Electronic concept, oxidation state and oxidation numbers, assignment of oxidation numbers, balancing of redox reactions, oxidation-reduction potentials, oxidizing reducing agents, Prediction of redox reaction.
5. Solvents and solutions: Solvent properties, donor and acceptor properties, protic and aprotic solvents, chemistry of some non-aqueous solvents: liquid NH_3, hydrogen fluoride, liquid N_2O_4, BrF_3, anhydrous sulphuric acid.
6. Bio-Inorganic Chemistry: A brief introduction to bio-inorganic chemistry, role of metal ions present in biological systems with special reference to Na+, K+ and Mg2+ ions: Na/K pump; Role of Mg2+ ions in energy production and chlorophyll. Role of Ca2+ in blood clotting, stabilization of protein structures and structural role (bones).

Recommended Books and References:
1. Haider, S. Z., Introduction to Modern Inorganic Chemistry
2. Lee, J. D., Concise Inorganic Chemistry
3. Cotton, Wilkinson and Gaus, Basic Inorganic Chemistry
4. Chang Raymond, General Chemistry
5. Ebbing, D., General Chemistry
6. Sharpe, Inorganic Chemistry
7. Huheey, J. E., Inorganic Chemistry

ENV 133 ENVIRONMENTAL DATA HANDLING AND STATISTICS
3.0 Credits, 3 hour/ week

1. Environmental Data: definition, sources, different kinds of environmental data, collecting methods. Sample and population, Random sampling, Steps in organising and sample survey, different types of sample survey method, Experimental design: Completely Random design, Rendomized Block Design and Split-plot-design.
2. Probability distribution and their uses: Sampling distribution and their uses.
Testing of hypothesis: definition of hypothesis, basic concepts concerning testing of hypothesis, hypothesis testing of means, hypothesis testing for comparing two related samples, hypothesis testing of proportions. Hypothesis testing for difference between proportions, testing of correlation co-efficiency, Chi square test for association.

3. Analysis of variance and Co-variance: Analysis variance of one way, two way, non-parametric or distribution free tests, Wilcoxon-Matched pairs test (Signed Rank Test), characteristics of distribution of non-parametric tests.
4. Uses of different types of software for statistical analysis (e.g., SPSS)

Recommended Books and References:
1. Mostofa, M. G., Method of Statistics Karim Press and publications, Dhaka
2. Morton, R., Richard, J., A Study Guide to Epidaciology and Bio-statistics Hebel University park press
3. Islam, M. N., Introduction to statistics and probability Book World
4. Stanfon A. G., Primer of Bio-statistics McGraw-Hill Book Company

ENV 135 ENVIRONMENTAL CHEMISTRY
3.0 Credits, 3 hours/week

1. Introduction: Concepts and Scope of Environmental chemistry, Nomenclature, Environmental segments, The natural cycles of the Environment.
2. Chemistry of Atmosphere: Composition of the atmosphere, Atmosphere structure, Evolution of the atmosphere, Earth's radiation balance, Particles, ions and radicals in the atmosphere, chemical and photochemical reactions in the atmosphere, Oxygen and Ozone chemistry, Sulphur dioxide, Nitrogen oxide, Organic compounds, Green House Effect., Ozone hole, Human activities in meteorology.
3. Chemistry of Hydrosphere: Water resources; The Hydrologic cycle, Composition and physical chemistry of sea water, sea water equilibrium, pH, Complexation in Natural water and waste water.
4. Chemistry of Lithosphere: Composition of lithosphere/soil, Water and air in soil, Inorganic and organic components of soil, Acid-base and ion-exchange reactions in soils, Micro and macro nutrients, Nitrogen pathways in soil, Wastes and pollutants in soil.
5. Chemistry of Biosphere: Components of biosphere, man, animals and plant kingdoms in ecological balance of the environment, food and nutrition in health and biological processes, food contaminants for human and animals, effects of drugs, enzyme actions, pest and pesticides, environmental toxicology, forests: afforestation and deforestation and desertification, effects of toxic elements on biota and enzymes, biochemical effects of Cd, Pb, Hg, As, CO, NO_x, SO_2.

Recommended Books and References:
1. Manahan, S. E., Environmental Chemistry- 9th edn., CRC Press.
2. Baird, C., Environmental Chemistry, W. H. Freeman and Company, NY
3. Harrison, R. M., Understanding our Environment-An Introduction to Environmental Chemistry and Pollution-Edited
4. De, A. K., Environmental Chemistry, New Age International Pvt. Ltd.
5. Baver, L. D., Soil Science, John Wiley & Son, New York

ENV 138: L BASIC ANALYTICAL CHEMISTRY LAB
1.0 Credit, 4 hour/ week

Qualitative and Quantitative analysis of chemical samples

ENV 100 SEMINAR AND ORAL
1.0 Credit

ENV 211 BASIC ORGANIC CHEMISTRY
3.0 Credits, 3 hours/week

1. Fundamentals of Organic Chemistry: Review of chemical bonding, Atomic and molecular orbitals, Shape of molecules with special reference to carbon compounds, Hybridization, Polar covalent bonds, Dipole moment, Polar and nonpolar molecules, Resonance, Inductive effect, Electrophiles and Nucleophiles.
2. Aliphatic Hydrocarbons: Alkanes**:** Nomenclature, General methods of preparation, Physical and chemical properties, Uses. **Alkenes:** Structure, Nomenclature, General methods of preparation, Physical and chemical properties, Uses. **Alkynes:** Structure, Nomenclature, General methods of preparation, Physical and chemical properties, Uses. Acidity of alkynes, Analysis of alkynes. Dienes**:** Alkadines and Polyunsaturated hydrocarbon. 1,3-Butadiene: Electron delocalization, stability of conjugated dienes. Electrophilic attack on conjugated dienes: 1,4 addition. The Diels-Alder Reaction: 1,4-cycloaddition, Reaction of Dienes.
3. Aromatic Hydrocarbons: Introduction to aromatic compounds, Structure of benzene, Preparations, Properties and uses. Electrophilic aromatic substitution, Orientation on substituted benzene derivatives, Determination of orientation, Friedel Crafts reaction, nitration, sulphonation, and halogenation of arenes.
4. Polycyclic Aromatic Hydrocarbon: Synthesis, physical and chemical properties of naphthalene, phenanthrene and anthracene.

5. Alkyl and Aryl Halides: Nomenclature and structure, General methods of preparation, Physical and chemical properties, Uses. Grignard reagent. Introduction to S_N1 and S_N2 mechanism.

Recommended Books and References:

1 Morrison, R. T., Boyd, R. N., Organic Chemistry, 6th edition
2 Solomon, G., Organic Chemistry, 5th edition
3. Finar, I. L., Organic Chemistry
4. Carey, F., Organic Chemistry

ENV 213 FUNDAMENTALS OF EARTH SCIENCES AND GEOMORPHOLOGY
3.0 Credits, 3 hours/ week

1. Introduction: The scope and subdivisions of geological sciences. Relationship between earth sciences and environmental science.
2. Rocks and Minerals: Igneous and Volcanic Rocks, magma and its origin, solidification of magma, characteristics of lava, different types of plutons, volcanic landforms, classifications of igneous, metamorphic and sedimentary rocks.
3. Deformation of Rock: Stress and strain, stages of deformation, ductile deformation vs. fracture, brittle-ductile properties of the lithosphere, evidence of former deformation.
4. Minerals' chemistry: Definition, physical properties, common minerals - silicate, carbonate, phosphate, and sulfate minerals, ore minerals.
5. Physical Geography : Introduction to Geomorphology , its relation to environmental science, definition and subject matter, objectives and methods of explanations, Agents, Processes and products (Geomorphic). Application of geomorphic knowledge to environmental problems, Development of geomorphological thoughts: Pre-davisian geomorphology, Davisian Cycle of Erosion, Penck and King's Concepts.
6. Modern Geomorphology: Morphogenic Regions and Climatic Geomorphology, Environmental Dynamism and Geomorphology.
7. Major Tectonic Elements of Earth's Surface: Structure and composition of the Earth's crust.

Recommended Books and References:

1. Chorley, Geomorphology
2. Emblemion, C., Thomas, J., Process in Geomorphology
3. Holmes, A., Principles of Physical Geology
4. King, L. C., Morphology of Earth.
5. Sharma, V. K., Geomorphology: Earth Surface, Process
6. Skinner, B. J., Porter, S.C., The Dynamic Earth . 3rd Edn, John Wiley & Sons, Inc., New York

ENV 215 ENVIRONMENTAL PHYSICS
3.0 Credits, 3 hours/ week

1. Measurement: The physical quantities, standards and units, international systems of units, precision and significant figures, dimensional analysis.
2. Essentials of Environmental Physics: The economic system and heat transfer and relevant physical processes, Noise; basic acoustics, human perceptions and noise criteria, reducing the transmission of noise.
3. Introductory concepts of properties of matter: elasticity, surface tension, viscosity.
4. Introductory concepts of electromagnetism: Basic laws of electromagnetism; Gauss's low, Amperes low, Faraday's law and Lenz's law.
5. Elementary spectroscopy: Introduction to solar spectrum, black body radiation, ozone and UV light, solar UV and light, ozone filter.
6. Radioactivity and Radiation Effects: Interaction of Radiation with Matter; Radioactivity, laws of radioactivity, important decay chains, Radiation effects; Acute effects, Delayed effects, Basic radiation dose limits and Standards; sources of environmental radioactivity, case study; Atomic Energy Center, Diagnostic Centers etc.
7. Radiation Protection: Basic principles, Techniques of radiation protection- time, distance and shielding, Dose measuring instruments, Survey meter, Pocket Dosimeters. TLD etc.

Recommended Books and References:

1. Boeker, E. R., Grondelle, V. Environmental Physics, John Wiley and Sons., 1996
2. Halliday, Resnick, Krane, Physics, Vol I and II 4th Edition, 1994
3. Herman, C., Introduction to Health Physics, McGRAW-HILL, INC
4. Martine, Harbison, S. A., An Introduction to Radiation Protection, London, Chapman and Hall

MAT 201 MATH I: ANALYTIC GEOMETRY

3.0 Credits, 3 hours/week

1. Two dimensional geometry: Coordinate system in two dimension; equations of straight line and its slope, distance between two straight lines, circle and its general properties. **Conic section**: parabola, ellipse, hyperbola. Pair of straight lines, polar and parametric equations of conic, general equation of the second degree, pole and polar, tangent and normal on a curve.
2. Three dimensional geometry: Coordinates in three dimensions; equations of straight lines and planes in space, sphere, cylinder, cone, ellipsoid and paraboloid.

Recommended Books and References:
1. Loney, S. L., Coordinate Geometry of Two dimensions
2. Smith, C., An elementary treatise on coordinate geometry of three dimension
3. Askwith, R. E. H., Analytical Geometry of Conic Sections

ENV 221 ANALYTICAL CHEMISTRY FOR ENVIRONMENTAL SCIENCE
3.0 credits, 3 hours/week

1. Introduction: The scope of the Analytical Chemistry, The types of analytical methods, Trends in development of analytical methods.
2. Errors in the Chemical Analysis and Sampling: Determinate and indeterminate error, normal distribution of error, data treatment, potential source of error. Sampling methods and colleting strategy of solid, liquid and gaseous samples, working curve, blank titration, standard titration, curve fitting.
3. Titrimetric Methods of Analysis: Definitions, Classification, examples.
4. Complexometric titration: Chelating agent, stability of metal chelates, metal indicators, effect of pH, masking agents and their role in EDTA titration.
5. Precipitation titration: Effects of acidity on the solubility of precipitates, effects of complexation on solubility, titration curves, application.

Recommended Books and References:
1. Analytical Chemistry, Gary G. Christian

ENV 223 ENVIRONMENTAL ORGANIC CHEMISTRY
3.0 Credits, 3 Hours/ Week

1. Introduction and Review: Classification of organic molecules and review of physical properties including, natural organic matter, halocarbons, phenols, polyaromatic hydrocarbons, organophosphates, surfactants; Review of sources such as agrochemicals, industries, by-products.
2. Chemical Distribution in the Environment: Introduction to the molecular interactions that lead to physical properties that affect chemical distribution in the environment.
3. Molecular Partitioning: Molecular interactions; partition constants; thermodynamic considerations.
4. Vapor Pressure: Thermodynamic considerations; molecular interactions; temperature; estimation methods.
5. Water solubility: Thermodynamic considerations; activity coefficients; excess free energy; effect of temperature and ionic strength; estimation methods; molecular fragment contributions
6. Air- Water and Air-Organic Solvent Partitioning: Thermodynamic considerations; Henry's Law constant; estimation methods
7. Organic-Water Partitioning: Thermodynamic considerations; linear free energy relationships; estimation methods.
8. Acid – Base partitioning: Acidity constants; substituent effects; effect of water solubility
9. Sorption Partitioning: Solid–water interfaces; sorption to particulate and dissolved organic matter; bioaccumulation; biomagnification; sorption to inorganic surfaces
10. Chemical Transformations in the Environment: Introduction to important reaction classes of organic molecules including substituent effects and structure – activity relationships.

Recommended Books and References:
1. Schwarzenbach, R. P., Gschwend, P. M., Imboden, D. M., Environmental Organic Chemistry, 2nd Edn., J. Wiley
2. Larson, R. A., Weber, E. J. Reaction Mechanisms in Environmental Organic Chemistry Lewis Publishers
3. Morrison, R. T., Boyd, R. N., Organic Chemistry, 6th edn.
4. Solomon, G., Organic Chemistry, 5th edn.
5. Finar, I. L., Organic Chemistry
6. Carey, F., Organic Chemistry

CSE 201 INTRODUCTION TO COMPUTER LANGUAGE

2 Credits, 2hours/week

Computer Basics: Concept on Computer Hardware, and Software, Computer Network and Internet.
C-Language: Preliminaries, Program constructs variables and data types in C. Input and output. Character and formatted I/O; Arithmetic Expressions and Assignment statements; Loops and Nested loops; Decision making; Arrays, Functions; Arguments and local variables, Calling Functions and arrays. Recursion and Recursive functions; Structures within structure. Files; File functions for sequential and Random I/O. Pointers; Pointers and structures; Pointer and functions; Pointer and arrays; Operation and Pointer; Pointer and memory addresses; Operations on Bits; Bit Operation; Bit field; Advanced features; Standard and library.

CSE 202 INTRODUCTIONS TO COMPUTER LANGUAGE LAB
2 Credits, 3 hours/week

C-Language: Laboratory works based on the theory classes.

ENV 224 L ENVIRONMENTAL CHEMISTRY LABS
1.5 Credit, 4 hours/ week

Recommended Books and References:
1. Laboratory Experiment in Environmental Chemistry, 1st Edition, Maritza De Jesús Echevarría
2. Laboratory Manual for the Examination of Water, Wastewater, and Soil, 2nd Edition, H. Rump, and H. Krist, VCH Publishers
3. Standard Methods for the Examination of Water and Waste Water, 17th edition, L. Clesceri, A. Greenberg and R. Rhodes
4. Hach, Water Analysis Handbook, 2nd Edition, HACH Company

ENV 220 FIELD WORK IN ENVIRONMENTAL SCIENCE-II
1.0 Credit

ENV 231 HYDROLOGY AND FUNDAMENTALS OF AQUATIC CHEMISTRY
3.0 Credits, 3 hours/week

1. Introduction to Hydrology: Hydrologic cycle, water budgets.
2. Groundwater: Darcy's law and hydraulic potential, the steady-state groundwater flow equation, streamlines and flow nets, Regional flow and geologic controls on flow, Transient flow, Aquifer storage and compressibility, Unconfined flow, Groundwater interaction with streams and lakes.
3. Contaminant Transport: Advection and dispersion, sorption and diffusive mass transfer, Aquifer remediation
4. Couples Flow and Transport: Density driven flow, freshwater/saltwater interaction, heat transport and groundwater flow.
5. The Role of Groundwater in Large-scale: Water and chemical budgets, importance and role of hydrology in environmental science and engineering.
6. Aquatic Chemistry: Introduction, importance of water, water: from molecules to oceans, sources and uses of waters, properties of waters, water molecules, characteristics of bodies of water. Introduction to aquatic chemistry, gases in water, oxygen in water, water acidity and CO_2 in water, alkalinity: contributors to alkalinity, influence of alkalinity at different pH values, Dissolved inorganic and Alkalinity, Complexation and chelation, Complexation by humic substances.

Recommended Books and References:
1. Dingman, S. L., Physical Hydrology. Prentice Hall, 2002
2. Chow, V. T., (Ed), Handbook of Applied Hydrology. McGraw-Hill, New York, 1964
3. David Keith, T., Groundwater Hydrology II Ed. John Wiley and Sons, 1980
4. Goodison, B. E., Hydrological applications of Remote Sensing and Remote data transmission. LASH Publication, No. 145, 1985

ENV-235 ENVIRONMENTAL ECONOMICS
3.0 Credits, 3 hours/week

1. Foundations of Environmental Economics: Theory of Public goods, Externalities and Market failure – The Problem of Social Cost - Design of Environmental Policy.
2. Economic Instruments for Environmental Protection: Command & Control versus Incentives and Subsidies - Available Policy Options - Effectiveness of these instruments, International Comparisons.
3. Economics of Natural Resource Exploitation: Renewable and Non-Renewable Resources – Methods of valuation of Environmental Costs and Benefits.

4. Economic Growth and the Environment: Environmental Kuznets' curve, Foreign Direct Investment Inflow and the Environmental quality
5. Sustainable Development: Concept of and issues in Sustainable Development, Strategic Planning for Sustainable Development, Economic reforms and sustainable development.

Recommended Books and References:
1. Hanley, Nick, Jason F. Shogren & Ben White, Environmental Economics in Theory and Practice, New Delhi: Macmillan – India, 1997
2. James, D. E., Economic Approaches to Environmental Problems, Techniques and Results of Empirical Analysis, Elsevier Scientific Publishing Co., 1978
3. Nash, R. F., The Rights of Nature: A History of Environmental Ethics, University of Wisconsin, 1989
4. Whytte, Anne, V., Ian Burton (eds), Environmental Risk Assessment, John Wiley & Sons, 1980
5. Arrow, K. J. and Scitovsky, T., Readings in Welfare Economics Part III, 1969
6. Allen, V. K., James, L. Sweeney, Handbook of Natural Resource and Energy Economics, North Holland, 1985

ENV 236L INDUSTRIAL CHEMISTRY LAB
1.5 Credit, 4 hours/week
Experiments related to analysis of some industrial raw materials and products.

MAT 202 MATHEMATICS 2 (CALCULUS)
3.0 Credits, 3 hours/week

1. Differential Calculus: Function of a real variable and their graphs; limit, continuity and derivatives; physical meaning of derivative of a function; successive derivatives; Leibnitz's theorem; Rolle's theorem; mean value theorem and Taylor's theorem (statement only); Taylor's and Maclaurin's series and expansion of functions; maximum and minimum values of functions; functions of two and three variables; partial and total derivatives.
2. Integral Calculus: Physical meaning of integration; different techniques of integrations fundamental theorem of integral calculus and its application to definite integrals; reduction formula; double integration; evaluation of areas and volumes by integration.
3. **Differential Equations:** Definition and solution of ordinary differential equations; first order ordinary differential equations; second order ordinary linear differential equations with constant coefficients; solutions by the method of undetermined coefficient and variation of parameter; initial value problems.

Recommended Books and References:
1. Thomas and Finney, Calculus and analytic geometry
2. Ross, S. L., Differential equations

ENV 200 SEMINAR AND ORAL
1.0 Credit

ENV 311 CHROMATOGRAPHIC METHODS
3.0 Credits, 3 hours/week

1. Chromatography: Principle and Classification.
2. Liquid Column Chromatography: (a) Adsorption Column Chromatography (LSC): Principle, methodology, stationary phase, mobile phase, Detectors, Application.
(b) Partition Column Chromatography (LLC): Principle methodology, stationary phase, solid supports, mobile phases. Application.
3. Gel Chromatography: Definition, principle, nature of the gel, methodology, application.
4. Electrophoresis : Principle, classification, paper electrophoresis, gel electrophoresis, application
5. Gas Chromatography (GC): Principle , Instrumentation of GLC, Column efficiency and resolution. Sampling techniques, column (Packed column, capillary column), column oven, Carrier gas, sample injection system, detector of GC (TC, FID, ECD etc.), application, Overview of gas solid chromatography .
6. High Performance liquid Chromatography (HPLC): Basic principle, modes of HPLC, Instrumentation, Retention, column efficiency, bond broadening and temperature effect. Column packing and stationary phase, solvents, solvent delivery system, pump, sample introduction system, detectors. Application of HPLC-MS, HPLC-FTIR.

Recommended Books and References:
1. Braithwaite and Smith, Chapman and Hall, London, 4th edn., Chromatographic Methods
2. Roger, M. Smith, Gas and liquid Chromatography in Analytical Chemistry
3. Braun, Introduction to Chemical Analysis
4. Braun, Introduction to Instrumental Analysis

5. Ewing, McGraw Hill International, 5th ed. Instrumental Methods of Chemical Analysis, EN

ENV 313 INDUSTRIAL POLLUTION AND MITIGATION
3.0 Credits, 3 hours/week

1. Industrial Pollution Emissions: Industrial emissions- liquids, industrial emissions- gases, Criteria and standards, Air pollution quality standards, Water quality criteria and standards for industrial effluents, Water quality management.
2. Industrial Waste: Social, economical, technological and environmental perspectives of industrial waste, physical, chemical and biological characteristics of wastewater. Methods of analysis of waste water, principal constituents of concern in wastewater treatment. Reuse of treated wastewater in society, residue quality and toxicity of wastewater.
3. Pollution Control for Specific Pollutants: Removal of Chromium, Mercury, Ammonia/urea, removal of particulate matter, removal of sulphur dioxide, removal of oxides of nitrogen, removal of organic vapor from effluent gases.
4. Pollution Control in Tanning Industries: Introduction, historical background of tanning industries in Bangladesh, Tanning processes, Chemicals used in the Tanning industries. Origin and Characteristics of the effluents, Polluting effects of waste water in the environment, Methods of pollution abatement.
5. Pollution Control in Fertilizer industries: Introduction, Nature, sources, concentration, adverse effects and tolerance limits of effluents from fertilizer industries, Effluent separation and treatment of liquid effluents, Pollution control of gaseous effluents.
6. Pollution Control in Textile Dyeing Industries: Introduction and historical background of industries in Bangladesh, Sources of effluents, quantities of effluents. Harmful effects of textile effluent, Pollution control in textile effluents.

Recommended Books and References:
1. Herbert, F. L., Industrial Pollution Control Hand book, McGraw Hill. New York
2. Mahayals, S. P., Pollution Control in Process Industries, Tata McGraw Hill
3. Harry, M. F., Industrial Pollution Privation Handbook, McGraw-Hill Professional. New York
4. Morris, B. J., Analytical Toxicology of Industrial Inorganic Pollution. John Wiley and Son, Inc., New York.
5. Sinha, R. K., Herat, S., Industrial and Hazardous Wastes, Pointer Publishers Jaipur, India

ENV 315 ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT
3.0 Credits, 3 hours/week

1. Introduction: Definition, scope and goal of Environmental impact assessment (EIA), international and national aspects of EIA, role of Department of Environment (DoE) on application of EIA in Bangladesh.
2. Background and Legal Framework: Baseline studies, capacity building, Project cycle- IEE and EIA, EIA characteristics and function of EIA, Methodologies (Adhoc, checklist, matrices, network diagram, overlays and mathematical modelling), social impact assessment, EIA reporting and review, case studies (water quality impact, Large dam construction, tourism development; industrial development, afforestation)
3. Public Involvement and Impact Assessment: Requirement of skill ecologist/personalities for EIA, Training provisions for EIA, Impact Assessment costs.
4. Environment Risk Assessment (ERA): Definition, legal framework, risk evaluation, risk characterization, public perception of risk Major steps in ERA , Risk characterization and comparative risk assessment, risk analysis, industrial issues and health risk, case studies.
5. Environmental Regulation and Auditing: Hazardous waste legislation, protocols, institutional and legal framework, ISO 14000, the nature of environmental auditing, audit planning, basic component of auditing, beneficiary groups.
6. Environmental management planning (EMP): Monitoring and mitigation of environmental problems, sustainability concept and development, valuing the environment.

Recommended Books and References:
1. Watheru, P., Environmental Impact Assessment – Theory and Practice, Chapman and Hall Ltd, New York. 1992
2. Center, L. Q., Environmental Impact Assessment. McGraw-Hill. Inc. New York
3. Barrow, C. J., Environmental and Social Impact Assessment. John Wilely & Sons. New York. 1997

ENV 317 ENVIRONMENTAL GEOGRAPHY
3.0 Credits, 3 hours/week

1. Continents and Oceans: Landmasses temperature of the atmosphere, Insulation, heating of the atmosphere, Horizontal distribution of temperature and pressure
2. Hydrosphere: Movements of ocean, waves, currents, tides, drifts and creep
3. Lithosphere: Layers of earth, Minerals and rocks
4. Earthquakes and Volcanoes: Theories on Various Tectonic Aspects of the Earth's crust: Plate tectonic, Wegner's Continental Drift Theory, Geological Technical Aspect of Land formation in Bangladesh.

5. Variable winds: Cyclones and anticyclones, Size & shape, velocity & speed, Moisture in the atmosphere, Humidity, Evaporation, Clouds, Types of rainfall
6. Biosphere: Climate, soil, plants and animals

Recommended Books and References:
1. Edward, A. K., Environmental Geology. 3rd Edition, Charles E. Merill Pub. Co., Ohio
2. Strahler and Strahler, Environmental Geology, Willey and Sons, NY, 1970
3. Blij, D. H. J., Muller, Peter O., Physical Geography of the Env. John Willey and sons, Inc. Brisbane., 1993
4. Das Gupta, A., Kapoor, A. N., Principles of Physical Geography. S. Chand and Company., 1986

ENV 321 SPECTROSCOPIC TECHNIQUES FOR ENVIRONMENTAL ANALYSIS
3.0 Credits, 3 hours/ week

1. Introduction to Spectroscopy: Interaction of electromegnetic radiation with matter; absorption, emission, fluorescence, phosphorescence and scattering, energy states in various species of matter, atomic and molecular spectroscopy. Basic components of these optical instruments.
2. Ultraviolet/ visible Spectroscopy: Origin of molecular electronic spectroscopy; types of electrons in molecular species and their transition probabilities, absorption spectra of functional groups, spectra of metal ions and other non-absorbing species, spectra-structure correlation, principles of quantitative determination: absorbance and transmittance, Beer's law and its limitations, instrumentation, applications.
3. Infrared Spectroscopy: Molecular motion and vibrational modes of molecules, theory of absorption of infrared energy by molecules; vibrational coupling and interpretation of IR spectra, sample preparation techniques, types of IR instruments.
4. Atomic Absorption Spectrometry: Theory of AAS, various techniques of atomization, methods of calibration, sample preparation, measurement, interferences encountered in AAS, determination of metal ions. Applications of AAS in environmental analysis.

Recommended Books and References:
1. Atkins, P. W., Physical Chemistry
2. Barrow, G. M., Introduction to molecular spectra
3. Banwell, Fundamental of molecular spectroscopy
4. Williams and Flaeming, Spectroscopic methods in organic Chemistry
5. Rao, C., UV-VIS Spectroscopy
6. Pavia. Spectroscopy in Chemical Analysis

ENV 323 ENVIRONMENTAL POLLUTION & ITS REMEDIATION
3.0 Credits, 3 hours/week

1. Environmental Components: Structure and composition of the atmosphere; hydrosphere, biosphere and lithosphere.
2. Water pollution: Sources, its effect and control; Sampling and measurement of water quality and their analysis, water pollution from pesticides, water quality standards, Eutrophication and restoration of lakes, remedial measures to protect water pollution.
3. Air Pollution: Types and sources of air pollution, Effects of air pollution; Sampling and measurement of air quality; Air pollution standards. Sources, types, remedial measures to protect air pollution.
4. Land, Marine, Thermal, Noise and Radioactive pollution: Sources, effect and control; Measurement of noise, its regulation and control, Pollution from road vehicles, remedial measures to protect noise pollution.

Recommended Books and References:
1. Buch, W., Atmospheric pollutionMcGraw Hill, New York
2. Natusch, D. F., Hopke, P. K., Analytical Aspects of Environmental Chemistry, John Wiley & Son, New York
3. Edward, A. L., Aquatic Pollution-An Introductory Text, John Wiley & Son, New York
4. Harrison, R. M., Principles of Environmental Chemistry. Royal Society of Chemistry, Cambridge, UK

ENV 325 NATURAL RESOURCES AND BIODIVERSITY CONSERVATION
3.0 Credits, 3 hours/week

1. Forest resources: Use and over-exploitation, deforestation, dams and their effects on forests and tribal people.
2. Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams benefits and problems.
3. Mineral resources: Usage and exploitation. Environmental effects of extracting and using mineral resources.

4. Food resources: World food problem, changes caused by agriculture effect of modern agriculture, fertilizer-pesticide problems.
5. Energy resources: Growing energy needs, renewable and nonrenewable energy resources, use of alternate energy sources. Solar energy, Biomass energy, Nuclear energy.
6. Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification, Role of an individuals in conservation of natural resources.
7. Biodiversity and its Conservation: Introduction, Definition, genetic, species and ecosystem diversity.
8. Value of biodiversity: Consumptive use, productive use, social, ethical, aesthetic and option values. Studies of some model mega diversity nation, Hot-spot of biodiversity.
9. Threats to Biodiversity Habitat Loss: Man- wildlife conflicts, Endangered and endemic species of Asia.
10. Conservation of Biodiversity: In-situ and Ex-situ conservation of biodiversity.

Recommended Books and References:
1. Agarwal, S. K., Tiwari, S., Biodiversity and Environment. APH Publishing Co. India
2. Hasan, M. A., Biodiversity and ConservationHasan book House, Dhaka
3. Schulze, E. D., Mooney, H. A., Biodiversity and Ecosystem Function. Springer-Verlag, Berlin

ENV 326L CHROMATOGRAPHIC AND SPECTROSCOPIC ANALYSIS OF ENVIRONMENTAL SAMPLES LAB.
1.5 Credits, 4 hours/week

5-10 Experiments will be carried out which will be based on:
Chromatographic Principle, Column Chromatography, Gas Chromatography, Gel Chromatography (GC), High Performance Liquid Chromatography (HPLC), Electrophoresis, etc.

ENV 320 FIELD VISIT
1.0 Credit

ENV 331 ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY
3.0 Credits, 3 hours/week

1. Introduction to Microbiology: History-scope-Types –structure, biology and classification of bacteria, mycoplasma, fungi, algae and virus-identification.
2. Basic tools in Microbiology: Basic principles of Autoclave, Hot air oven, laminar air flow Microscopy-Bright field-phase contrast-dark field-fluorescent-con-focal-electron microscopy (SEM, TEM) Centrifuge-spectrophotometer.
3. Sampling Techniques: Preparation of samples, types of media-sterilization techniques-cultivation and preservation of microorganism-methods of estimation and isolation of microorganism in soil, water and milk.
4. Soil-microbial flora: Interaction among soil microorganism-roof soil microorganisms, roles of microorganism in nitrogen, carbon, sulphur cycles; aquatic micro organism. Air microbiology-distribution, techniques and role of air microorganisms.
5. Microbial Genetics-concept of the gene mutations: Transformation, conjugation, transduction, plasmids, microbial control of environmental pollution; genetic engineering and recombinant DNA techniques.
6. Xenobiotic compounds and their bio remediation.

Recommended Books and References:
1. Paul. A. K., Microbiology, John Wiley and Sons, New York. 1984
2. Prescott, L. M., Harley, J. P., Klein, D. A., Microbiology, 2nd Edn. Wm. C. Brown Publishers
3. Doelle, N. W., Bacterial Metabolism. 2 nd Ed. Academic Press
4. Freigelder, D., Microbial Genetics. Jones Bartkett Publishers, Inc, Boston. 1987
5. Mitchell, R. Introduction to Environmental Microbiology. Prentice Hall Int. 1974
6. Glazer, A. N., Nikadio, H. Microbial Biotechnology. W. H., Freeman & Co. New York. 1995

ENV 333 SUSTAINABLE MATERIALS AND GREEN CHEMISTRY
3.0 Credits/ 3 hours/week

1. Resources and Sustainable Materials: Minerals in the Geosphere, evaluation of mineral resources, extraction and mining, metal resources and industrial ecology, nonmetal mineral resources.
2. Sustainable Energy: Energy problem, Nature of energy, Sources of energy used in the atmosphere, energy devices and conversions, Green technology and energy conversion efficiency, Petroleum and Natural Gas, Geothermal Energy, Nuclear Energy, Renewable Energy resources, Biomass Energy.
3. **Green Chemistry and Industrial Ecology:** Principles of Green Chemistry, Reduction of risks related to hazardous materials, Waste prevention, Synthetic chemistry versus Green Chemistry, Feedstocks, Stoicheiometric and Catalytic Reagents, Various

solvents and their merits and demerits, Industrial Ecosystem, Industrial Metabolism, Materials flow and recycling, economic advantages to green chemistry.
4. Nano Structured Materials : Nano materials in catalysis, Nano technology in environmental problem abatement, State of the art in nanotechnology.

Recommended Books and References:
1. Manahan, S. E., Environmental Chemistry, 9th edn. CRC Press, Tailor & Francic Group
2. Baird, C., Cann, M., Environmental Chemistry, 3rd edn. Freeman and Co. New York
3. Jones, J. C., Atmospheric Pollution, ISBN 978-87-7681-416-8
4. Ramsden, J., Essentials of Nanotechnology, Ventus Publishing APS, ISBN 978-87-7681-418-2
5. Wilson, J. R. Minerals and Rocks, Ventus Publishing APS, ISBN 978-87-7681-647-6
6. Jones, J. C., Thermal Processing of Waste, Ventus Publishing APS, ISBN 978-87-7681-590-5

ENV 335 WASTE MANAGEMENT
3.0 Credits, 3 hours/week

1. Introduction: Sources, nature and characteristics of different types of wastes, Quantities and qualities, Problems associated with these waste materials.
2. Solid Waste Generation: Sources, nature and characteristics, Quantities and qualities, Problems and Impacts of Municipal Solid Waste (MSW). Rates of generation and factors affecting them.
3. Consequences of Solid Waste on Environmental: Potential of diseases, nuisances and other problems due to solid wastes, Changing nature of solid wastes and its impact on solid waste management.
4. Disposal of Solid Waste: Collection process of waste, disposal methods such as sanitary landfill biological digestion etc., Segregation, Non-compostable-reusable-recyclable- non recyclable-compostable waste.
5. Management of Solid Waste: Processing methods, recovery and reuse of materials and energy, Composting types: Windrow method-Aerobic composting- Vermicomposting-Compost pit -Garbage filled compost pit-Composed garbage, Green waste treatment by photolysis and sonolysis, Biodegradation of wastes, Disposal of wastes.
6. Waste Water: Sources of waste water, properties of waste water, water treatment for municipal use, industrial use and disposal or, water treatment for different purposes. Different treatment processes (primary, secondary and tertiary).
7. Industrial Waste Water Treatment: Removal of - solids, metals, dissolved organics and Inorganics, sludge; Water disinfection.
8. Gaseous Waste and Pollutants: Sources of gaseous pollutants, types and classification of air pollutants: particulate, hydrocarbons, carbon monoxide, oxides of sulfur, oxides of nitrogen, photochemical oxidants, Gaseous waste and pollutants in Portland cement, glass, fiber glass, petroleum refineries, iron and steel and acid manufacturing industries, pharmaceuticals, etc.

Recommended Books and References:
1. Vesilind, P. A., Reinhart, W. W., Solid Waste Engineering
2. Manahan, S. E., Environmental Chemistry, 9th edn., CRC Press, Tailor & Francic Group
3. Howard, S. P., Rowe, D., Environmental Engineering, McGraw Hill International
4. Pyle, J. L., Chemistry and Technological Backlash
5. Dara, S. S. A., Textbook Of Environmental Chemistry and Pollution Control
6. Ramachandra, T. V., Management of Municipal solid waste. Capital Publishing Company

ENV 338L ENVIRONMENTAL POLLUTION AND MITIGATION LAB
1.5 Credit, 4 hours/week

Analysis of some industrial waste and pollutants

ENV 300 SEMINAR AND ORAL
1.0 Credit

ENV 411 CURRENT ENVIRONMENTAL ISSUES AND BANGLADESH PERSPECTIVES
3.0 Credits, 3 hours/week

1. Global Warming, Greenhouse Effect and Global Ozone Problems: Introduction, greenhouse gases and global climate changes, Global warming potential, Possible impact of global warming, Greenhouse effect – Policy Response, Kyoto Protocol, EI NINO- Climate Cycle, Ozone in the atmosphere, Ozone depletion process, Ozone Hole, Worldwide ozone trends, The Montreal Protocol, Consequence of ozone depletion.
2. Acid Rain and Atmosphere Turbidity: Introduction, nature and development of Acid rain, acid rain and geology, Acid rain and aquatic environment, Acid rain and Terrestrial environment, Acid rain and Build environment, Acid rain and human health, Mitigation of acid rain problems, Aerosol types, Production and distribution, Atmospheric Turbidity – Natural and Man-made sources.

3. Global Carbon Dioxide Rise and Impact on Biosphere: Vehicle Pollution:- Introduction, consequences of global CO changes, strategies for conservation of environmental changes induced by CO_2 Rise, Automobile emission characteristics, impact of automobile pollutants, Automobile Pollution Abatement.
4. Radiation Hazards and Environmental Degradation: Introduction, Atomic radiation, Natural background radiation, Measurement of radio activity, Effects of radiations, Radioactivity and effects on man, Impact of radioactive radiation, Radioactive waste, Ionizing radiation and effects on man, Radiation protection.
5. Natural Recourses exploration in Bangladesh: Hopes and threats related to Natural gas, coal, and radioactive materials.

Recommended Books and References:
1. Santra, S. C., Environmental Science, 2nd Edn, New Central Book Agency Ltd, Kolkata, India
2. Joner, J. A. A., Global Hydrology: Processes, Resources and Environment, Longman, Essenx, England
3. Wilson, E. O., Biodiversity, National Academy Press, Washington, DC
4. Tudge, C., Global Ecology, New York
5. Bridgeman, H., Global Air Pollution: Problems for the 1990S, Belhaven Press, New York
6. Manahan S. E., Environmental Chemistry, Willaw Grant Press, Beston, USA
7. Moeller, D. W., Environmental Health, Harvard University Press, Cambridge

ENV 413 REMOTE SENSING AND GIS IN ENVIRONMENTAL MONITORING
3.0 Credits, 3 hours/week

1. Introduction to Remote Sensing: Types of Remote Sensing, history, advantages and applications of remote sensing. Physical basis of remote sensing, The electromagnetic spectrum, spectral reflectance curves, spectral signatures, Resolution.
2. Remote Sensing Platforms: Ground, airborne and satellite based platforms; Some important remote sensing satellites. Sensors: Passive and Active sensors; Major remote sensing sensors; Satellite band designations and principal applications; Color/ False Color; Aerial photography/ Aerial photo interpretation.
3. Digital Image Processing: Pixels and Digital Number; Digital Image Structure; Format of Remote Sensing Data; Image Processing functions: Image Restoration, Image Enhancement, Image Transformation, Image Classification and Analysis; Image interpretation strategies.
4. Geographic Information System: Introduction, Preparation of thematic map from remote sensing data, Co-ordinate systems, GIS components: Hardware, software and infrastructures; GIS data types: Data Input and Data Processing; DEM/ DTM generation. Integration of Remote Sensing and GIS techniques and its applications in Environmental Impact Assessment and Management including some case studies.

Recommended Books and References:
1. Sabnis F., Remote Sensing, Principles and interpretation -WH & Freeman & Co. NY
2. Gupta R. P., Remote Sensing
3. Jensen J. R., Introductory Digital Image Processing -Pentice Hall NZ

ENV 415 ENVIRONMENTAL TOXICOLOGY
3.0 Credits, 3 hours/week

1. Concept of Toxins: Toxicity and toxicology, sub disciplines of toxicology environmental toxicology, aquatic toxicology, forensic toxicology, chemical toxicology, toxicogenomix. Types of toxicants, classification of toxicants- factors that affect environmental concentration of toxicants.
2. Toxicology of Inorganic Compounds: Toxic chemicals in air: Acid fumes - SO_2, NO_x, H_2S, particulate matter, ozone, Dioxins and heavy metals, toxic chemicals in water, industrial chemicals, agro chemical and fertilizers - Ammonium sulphate, potash, pesticides, organochlorines (DDT, BHC, Endosulphan), organo-phosphates (Malathion, Parathion) and carbamates, persistent organic pollutants (POPs').
3. Food Adulteration and Preservation: Food poisoning –food poisoning caused by chemicals, poisonous plants and micro organisms, Food hygiene in the prevention of food poisoning, factors contributing to outbreak of food poisoning. Common adulterants, intentional and incidental adulteration, methods for detection of food adulterant (formaline).

Recommended Books and References:
1. Jacob, T., Food Adulteration, MC Millan publishers Pvt. Ltd.
2. Kalia M., Sood, Food preservation and processing, Kalyani Pub. Ludhiana, New Delhi
3. Sharma, B. K.; Kans, H., Environmental chemistry
4. Sharma, P. D., Environmental biology and toxicology, 1997-98
5. Hobbs B. C & Roberts D. Food poisoning and Food Hygiene 6th Ed. Arnold pub. London
6. Butler, G. C., Principles of Eco toxicology Duffus, John H
7. Shukla, J. P., Pandey, Elements of Toxicology, Radha Publ. New Delhi
8. Rand, G. M., Perocelli, S.R., Fundamental of Aquatic Toxicology, Hemisphere publishing Corporation, Washington
9. Cockerham, L. G., Shane. B. S, Basic Environmental Toxicology, CRC press, Bocaraton, USA

ENV 417 COMPUTER MODELLING FOR ENVIRONMENTAL STUDIES
3.0 Credits, 3 hours/week

1. Introduction: Definition, scope and purpose of environmental modelling; Model classification, conceptual model, physical model, analytical model, numerical model, computer model; elements and steps of modelling, Calibration and Verification of model; Mass balance equation.
2. Transport Phenomena: Pollution transport process in the aquatic environment, Advection, Diffusion and Dispersion; advective and dispersive transport equations; selection of model; Compartmentalization and box model, Simple Transport Model.
3. Groundwater modelling: Introduction, Darcy's Law, Flow Equations, conceptual model design, grid design, boundary conditions, testing of model; Contaminant Solute Transport Equation, Sorption, Retardation and Reactions, Unsaturated Zones, Remediation, Numerical Methods; introduction to MODFLOW, MODPATH, MT3D etc.
4. Surface water modelling: Conventional Pollutants in Rivers; Plug-Flow system, Streeter-Phelps Equation, Modification to Streeter-Phelps Equation, Waste load allocations, Dissolved Oxygen in Large rivers and Estuaries; introduction to relevant software.
5. Global Change and Models: Introduction to Global Climate models (GCMs), and Regional Climate Models(RCMs), Hydrological Models; Other emerging models; model predictions, limitations of model and uncertainties.

Recommended Books and References:

1. Schnoor, J. L., Environmental Modeling, John Willey & Sons, 1996
2. Jakeman, A. J., (Eds.) Environmental Modelling, Software And Decision Support-State of the Art and New Perspectives. Elsevier. 2008
3. Anderson, M. P., and Woessner, W.W., Applied Groundwater Modeling, Simulation of Flow and Advective Transport, Academic Press Inc. 1991
4. Clark, M. M., Transport Modeling for Environmental Engineers and Scientists, John Willey & Sons, 1996
5. Bala, B. K., Energy and Environment - Modeling and Simulation. Nova Sci Pub, USA, 1998

ENV 421 ENVIRONMENTAL LAW, ETHICS AND POLICY
3.0 Credits, 3 hours/ week

1. International Environmental Laws: Evolution and development of International Environmental laws with reference to Stockholm Conference, Nairobi Declaration, Rio Conference, Rio+5 and the Rio+10, etc. Global environmental issues and International laws: to control Global warming, Ozone depletion, Acid rains, hazardous waste, CITES etc. Role of UN authorities in protection of Global Environment, Multinational authorities and agreements, future of International laws.
2. Environmental laws in Bangladesh.
3. Equity Environment versus Development: Importance of critical review of plan with respect to local, regional & immediate & long term gains & Effect of Development. Comparison between a. Exploitation and safe guard for conservation, b. Rate of utilization and regeneration, c. Natural and manmade growth, d. Survival need of mankind and protection of environment Integration of development with carrying capacity of Environment,
4. National Environmental Policy of Bangladesh:

Recommended Books and References:

1. Declaration of The Stockholm Conference
2. Jerry; A. Basic environmental technology
3. Holmes, G., Singh, B. R., Theodore, L. Handbook of environmental management and technology
4. The ISO 14000: Environmental management systems: General guidelines on principles, systems and supporting techniques (ISO 14004: 1996 (E))
5. ISO 14001: Environmental management systems: Specification with guidance for use (ISO 14001: 1996b (E)). (International organization for standardization –Switzerland)

ENV 423 AGRICULTURAL WASTE MANAGEMENT
3.0 Credits, 3 hours/ week

1. Agricultural sources of pollution: Pesticides, commercial fertilizer, on-farm food processing wastes and animal manure, their effect on the total environment. Physical, chemical and biological properties of agricultural waste materials. Design of storage and pumping systems for manure holding facilities. Physical, chemical and biological treatment processes of agricultural wastes in relation to pollution control and waste utilization. Various methods of land application of agricultural wastes in relation to pollution problems and fertilizing value.
2. **Technologies for utilization of agricultural wastes**: Use for biogas production and animal feed, Air pollution and greenhouse gas emissions control. Water quality parameters and lake and river water quality management.

Recommended Books and References:

1. Unger, P. W., Managing Agricultural Residues. Lewis Pub., 1994. ISBN: 0-873-71730-9

ENV 425 INSTRUMENTATION IN ENVIRONMENTAL STUDIES

3 Credits, hours/ week

1. Basics of instrumentation: Definition, tools, instrument, machine, concepts of Instrumental Analysis and Analytical process. Analytical Methods and their classification: Qualitative and Quantitative Methods, Classical and Instrumental Methods, Classification based on concentration range; Analytical Process and its subdivisions; Physical and chemical properties used in instrumental analysis, Analyte concentration and instrumental response relationship.

2. X-Ray Instruments: X-RD, X-RF, Inductively Coupled Plasma (ICP), basic principle, application, sampling, environmental aspects.

3. Electronic Microscopic Instruments: Scanning Electron microscopy (SEM), Transition Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Working principles, applications, sampling techniques, hazards and environmental aspects.

Recommended Books and References:

1. Skoog, D. A., Holler, F. J., Nieman, T. A. Principles of instrumental analysis, 6th Edn., Thomas Asia Pte. Ltd., Singapore
2. Mendham, J.; Denney, R. C.; Barnes., J. D., Vogel's textbook of quantitative chemical analysis, 6th Edn., Pearson Education (Singapore) Pvt. Ltd., Delhi, India
3. Christian, G. D. Analytical chemistry, 5th Edn., John Wiley & Sons, Inc., N.Y / Singapore

ENV 428L ENVIRONMENTAL BIOLOGY LAB

1.0 Credit

ENV 431 METEOROLOGY AND CLIMATIC CHANGE

3.0 Credits, 3 hours/week

1. Meteorology: Definition, Scope and Sub-classifications, History of meteorology, Nature, origin and composition of the atmosphere, Vertical divisions of the atmosphere; Meteorological equipment and Weather forecasting: Surface measurements, Application of remote sensing, Satellite observation.

2. Heating Earth's Surface and Atmosphere: Solar Insulation of the earth and heat budget, Variability of insulation, World distribution of insulation, Vertical distribution of temperature.

3. Water balance of the atmosphere: Humidity, Physical changes of state of water Processes of cooling to produce condensation and sublimation, Clouds formation and classification, Fog formation and type, Precipitation, causes, forms and types.

4. Air Pressure and Winds: Pressure, vertical distribution of pressure, Pressure gradient and wind, Factors affecting wind speed and direction; General atmospheric circulation, Seasonal changes in the general circulation, Oceanic circulation, Monsoon, local winds, mountain and valley breeze; Stability and instability, air masses sources region and classification, Extra tropical cyclone, anti cyclone, Thunderstorms.

5. Climate controls and Climate: Definition, production of climates, Climatic classification of the world and Worlds climatic regions, the role of oceans, *El Nino*-Southern Oscillation (ENSO) events, *La Nina* events, preliminary concepts of climate change.

Recommended Books and References:

1. Franklyn, W. C., Introduction to Meteorology, 3rd Edn, John Wiley and Sons
2. Roger G. B.; Chorley, R. J. Atmosphere, weather and climate, 7th Edn
3. Edward Bryant, Climate Process and Change, Cambridge University Press
4. Trewartha and Horn, An Introduction to Climate, 5th Edn
5. IPCC report (recent edition)

ENV 433 DISASTER MANAGEMENT

3.0 Credits, 3 hours/ week

1. Introduction to disaster: Types of natural calamities, major and minor calamities – impact of calamities.

2. Natural disaster: Cyclone, Tsunami, flood, Landslides, earthquake.

3. Manmade disaster: Wars – Biological war (introduction of pathogens), misuse of atomic bombs, major accidents from industries etc.

4. Medical Management of disaster: Disaster Impacts and response, Identification of dead, Search rescue, first and relief phase, Vaccination, basic sanitation and personal hygiene.

5. Environmental Disaster: Assessment, Planning – mitigation program, preparedness, resettlement rehabilitation, role of NGOS, Gos (relief camp), Psychotherapy – simplified yoga and meditation, stress management.

Recommended Books and References:

1. Tsunami, A text book from Department of Science and Technology, New Delhi
2. Proceedings "Brainstorming seminar on Disaster Management and Mitigation programmes. Sri Venkateswara University, Tirupati
3. Pollution control Legislations. Environmental Laws – Vol. II. Tamilnadu Pollution Control Board.
4. Shailaendra, K., Singh, Subash C., Kundan, and Singh, S., Disaster Management. Mittal Publications. New Delhi.
5. Natural disasters – A guide for relief workers – JAC Adhyatma Sadhema, Kendra Mehrani, New Delhi

ENV 435 CHEMISTRY AND THE TECHNOLOGICAL BACKLASH
3.0 Credits, 3 hours/ week

1. Introduction: The technological backlash, Comments on writing organic structures, chemical orientations and some chemical comments.

2. The Energy Problem: Perspective on Energy, Energy form, the sun, Plants and Photosynthesis. Heat, Work and Energy in the biosphere. Alternatives to fossil fuels, A side issue in the Energy problem,-strip mining. The effect of increasing atmospheric CO_2,

3. **Pollution of our Natural Waters by nutrients**: Introduction, The role of nitrogen, Phosphorous compounds as Nutrients. The chemistry and Ecology of Inorganic fertilizers.

4. The Organic Chemical Industries: Petroleum: The Foundation of the Organic Chemical Industries, The Chemical Process Industry, The Pulp and Paper Industry, The Food Process Industries, Summery.

6. The Chemical Detectives: Pollution and Analytical Chemistry: Analysis of Pesticides, Analysis of Trace Metals by Spectroscopic Analysis, Air Pollution Analysis and Monitoring.

7. The Population Problem: Multiply and Subdue, The Chemistry of Contraception, Contraception in the Future.

8. Extra Chemicals in our Food: A Summery of the Food Additive, The Artificial Sweeteners, MSG-The All Purpose Flavour Additive, Diethylstilbestrol, Nitrities.

9. The Chemical Crutches-The Drug Problem: The Nervous System. The Rollercoaster: Amphetamines and Barbitutares, The World of Unreality, Americas Most Serious Drug Problem, Marijuna, White Death, The Opiates, Epilogue.

Recommended Books and References:

1. James L. Pyle, Chemistry and the Technological Backlash

ENV 400 SEMINAR AND ORAL
1.0 Credit

ENV 430 PROJECT / INTERNSHIP
3.0 Credits

Optional Courses for Major in Environment and Agricultural Management

ENV 4311 AQUACULTURE
3.0 Credits, 3 hours/ week

1. Fish Culture: Cultivable fresh water fishes; Culture Pond-Pond construction and management: Selection of site-soil quality-layout-inlet-outlet-dykes-Water quality Management- Fertilizing-Eradication of predators-weeds.
2. Induced Breeding: Seed -Procurement-Collection and Transport of seeds and breeders Types of hatcheries. Economic importance of fishes- Nutritive value of fish-Crafts and gears.
3. Fish Diseases: Symptoms-treatment-prevention-Preservation and Processing of fish:- Methods of preservation processing-Refrigeration, Deep freezing, Salting, Drying, Smoking, Canning, pickling Causes for fish spoilage-Rigor mortis. Aquarium and Ornamental fishes-Aquarium tanks-maintenance-ornamental fishes.

Recommended Books and References:
1. Jhingaran, C. G. 1981. Fish and Fisheries of India, Hindustan Publishing corporation. Delhi
2. Novikov, V. M. Handbook of Fishery Technology. Vol I American Publishing co Pillay, T. V. R. 1990
3. Aquaculture. Principles and Practices. Blackwell Publishing .Oxford. pp575
4. Rath, R. K. Freshwater aquaculture-Scientific Publishers Samuel, C. T. 1968
5. Santhanam, R.1990. Fisheries Science. Daya Publishing House, New Delhi
6. Srinivasulu reddy, M and K. R. S Sambasiva Rao.2004.A text book of Aquaculture. Discovery Publishing House, New Delhi
7. Talwar, P. K. and Jhingaran, A. G. 1991. Inland fishes of India and adjacent countries. Vols. I &II. Oxford and IBH Publishing Co. Pvt Ltd. New Delhi

ENV 4312 ENVIRONMENTAL BOTANY
3.0 Credits, 3 hours/ week

1. Fundamentals of Classification: Basic unit of classification - Classification of plants; Taxonomic hierarchy, Artificial and natural classification.
2. Diversity of Plant Species: Trees, shrubs, herbs, grasses - halophytes, hydrophytes, mesophytes and xerophytes.
3. Anatomy: Dicot - stem, root, monocot - stem, leaf. Vegetation (forest types): Moist deciduous, dry deciduous, ever green, semi-evergreen, grassland, thorn forest, mangroves.
4. Mendalism: Monohybrid and dihybrid cross, Origin of life - Theories of Evolution. Lamarck, Charles Darwin and De - vries. Cereal, fiber crops.
5. Economic botany: Medicinal plants, edible oil seeds, pulses, vegetables, fruits, mushroom, single cell protein, Spirulina.
6. Ecology: Definition, habitats, ecosystem, environmental factors, food web, food chain, ecological pyramid, etc.

Recommended Books and References:
1. Jeffery, C., An Introduction of Plant Taxonomy, Cambridge, press
2. Smith, Gilbert, M., Cryptogrammic Botany, VOL I &II, McGraw Hill,. New York
3. Verma, P. S. and V. K. Agarwal, Principals of Ecology, S. Chand & Company, New Delhi
4. Hill, A. W., Economic Botany. McGraw Hill Publications
5. Dash, M. C., Fundamentals of Ecology, M. C. Graw Hill Publications
6. Mitra, S., Genetics - A Blue Print of life. Tata McGraw Hill

ENV 4313 SUSTAINABLE AGRICULTURAL AND RURAL LAND MANAGEMENT
3.0 Credits, 3 hours/ week

1. Introduction: Learning objectives, expectations, current critical water quality issues in agricultural and urban areas, federal, state, and local regulations, agency responsibilities.
2. Plant nutrition and physiology: Aspects relating to nutrient uptake, transport, and utilization. Nutrient mass balance, nutrient imports and exports, transformations, transport and fate, crop nutrient requirement concept.
3. **Current agricultural production systems**: Soil management, soil testing philosophies, fertilization, irrigation, nutrient losses. Agricultural nutrient management, soil testing, modern fertilizers, nutrient use efficiency, best management practices.
4. Irrigation: irrigation nutrient management technologies, crop monitoring technologies, comprehensive nutrient management plans.
5. Integrated animal/crop systems: Livestock waste utilization, sustainable agriculture, organic crop production, protected agriculture systems. Agriculture nutrient and water management research, breeding plants for nutrient efficiency. Urban water quality issues, construction, soils.
6. Urban landscape best management practices: Designing best management practices and plans, watershed scale, modeling, economic and social aspects.

ENV 4314 AGRICULTURAL RESOURCE, PLANNING AND MANAGEMENT
3.0 Credits, 3 hours/ week

1. Water Resources: Introduction, hydrological cycle, world water distribution, need for conservation & development of water resources, requirement/water demand for Domestic, industrial hydropower generation, irrigation, navigation & recreation etc.
2. Hydrological Analysis of Precipitation: Precipitation, measurement of rainfall, index of wetness, design of rain gauge network, probable maximum precipitation curve, infiltration, infiltration capacity curve, Measurement & estimation of water losses, runoff cycle, runoff coefficients, computation of runoff: rational formulae, unit hydrograph, Bernard`s distribution, unit storm method Streams & reservoir: Stream flow measurement: Notches, weirs, control meters, Venture-Flumes, Velocity area method, slope area method, capacity elevation curve of river, Types of reservoirs, storage zones, catchment yield & reservoir yield, reservoir capacity mass curve of inflow and outflow, hydrological reservoir routing, reservoir sedimentations and losses, selection of site for a reservoir, economic height of dam Groundwater hydrology: Aquifers, hydrological properties i.e. porosity, permeability, transmissivity, specific retention, yield etc. measurement of yield, Laws of ground water movement: Darcy`s law, Thiems equilibrium formula, Duipuits formula etc. Recharging of underground storage, infiltration galleries, infiltration wells, springs, wells Flood flows and management: Definition & causes of flood, estimation of design flood and flood flows for design of hydraulic structures, flood forecasting techniques: flood routing, inflow outflow curve, mathematical models etc. Flood control measures Water resources planning & management: Planning of water resources projects, Engineering economics study, cost benefit analysis, optimization in planning of water resources projects
3. Land Management: Principles and Design: Pertinent land characteristics for planning. Land use planning and management for commercial, residential, agricultural, wetland areas etc and regulatory requirements. Impacts of natural and man-made activities on land characteristics and land use planning. Erosion and sedimentation
control. Soil transportation and impacts on land use. Land reclamation principles and requirement, Removal, storage and replacement of topsoil, and subsoil on reclaimed lands. Bonding requirements. Rehabilitation of seriously disturbed lands using physical, chemical and biological methods. Planning for bio-diversity on reclaimed lands. Land use planning models and their limitations.

ENV 4315 GROUNDWATER HYDROLOGY AND CONTAMINATION
3.0 Credits, 3 hours/ week

1. Introduction: Definition of ground water, aquifers, vertical distribution of subsurface water, hydrological properties of water bearing strata, ground water in hydrologic cycle. Ground water hydraulics: Darcy's law, its range of validity, Dupuit Forchheimer assumptions, Applications of Darcy's law for simple flow systems, Governing differential equations for confined and unconfined aquifers, Steady and unsteady flow solutions for fully penetrating wells, partially penetrating wells, interference of wells, test pumping analysis with steady and unsteady flows, delayed yield, method of images, Ground water quality.
2. Ground water pollution: Sources, remedial and preventive measures. Ground water conservation: Ground water budget, seepage from surface water, artificial recharge. Models for Groundwater Flow, Sampling and Monitoring Methods, Transport Mechanisms, Modeling Advective-Dispersive Transport, Adsorption and Chemical Reaction, Biodegradation Kinetics, Numerical Flow and Transport Modeling, Waste Site Characterization/Investigation, Ground Water Remediation, Legal Issues in Groundwater Contamination Appendices.

Recommended Books and References:
1. Raghunath, Ground Water
2. Todd, D. K., Ground Water Hydrology
3. Walton, W. C., Groundwater Resources Education
4. Roger Diewest , Numerical Ground Water Hydrology
5. Nicholas Cheremenisoff , Ground water hydrology and contamination

ENV 4316 AGROCHEMICALS; IMPACT AND BIO-ALTERNATIVES
3.0 Credits, 3 hours/week

1. Introduction: General discussion on different types of commonly used commercially available chemical fertilizers, insecticides, and herbicides; their classification, formulation, characteristic chemical and physical properties, uses, and back drop.
2. Organic Herbicides: Elementary treatment of some of the weedicides of the following groups :Carboxylic - Aromatic compound - Phenoxy acids. Phenyl acetic acids, benzoic acid, phthalic acid, phathalmic acid. Aliphatic acids - TCA, Propionic (Calopon). Substituted Phenols - Penta chlorophenol, dinitros. Heterocyclic nitrogen derivatives - simazinc, atrazine, maleic hydrazide amino triazole. Aliphatic organic nitrogen derivates (substituted ureas, carbamates, other amides).Other organic herbicides -(Hydrocarbons, methyl bromide, carbon disulpbide, chloropicrin).
3. Synthetic Organic Insecticides: Chlorinated hydrocarbons, organophosphorous compounds, carbonates, organic sulphur compounds and other miscellaneous organics.

4. Inorganic Insecticides: Arsenicals, Flourine and miscellaneous.
5. Organic Insecticides: Plant products - Nicotine, Pyrethrum, Rote tone and other plant insecticides.
6. Biological Insecticides: Pheromone, etc.; advantages and disadvantages.

Recommended Books and References:
1. Insecticides, Pesticides and Agro-based industries by R. C. Paliwal, K. Goel and R. K. Gupta. Small business Publications Post Box No. 2131, 4/45, Roop Nagar, New Delhi-7
2. Chmesitry of Pesticides by N. M. Melnikov (springer - Verlag New York - Hiedelberg - Berlin)
3. chemistry of pesticides by D. E. H Frear, D. Van Nostrand Company Inc. (Tronto, New York, London)

Major in Environment and Health

ENV 4321 BIOLOGICAL POLLUTION AND MITIGATION
3.0 Credits, 3 hours/ week

1. Introduction: Types of pollution and their fate in Environment, Major categories of environmental pollution, Concepts of biological pollution, Entry of Pollutants in the environment; Transfer, transport and dilution of pollutants; Carrying capacity.
2. Biomanipulation: The Biomanipulation concept; Biomanipulation studies on reduction of fish abundance; Biomanipulation studies on phytoplanktivorus fish; Biological control of macrophytes; Relationship between biomanipulation in the limnetic and littoral zones; Future trends; Biomanipulation by introduction of herbivorous zooplankton; Applicability of planktonic biomanipulation for managing eutrophication; Conditions for effective biomanipulation; The first biomanipulation conference; ecosystem stability; Biomanipulation and ecosystem research.
3. Indicator Organism: Indicator Organism to determine biological pollution.
Biosensor detection of pollutants; Bioremediation; Bioremediation of various ecosystems.
4. Algal Nuisances: Blooms, Nuissance blooms of Cyanobacteria in tropical fresh water system, Red tides.
5. Eutrophication: Sources of nutrients: Urban sources and Rural sources; General effects of eutrophication on the biota of freshwater: Plankton, Macrophytes, Benthos, Fish; Community interactions and eutrophication.
6. Eutrophication as Problems: Water purification, Nitrates, Amenity values, Algal and Cyanobacterial toxins; Controlling eutrophication.
7. Intrusive Microorganisms and Bioassays: Intrusive Microorganisms: Bacteria, Viruses.
8. Bioaccumulators: Bryophytes, Bivalves, Fish; Biomarkers; Bioassay: Biostimulation, Toxicity tests, Automated biomonitors.
9. Emerging Technologies: Bioreporters, Biosensors and Microprobes.
10. Wastewater treatment with aquatic macrophytes: Aquatic macrophytes in wastewater treatment systems; Suitability, mechanisms of action, design considerations, economics and environmental impact.
11. Biotechnological methods in pollution abatement: Biotechnology in the reduction of CO_2 emission; Algal photosynthesis in waste treatment; Eutrophication in biological phosphorus removal; Metal pollution and its bioabetement; cell immobilization as a tool in waste treatment.
12. Environmental health: Monitoring of environmental health by using biological indicator.

Recommended Books and References:
1. Environmental Microbiology. Christon, J. Hurst et al. Second Edition, ASM Press, Washington, D.C.
2. Introduction to Environmental Biotechnology. A. K. Chatterji, Prentice Hall of India Pvt. Ltd.
3. Biology of Freshwater Pollution. C. F. Mason, Third Edition, Longman Group Ltd. England
4. Biotechnological Methods of Pollution Control. S. A. Abbasi and E. Ramasami, First Edition, Universities Press Ltd., India
5. Modern Concepts of Microbiology. H. D. Kumar and Swatic Kumar, First Edition Vikas Publ. House, India
6. A Textbook of Microbiology. R. C. Dubey and D. K. Maheshwari, First Edition, Chand and Company Ltd. New Delhi.

ENV 4322 ENVIRONMENTAL SANITATION
3.0 Credits, 3 hours/ week

1. Control of Communicable and Certain Noninfectious Diseases: Types, agents, control of water, Food and insect borne diseases and zoo noses Residential and Institutional Environment: Appraisal Quality of Living, Hygiene Indices, Health Principles of Housing and its Environment.
2. Indoor Quality Standards: Causes and sources of indoor air pollution, Biological contaminants, Thermal and moisture requirement, ventilation.
3. Radiation Protection: Radiation fundamentals - Types of radiation, Ionizing and Non-Ionizing radiation, their uses and biological effects. Radioactive waste disposal, Radioactive substances soil, water and air and their fate.
4. Treatment and disposal Liquid and solid Radioactive wastes.

Recommended Books and References:
1. Environmental Engineering and Sanitation, Joseph, A.; Salvato, P. E. Dee - Wiley International latest edition, 1992
2. Environmental Protection by Chanlett McGraw Hill Publishing Co.
3. Environmental Engineering Hand Book Lee and Tchobanoglous Mc Graw Hill

ENV 4323 ENVIRONMENTAL SAFETY, HEALTH AND MANAGEMENT
3.0 Credits, 3 Hours/ Week

1. Definition: Need for good health, factors affecting health, types of diseases (deficiency, infection, pollution diseases), Personal hygiene – Food (Balanced die), food habits and cleanliness, food adulterants, avoiding smoking, drugs and alcohol.
2. Public Health: Communicable diseases, Mode of transmission (Epidemic and endemic diseases), Management of Hygiene in public places (railway stations, bus stands and other public places) hospitals – Nosocomial infections and hygiene in Educational institutions.
3. Occupational Health and Safety: Occupational health and hazards – physical, chemical and biological hazards. Principles of ergonomics. Occupational diseases – prevention and control. Health protection measures for workers – health education – first aid. Management of medical emergencies.
4. Industrial Safety and Management Techniques: Industrial safety standards and regulations. Accidents – definition, frequency rate – prevention and control. Risk Analysis and assessment. Work study, work measurement – measurement of skills, Safety cost and expenses. Principles of functions and safety management.
5. Safety Management System: Concepts of safety management systems. Environmental management Systems (EMS) ISO 14000 and 14001. OSHA and NIOSH compliance, Compensation Act, Public Liability Insurance Act, Mining Act, Good Manufacturing Practices (GMP) and Good Laboratory Management Practices (GLP).

Recommended Books and References:
1. Scott, R. M. Basic concepts of Industrial Hygiene, Lewis Publishers, New York
2. Peterson, R. D., and Cohen, J. M. the complete (vide to OSHA Compliance, Lewis Publishers, New York
3. Diberardins, L. J., Handbook of Occupational Safety and Health, John Willey, New York
4. Park, J. E. and Park, Preventive and Social Medicine.
5. John Lenihan and William, W. Felcher (ED) Health and Environment and man series, Academic press, New York
5. Khan, M. A. O., and John, P. Bederka, J. Survival in Toxic Environments, Academic Press, New York
6. Schilling, R. S. E., (ED) Occupational Health Practice, Butter Worth, London

ENV 4324 FOOD HYGIENE, HEALTH AND SAFETY
3.0 Credits, 3 hours/ week

1. Costs of Poor Standards & Benefits of Good Standards: The symptoms of food poisoning & the at risk groups. Common types & causes of work related accidents & ill health. Occupational, environmental & human factors and their effect on health & safety.
2. Legislation in Hygiene, Health & Safety: The scope of legislative requirements, Outline of legal responsibilities applied to organizations. Training, refresher training & training records. Consequences of non-compliance.
3. Creating a Safe Environment: Health & safety policy, employer & employee responsibility. Identifying hazards & assessing risks. Monitoring & reviewing procedures.
4. Food Safety: Preventing cross contamination, microbiology/bacteria. Maintaining personal hygiene. Correct storage of foodstuffs, food safety control, temperature control.
5. Risk Assessment: Definition of the terms risk & hazard, the risk assessment process, control measures & degrees of effectiveness, specialized assessments

Major in Energy and Environment

ENV 4331 ENERGY, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT: BANGLADESH PERSPECTIVE
3.0 Credits, 3 hours/ week

1. Energy: Definition, forms and classification of energy; Units of energy; Energy usage in past civilisations; role of energy use in the evolution of human civilization; Energy scenario and utilization pattern in Bangladesh.
2.Renewable energy: Sources (solar energy, hydropower, wind energy, bio-mass, bio-gas, tidal, geo-thermal etc.); advantages and disadvantages of renewable energy; future prospects.
3. Energy use and Environmental Pollution: Impacts of fossil fuel burning at local, regional and global levels; air pollution, climate change, global warming etc.
4. Energy Conservation and Efficiency: Energy conversion process and efficiency; importance of energy conservation, techniques of energy saving in house hold, industrial and transport sector; energy saving initiatives in Bangladesh; improved stove, energy saving bulb, cogeneration etc. and National energy policy of Bangladesh.
5. Energy and Sustainable Development: Concept of sustainable development; Energy resources and estimation of energy reserves and resources; Energy security and crisis Demand for energy services; Energy trade patterns and globalization; Energy prices and taxes; Energy investment; Global and regional energy needs.
6. Economic and Social Issues for Sustainable Energy Development: Energy and economic prosperity: energy consumption and economic well being; Disparities in Income and energy consumption, Energy intensities.
7. Energy and Geopolitical Issues: Politics regarding fossil fuel (oil, coal, gas) at National, Regional and International regarding.

Recommended Books and References:
1. Joseph Priest, Energy Principles, Problems and Alternatives, 3rd Edition, Addision-Wesley Publishing Company
2. Devid Reed, Editor, Structural Adjustment, the Environment, and Sustainable Development, Earthscan Eastern Publications Ltd. London
3. Srivastava, A. K. Sustainable Development. Dragana Pilipovic, Energy Risk, McGraw-Hill

ENV 4332 ALTERNATIVE AND SUSTAINABLE SOURCES OF ENERGY
3.0 Credits, 3 hours/ week

1. Introduction: Water-Based energy, Biomass, Energy from Wastes, Research and Development, Biogas Technology, Biogas Programs in Developing Countries, Experience with Biogas in Bangladesh, Utilization of Effluent, Cost of Installation, Annual Costs and Savings, Financial Assistance from Government, Organization of the Biogas Sector, Potential for Biogas Generation and Digester Construction, Future Energy Scenario of the World.
2. Alternative and Renewable Energy: Introduction, Solar energy, Wind energy, Tidal power, Biomass and Bio-fuels, Energy Tree Plantations, Specific Energy Crops, Biomass Programs, Biomass and the Environment.

Recommended Books and References:
1. Andrew R. W., Jackson & Julie M. Jackson, Environmental Science – The Natural Environment and Human Impact, Addison Wesley Longman Limited
2. Santra, S. C., Environmental Science, 2nd Edition, New Central Book Agency Ltd., Kolkata, India
3. Flowler, John M., Energy and the Environment, 2nd Edition, McGraw Hill, New York
4. Atkins P. W., and Beran, J. A., General Chemistry, 2nd Edition, W.H. Ereeman, New York
5. Weast R. C., Handbook of Chemistry and Physics, CRC Press
6. Ebbing, D. D., General Chemistry, (International 4th Edition) MA: Houghton Mifflin, Boston
7. Carless, Jennifer, Renewable Energy: A Concise Guide to Green Alternative, Walker, New York
8. Gray, N. E., Biology of Wastewater Treatment, Oxford University Press, New York

ENV 4333 GLOBAL ENERGY SCENARIO AND ENERGY SECURITY OF BANGLADESH
3.0 Credits, 3 hours/ week

1. Introduction to Energy: Primary and Secondary Energy; Difference between Energy, Power and Electricity.
Renewable and Non-Renewable Sources of Energy; The concept and Significance of Renewablity; Social, Economic, Political and Environmental Dimension of Energy.
2. Major Types and Sources of Energy: At the Global and at the National Level; Global and Bangladesh Reserves and Resources of Natural Oil and Gas, Coal and Nuclear Minerals: Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based Power and Energy: Globally and in Bangladesh.
3. Energy Sources and Power Generation: Thermal, Nuclear, Hydroelectric, Solar, Wind and Wave; General Principles; Relative Merits and Demerits including, Conversion Efficiency, Generation Cost and Environmental Impact: Concepts of Open and Combined Cycles, Co-generation: Clean Coal Initiatives.
4. Power Transmission and Distribution: General Principles; Demand Side Management; Social, Political, Economic and Legal Issues Involved in the Generation Transmission Distribution of Power in Bangladesh: Current Scenario and Future Prospects of Carbon Sequestration, Coal Gasification and CBM; Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells; Energy cum Power Scenario of Bangladesh, India, China, South Africa and the USA. Global Energy Politics.
Recommended Books and References:
1. Non-Conventional Energy Sources, G. D. Rai

2. A Textbook of Power Plant Engineering, R. K. Rajpur
3. Integrated Energy Policy, GOI

Optional Major courses for Major in Biotechnology

ENV 4341 BIOCHEMISTRY AND MOLECULAR BIOLOGY
3.0 Credits, 3 hours/ week

1. Introduction to bio- and macro molecules: Carbohydrates: Monosaccharides, disaccharides and polysaccharides, structure and functions. **Amino acids:** Classification based on structure and polarity, aphoteric property, general chemical reactions, urea cycle, metabolism.
2. Peptide and Proteins: Peptide linkage, Classification, primary, secondary and tertiary structure and biological function of proteins.
3. Lipids: Classification, fatty acids, triacylglyceride, phosphoglycerides, sphingolipids, Steroids.
4. Nucleic acids: Structure of purines, pyramidines, different conformational forms of DNA, DNA as the carrier of genetic information, DNA Double helix, The Replication of DNA, Salient features of double helix, Genetic code, Direction of Protein Synthesis, Genomics. Denaturation and renaturation. DNA topology - linking number, topoisomerases.
5. Enzyme: Classification, Nomenclature, Mechanism of enzyme action, Enzyme inhibition, Factors affecting enzyme activity, Allorteric enzymes, Isoenzymes.
6. Vitamins and Hormones: Classification, physiological functions and deficiency disorders of vitamins and hormones (thyroxine, insulin, growth hormones), an overview to the functions of phytohormones.

Recommended Books and References:

1. Lehninger, Cox and Nelson: Biochemistry
2. Stryer K. Biochemistry, W.H., Freeman & Company, New York
3. Neal, A. C., Chemistry & Biochemistry: A Comprehensive Introduction. McGraw Hill Book Company
4. Donald Voet, Judith G. Voet, Biochemistry, Second edition
5. David L. Nelson, Michael M. Cox, Lehninger, Principles of Biochemistry, third edition
6 .Karp, G., Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc
7. Becker, W. M., Kleinsmith, L. J., Hardin. J. and Bertoni, G. P., The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

ENV 4342 FOOD MICROBIOLOGY AND BIOTECHNOLOGY
3.0 Credits, 3 hours/ week

1. Foods as a substrate for microorganisms: Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general.
2. Microbial spoilage of various foods: Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods.
3. Principles and methods of food preservation: Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.
4. Fermented foods and Dairy products: Starter cultures, fermented dairy products: yogurt, acidophilus milk, kumis, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh and probiotics.
5. Food borne diseases: Causative agents, foods involved, symptoms and preventive measures, Food intoxications: Staphylococcus aureus, Clostridium botulinum and mycotoxins; Food infections: Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Salmonellosis, Shigellosis, Yersinia enterocolitica, Listeria monocytogenes and Campylobacter jejuni
6. Food sanitation and control: HACCP, Indices of food sanitary quality and sanitizers.
7. Water Potability: Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests
Food preservation: Principles of food preservation – methods of preservation: Physical (irradiation, drying, heat processing, chilling and freezing, high pressure and modification of atmosphere); Chemical (Sodium benzoate Class I & II); Biological: Probiotics and bacteriocins.
Food process technology: Packaging and canning of foods – preparation for packaging, thermal processing of foods: Microwave heating, thermal inactivation of microorganisms, thermal process, evaluations, freezing and thawing of foods. Food process operations: Evaporation –single and multi effect evaporation, dehydration, psychomatric charts, drying-tunnel, tray, spray, drum, freeze, distillation; food processing aid through biotechnology.

Recommended Books and References:

1. Adams, M. R. and Moss, M. O. Food Microbiology. 4th ed., New Age International Ltd. Pub. New Delhi, India
2. Banwart, J. M. Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India

3. Frazier, W. C. and Westhoff, D. C. Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India
4. Gould, G. W. New Methods of Food Preservation. Blackie Academic and Professional, London
5. Jay, J. M, Loessner, M. J.; and Golden, D. A. Modern Food Microbiology. 7edition, CBS Publishers and Distributors, Delhi, India
6. Food Biotechnology, Knorr, D. Marcel Dekker, New York
7. Fundamentals of Food Process Engineering, Toledo, R. T., AVI Publishing Co., USA

ENV 4343 INDUSTRIAL MICROBIOLOGY AND BIOTECHNOLOGY
3.0 Credits, 3 hours/ week

1. Introduction to industrial microbiology: Brief history and developments in industrial microbiology.
2. Fermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations; Batch, fed-batch and continuous fermentations,
3. Bioreactors/fermenters, Components of a typical bioreactor, types of bioreactors-Laboratory, pilot- scale and production fermenters; constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.
4. Measurement and control of fermentation parameters pH, temperature, dissolved oxygen, foaming and aeration Isolation of industrially important microbial strains Primary and secondary screening, strain development, preservation and maintenance of industrial strains Media and ingredients for industrial fermentations Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey
and yeast extract.
5. Down-stream Processing: Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying
6. Microbial production of industrial products: Citric acid, ethanol, penicillin, glutamic acid, riboflavin, enzymes (amylase, cellulase, protease, lipase, glucose isomerase, glucose oxidase), bioinsecticides (Bt) and Steroid. Enzyme immobilization;- Methods of immobilization, advantages and applications, application of immobilized enzymes (glucose isomerase and penicillin acylase).

Recommended Books and References:
1. Casida L. E. Industrial Microbiology, 1st edition. Wiley Eastern Limited
2. Crueger, W.; Crueger, A., Biotechnology: A textbook of Industrial Microbiology, 2nd edition, Panima Publishing Co. New Delhi
3. Patel, A. H. Industrial Microbiology, 1st edition, Macmillan India Limited
4. Stanbury, P. F.; Whitaker, A. and Hall, S. J.; Principles of Fermentation Technology, 2nd edition, Elsevier Science Ltd.
5. Sullia, S. B. & Shantharam, S. General Microbiology, Oxford & IBH Publishing Co. Pvt. Ltd.
6. Bisen, P. S. Frontiers in Microbial Technology, 1st Edition, CBS Publishers
7. Glaser, A. N. & Nilaido, H., Microbial Biotechnology, W. H. Freeman & Co.
8. Prescott & Dunn, Industrial Microbiology, 4th Edition, CBS Publishers & Distributors
9. Crueger, W., Crueger, A. A., text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.

ENV 4344 RECOMBINANT DNA TECHNOLOGY & GENOMICS
3.0 Credits, 3 hours/ week

1. Genome Structure, The Replication of DNA, Enzyme involved in DNA replication – DNA polymerases, DNA ligase. Mutation of DNA, types of mutation; physical and chemical mutagenesis; molecular basis of spontaneous and induced mutations. Chromatin and the Nucleosome Genome Sequence and Chromosome Diversity, Chromosome Duplication and Segregation, The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin. Regulation of Chromatin Structure and Nucleosome Assembly.
2. Cutting and joining of DNA molecules: Biology of vectors – plasmids, bacteriophages, single stranded DNA vectors, cosmids, phasmids, specialized vectors Cloning strategies: cloning of genomic DNA, cDNA cloning; screening strategies; differential cloning
3. Techniques in genetic engineering: Blotting techniques – Southern, Northern and Western blotting; transformation of *E. coli*, PCR; probe construction, RFLP, AFLP, RAPD, SSCP and SNP. Construction of cDNA library, molecular mapping of genome – genetic and physical maps.
4. Methods of DNA, RNA and Protein analysis and DNA typing: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot and colony hybridizations. Chromosome walking and jumping. DNA fingerprinting by RFLP and RAPD. Gel retardation assays. DNA footprinting by DNase I, DNA microarray analysis.
5. Construction of Genomic and cDNA libraries: Genomic and cDNA libraries: Preparation and uses. Screening of libraries by colony hybridization and colony PCR.
6. DNA sequencing and synthesis: Maxam-Gilbert's and Sanger's method. Automated sequencing. Human genome sequencing project.

7. Product of DNA technology: Human protein replacements-insulin, hGH and Factor VIII. Human therapies - tPA, interferon, antisense molecules. Bt transgenics-rice, cotton, brinjal.

Recommended Books and References:

1. Gardner, E. J., Simmons, M. J., Snustad, D. P. 8th ed. Principles of Genetics. Wiley India
2. Glick, B. R., Pasternak, J. J. Molecular Biotechnology- Principles and Applications of recombinant DNA
3. Christopler H. Gene cloning and Manipulating, Cambridge Universoty Press
4. Nicholl, D. S. T An Introduction of Genetic Engineering, Cambridge University Press
5. Brown T. A. Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K
6. Nigam, A. and Ayyagari, A. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill, India
7. Microbial genetics – Friedfelder

ENV 4345 NANOBIOTECHNOLOGY
3.0 Credits, 3 hours/ week

1. Introduction: Synthesis and Characterizations of Nano-scale Materials. Strategies for Nano-architecture (top down and bottom up approaches), Fabrication Technologies and Characterizations. Self-assembly Systems Basic aspects of nano-materials.
2. Nano-fluids: surfactants, polymers, emulsions and colloids. Nano-scale Artificial Platforms: Lipids in Self-assembly Structures.
3. Nano-structured materials: Fullerenes - Properties and Characteristics. Carbon Nanotubes -Characteristics and Applications Quantum Dots and Wires. Gold Nanoparticles. Nanopores. Applications of Nano Molecules in Biosystems.
4. Application of Nano-biotechnology in drug Delivery: Nano-scale Devices for Drug Discovery. Micelles for Drug Delivery. Protein targeting: Small Molecule-Protein Interactions. Micro-array and Genome Chips.
5. Nanotechnology and the Cell: Cell Motility: Nano Motors and Cellular Navigation hemotaxis - Transmembrane Signalling and Related Protein.
6. Nano-technology for Cancer Diagnostics and Treatment: Nano-technology for Cancer Research and Therapy. siRNA. Tumor-targeted Drug Delivery Systems. Nano-technology for Imaging and Detection.
7. Preparation and characterization of nano-particles: Nano-particular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Micro-fabrication, Biosensors, Chip technologies, Nano-imaging, Metabolic engineering and Gene therapy.

Recommended Books and References:

1. NANO by Pradeep, T. 2006, Tata Mc Graw Publishers. India
2. Nanobiotechnology Concepts, Applications and Properties, Christef , M.; Niemeyer, C. A.; Mirkin, Wiley – VCH Publishers
3. Nanotechnology a Gentle Introduction to the Next big idea by Mark Ratner and Daniel Ratner, Pearson education. Inc.
4. Nalwa, H. S., Handbook of Nanostructured Biomaterials and Their Applications
5. Niemeyer, C. M. & Mirkin, C. A., Nanobiotechnology. Wiley Interscience

ENV 4346 BIOSAFETY, BIOETHICS & IPR ISSUES
3.0 Credits, 3 hours/ week

1. Introduction to ethics and bioethics: Personal ethics: profession and professionalism–Moral Reasoning – Ethical theories – person as an experimenter – Moral leadership (integrity and ingenuinity) - framework for ethical decision making.
2. Biotechnology and ethics: Biotechnology in agriculture and environment: benefits and risks – benefits and risks of genetic engineering – ethical aspects of genetic testing – ethical aspects relating to use of genetic information – genetic engineering and biowarfare.
3. Ethical implications of cloning: Reproductive cloning , therapeutic cloning ; Ethical, legal and socio-economic aspects of gene therapy, Ethical Issues in Genetically Modified (GM) Foods and Crops – biotechnology and biopiracy. Stem Cell Research - Ethical Issues, Use of animals in research, and its alternatives.
4. Introduction to biosafety: Biosafety issues in biotechnology – risk assessment and risk management – safety protocols: risk groups – biosafety levels – biosafety guidelines and regulations (National and International) – operation of biosafety guidelines and regulations –types of biosafety containment
5. Intellectual property and intellectual property rights: Types, patents, copy rights, trade marks, design rights, geographical indications – importance of IPR –patentable and non patentable – legal protection of biotechnological inventions – world intellectual property rights organization (WIPO). Intellectual Property Rights and Agricultural Technology and their Implications for Bangladesh and Developing Countries.

Recommended Books and References:

1. Principles of cloning, Jose Cibelli, Robert P. lanza, Keith H. S . Campbell, Michael D. West, Academic press
2. Glimpses of Biodiversity – B. Bltosetti
3. Ethics in engineering, Martin. M. W. and Schinzinger, R. 3rd Edition, Tata McGraw-Hill, New Delhi