BANGALORE UNIVERSITY

Syllabus of M.Sc Environmental Science

CBCS Semester Scheme

Effective from 2014-2015 Academic Year

Department of Environmental Science
Jnana Bharathi Campus
Bangalore – 560 056

BANGALORE UNIVERSITY

DEPARTMENT OF ENVIRONMENTAL SCIENCE

CHOICE BASED CREDIT SYSTEM (SEMESTER SCHEME)

ELIGIBILITY FOR M.Sc. IN ENVIRONMENTAL SCIENCE

A graduate in Science/Agriculture/Horticulture with a minimum of 50% marks in the aggregate of all the following optional subjects: Applied Botany/Zoology, Biological Sciences, Biotechnology, Botany, Computer Science, Electronics, Environmental Science, Geology, Genetics, Life Science, Microbiology, Physics and Zoology, with Chemistry/Biochemistry atleast at the PUC level is eligible.

SCHEME OF EXAMINATION

THE SCHEME OF EXAMINATION

There shall be examinations at the end of each semester ordinarily during November/December for odd semesters and during April/May for even semesters. The details of schemes of examinations in various subjects are given in appendix "A".

Project Work/dissertation may be offered as per the schemes prescribed in respective courses. It shall be evaluated by two examiners, one external and one internal appointed by the University. Wherever there is viva-voce, it shall be conducted by the Viva-Board consisting of the internal guide and one external expert from the panel of examiners and as approved by the Registrar (Evaluation).

INTERNAL ASSESSMENT

Marks for internal assessment shall be awarded on the basis of seminars, field work, tests, assignments etc. as determined by the Board of Studies in the respective subject. The internal assessment marks shall be notified on the department/college notice board for information of the students and they shall be communicated to the Registrar (Evaluation) before the commencement of the University examinations, and the Registrar (Evaluation) shall have access to the records of such internal assessment evaluations.

REGISTERING FOR THE EXAMINATIONS

A candidate shall register for all the papers in the subject of a semester when He/She appears for the examination of that semester for the first time.

VALUATION OF ANSWERSCRIPTS

Each written paper shall be valued by one internal examiner and one external examiner. Each practical examination shall be jointly conducted and evaluated by one internal examiner and one external examiner or two external examiners if there are no internal examiners. But not by two internal examiners.

If the difference in marks between two valuation is more than 15% of the maximum marks, the Registrar (Evaluation) or his nominee shall check the entries and the total marks assigned by the two valuers. If there is any mistake in totalling, it shall be rectified. While checking the total, if it is observed that any one or more of the answers is not valued by one of the valuers, the Chairman, BOE shall advise internal members of the Board of Examiners to value that answer. After receiving the marks, the Chairman, BOE shall make the necessary corrections. Despite all these corrections, if the difference between the two valuations is still more than 15%, the Chairman, BOE shall arrange for third valuation by examiners from the approved panel of examiners.

In case of two valuations, the average of the two valuations and if there are three valuations, the average of the nearest two valuations shall be taken for declaring results. The candidates not satisfied with the results may apply for photocopies of the answer scripts and / or challenge valuation.

CLASSIFICATION OF SUCCESSFUL CANDIDATES

The results of successful candidates at the end of each semester shall be declared on the basis of Percentage of Aggregate Marks and in terms of Grade Point Average (GPA) and alpha – sign grade. The results at the end of the fourth semester shall also be classified on the basis of Percentage of Aggregate Marks and on the basis of the Cumulative Grade Point Average (CGPA) obtained in all the four semesters and the corresponding overall alpha – sign grade. An eight point grading system, alpha – sign grade as described below shall be adopted.

First Class with Distinction	70% and above (A+, A++ or O)
First Class	60% and above but less than 70% (A)
High Second Class	55% and above but less than 60% (B+)
Second Class	50% and above but less than 55% (B)
Pass Class	40% and above but less than 50% (C)

Eight Point Alpha – Sign Grading Scale:

Grade Point Average	<4	4-<5	5-<5.5	5.5-<6	6-<7	7-<8	8-<9	9-10
Alpha-Sign Grade	D	C	B	B+	A	A+	A++	O

The Grade Point Average (GPA) in a Semester and the Cumulative Grade Point Average (CGPA) at the end of fourth semester shall be computed as follows:

Computation of Grade Point Average (GPA): The grade points (GP) in a course shall be assigned based on the basis of actual marks scored in that course as per the table below. They shall be generally percentages divided by 10. The

Grade Point Weights (GPW) shall then be calculated as the product of the grade points earned in the course and the credits for the course. The total GPW for a semester is obtained by adding the GPW of all the courses of the semester.

ILLUSTRATION 1 (26 Credits)

Papers	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**Total**
Max. marks	100	100	100	100	100	100	100	700
% Marks Obtained	77	73	58	76	64	66	82	496
Grade Points Earned (G.P)	7.7	7.3	5.8	7.6	6.4	6.6	8.2	-
Credits for the Course (C)	4	4	4	4	4	4	2	26
Total GPW = GP x C	30.8	29.2	23.2	30.4	25.6	26.4	16.4	182

Semester Aggregate Marks : **496 / 700 = 70.86%**

Classification of Result : First Class with Distinction

The GPA shall then be computed by dividing the total GPW of all the courses of study by the total credits for the semester, GPA = Total GPW / Total Credits = 182 / 26 **= 7.0**

Semester Alpha Sign Grade: **A+**

ILLUSTRATION 2 (24 Credits)

Papers	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**Total**
Max. marks	100	100	100	100	100	100	600
% Marks Obtained	67	73	78	76	84	88	466
Grade Points Earned (G.P)	6.7	7.3	7.8	7.6	8.4	8.8	-
Credits for the Paper	4	4	4	4	4	4	24
Total GPW = GP x C	26.8	29.2	31.2	30.4	33.6	35.2	186.4

Semester Aggregate Marks : **466 / 600 = 77.67%**

Classification of Result : First Class with Distinction

GPA = Total GPW / Total Credits = 186.4 / 24 **= 7.77**

Semester Alpha Sign Grade: **A++**

Calculation of Cumulative Grade Point Average (CGPA):

The Cumulative Grade Point Average (CGPA) at the end of the fourth semester shall be calculated as the weighted average of the semester GPW. The CGPA is obtained by dividing the total of GPW of all the four semesters by the total credits for the programme.

ILLUSTRATION I

Semester	I	II	III	IV	Total
Total Marks per Semester	700	700	600	600	2600
Total Marks Secured	496	560	466	510	2032
Semester Alpha Sign Grade	A+	A++	A+	A++	-
Semester GPA	7.0	8.0	7.77	8.5	-
Semester Credits	26	26	24	24	100
Semester GPW	182	208	186.5	204	822.9

Aggregate Percentage of Marks = 2032 / 2600 = 78.15 **%**

Classification of Result : First Class with Distinction

Cumulative Grade Point Average (CGPA) = Total of Semester GPW / Total Credits for the programme = 780.5 /100 **= 7.805**

Programme Alpha Sign Grade: **A++**

These are the sample illustrations of computing semester grade point averages and cumulative grade point average and the alpha – sign grades assigned.

MINIMUM FOR A PASS

A candidate shall be declared to have passed the PG program if He/She secures at least a CGPA of 4.0 (Course Alpha-Sign Grade C) in the aggregate of both internal assessment and semester end examination marks put together in each unit such as theory papers/practical's/project work/dissertation/viva-voce.

The candidates who pass all the semester examinations in the first attempts are eligible for ranks provided they secure at least CGPA of 6.0 (or Alpha-Sign Grade A).

The results of the candidates who have passed the fourth semester examination but not passed the lower semester examinations shall be declared as NCL (Not Completed Lower semester examinations). Such candidates shall be eligible for the degree only after completion of all the lower semester examinations.

A candidate who passes the semester examinations in parts is eligible for only Class/CGPA and Alpha-Sign Grade but not for ranking.

There shall be no minimum in respect of internal assessment.

A Candidate who fails in any of the unit/project work/Project Report/dissertation/viva-voce shall reappear in that unit/project work/Project Report/dissertation/viva-voce and pass the examination subsequently.

CARRY OVER PROVISION

Candidates who fail in a lower semester examinations may go to the higher semesters and take the examinations.

REJECTION OF RESULTS

i. A candidate who fails in one or more papers of a semester may be permitted to reject the result of the whole examination of that semester. Rejection of result paper wise shall not be permitted. A candidate who rejects the results shall appear for the examination of that semester in the subsequent examination.

ii. Rejection shall be exercised only once in each semester and the rejection once exercised shall not be revoked.

iii. Application for rejection along with payment of the prescribed fee shall be submitted to the Registrar (Evaluation) through the department/college together with the original statement of marks within 30 days from the date of publication of the result.

iv. A candidate who rejects the result is eligible for only class and not for ranking.

IMPROVEMENT OF RESULTS

1. A candidate who has passed in all the papers of a semester may be permitted to improve the result by reappearing for the whole examination of that semester.

2. The reappearance could be permitted twice during double the period without restricting it to the subsequent examination only. The regulation governing maximum period for completing various degree/ diploma programme notified by the University from time to time shall be applicable for improvement of results also.

3. The student could be permitted to apply for the improvement examination 45 days in advance of the pertinent semester examination whenever held.

4. If the candidate passes in all the subjects in reappearance, higher of the two aggregate marks secured by the candidate shall be awarded for that semester. In case the candidate fails in the reappearance, candidate shall retain the first appearance result.

5. A candidate who has appeared for improvement is eligible for class only and not for ranking.

Internal assessment marks shall be shown separately in the marks card. A candidate who has rejected the result or who, having failed, takes the examination again or who has appeared for improvement shall retain the internal assessment marks already obtained.

A candidate who fails in any of the semester examinations may be permitted to take the examinations again at a subsequent appearance as per the syllabus and scheme of examination in vogue at the time the candidate took the examination for the first time. This facility shall be limited to the following two years.

POWER TO REMOVE DIFFICULTIES

i) If any difficulty arises in giving effect to the provisions of these regulations, the Vice-Chancellor may by order make such provisions not inconsistent with the Act, Statutes, Ordinances or other Regulations, as appears to be necessary or expedient to remove the difficulty.

ii) Every order made under this rule shall be subject to ratification by the Appropriate University Authorities.

Repeal and Savings: **The existing Regulations governing three years Bachelor degree programmes in the faculties of Arts, Science and Commerce shall stand repealed. However, the above Regulations shall continue to be in force for the students who have been admitted to the course before the enforcement of this regulation.**

BANGALORE UNIVERSITY
DEPARTMENT OF ENVIRONMENTAL SCIENCE
JNANBHARATHI CAMPUS, BANGALORE

CHOICE BASED CREDIT SYSTEM (SEMESTER SCHEME)

SYLLABUS OF M.Sc. ENVIRONMENTAL SCIENCE

Structure of the course

I SEMESTER

Subject Code	Title of paper	Teaching hours per week	Examination duration (hrs)	Internal assessment Marks	Exam. Marks	Total	Credits
Core Papers							
ES 101	Environmental Biology	04	03	30	70	100	4
ES 102	Environmental Chemistry	04	03	30	70	100	4
ES 103	Environmental Geology	04	03	30	70	100	4
ES 104	Meteorological Sciences	04	03	30	70	100	4
Soft core (No practicals)							
ES 105	Environmental Sampling & Applications of Statistics	03	03	30	70	100	2
Practicals							
ES 106	Part A: Environmental Biology Part B: Environmental Chemistry	04	03	30	70	100	4
ES 107	Part A: Environmental Geology Part B: Meteorological Sciences	04	03	30	70	100	4
Total credits of semester							**26**

II SEMESTER

Subject Code	Title of paper	Teaching hours per week	Examination duration (hrs)	Internal assessment marks	Exam. Marks	Total	credits
Core Papers							
ES 201	Environmental Toxicology	04	03	30	70	100	4
ES 202	Environmental Engineering	04	03	30	70	100	4
ES 203	Environmental Microbiology	04	03	30	70	100	4
ES 204	Environmental Pollution Control & Management	04	03	30	70	100	4
Soft core (No practicals)							
ES 205	Occupational health hazards	04	03	30	70	100	2
Practicals							
ES 206	Part A: Environmental Toxicology Part B: Environmental Engineering	04	03	30	70	100	4
ES 207	Part A: Environmental Microbiology Part B: Environmental Pollution Control & Management	04	03	30	70	100	4
Total credits of semester							**26**

III SEMESTER

Subject Code	Title of paper	Teaching hours per week	Examination duration (hrs)	Internal assessment Marks	Exam. Marks	Total	credits
Core Papers							
ES 301	Solid and Hazardous waste management	04	03	30	70	100	4
ES 302	Natural resource management	04	03	30	70	100	4
ES 303	Remote sensing & GIS applications	04	03	30	70	100	4
Open Elective - Any one paper for the sister Departments							
ES 304	• Climate Change and current issues • Water Supply & Management • EIA and Environmental Policy • Natural Resources Management	04	03	30	70	100	4
Practicals							
ES 305	Part A: Solid and Hazardous waste management Part B: Natural resource Management	04	03	30	70	100	4
ES 306	Part A: Applications of Remote Sensing Part B: GIS & its applications	04	03	30	70	100	4
Total credits of semester							**24**

IV SEMESTER

Subject Code	Title of paper	Teaching hours per week	Examination duration (hrs)	Internal assessment Marks	Exam. Marks	Total	credits
Core Papers							
ES 401	Environmental Economics & Sustainable Development	04	03	30	70	100	4
ES402	Environmental Impact Assessment & Environmental Law	04	03	30	70	100	4
ES403	Disaster Management	04	03	30	70	100	4
ES404	Ecofriendly Technologies and Environmental modeling	04	03	30	70	100	4
ES 405	**Dissertation**	-	-	-	-	150	6
	Viva-voce	-	-	-	-	50	2
Elective- Dissertation in any one of the field /Viva Voce. Project work /Dissertation in place of Practical's. Research topic to be decided in consultation with guide and students.							
					Total credits of all semester		**100**

Marks for internal assessment shall be awarded on the basis of seminars, field work, tests, assignments etc.,

Scheme of Internal Assessment for I – III Semester

Theory	**30**	**Practical (Each Part = 15Marks)**	**15 x 2=30**
Tests	10	Test	5
Assignments	05	Class records	5
Seminar	05	Attendance	5
Field visits	05	Total IA of Practical for each paper	30
Attendance	05	-	-

Scheme of Internal Assessment for IV Semester & Dissertation

Theory	**30**	**Project work /Dissertation**	**Total**
Tests	10	Dissertation	150
Assignments	05	Viva Voce	50
Seminar	05	-	-
Field visits	05	-	-
Attendance	05	-	-

SYLLABUS

I SEMESTER M.Sc ENVIRONMENTAL SCIENCE

ES 101: ENVIRONMETAL BIOLOGY (Core)

4 Credits, 4hrs/Week, 52 hrs/semester

Unit 1: Definition, principle and scope of Environmental Science and Ecology, inter relation with other fields. Interaction between Man and Environment; Factors affecting the environmental systems - physico-chemical and biological factors. **08 hrs**

Unit 2: Ecosystems: Fundamental concepts and principles; Structure and function, Food chain disruption and consequences, modern concept of ecosystem, classification – aquatic and terrestrial ecology (biotic and abiotic factors). Major biomes –Temperate forests, Tropical rain forests, Tropical savannah and Deserts. Population ecology – Fundamental concepts, characteristics, growth and regulation. Community ecology – species diversity, richness and dominance. **12 hrs**

Unit 3: Primary and secondary productivity - Definition, measurement of biomass and productivity in terrestrial and aquatic communities. Productivity of terrestrial ecosystem; forest and grassland ecosystems. Ecosystem Pathways; basic laws of energy flow; Energy flow models, Energetic relations in Ecosystems. **10 hrs**

Unit 4: Biodiversity: Definition, biodiversity hot spots of world & India and strategies for its conservation. CBD and Agenda 21, National parks. and sanctuaries, biosphere reserves. Ecological indicators. Endemic and RET species, Concept of keystone & flagship species. Biodiversity of agro-ecosystems and Sacred grooves. **10 hrs**

Unit 5: Forest ecosystem: Forest influence on Climate regulation, flood & soil erosion control and wildlife habitat protection, maintaining hydrology, nutrient cycling and moisture conservation. Green belt and its influence on urban environment. Carbon sequestration and Kyoto convention. Effect of fire on forest ecosystem – soil moisture, nutrient content, micro & macro fauna, wildlife habitat. **12 hrs**

Reference Books:

1. Ramesh Vijaya K. (2005). Environmental Microbiology. MGP Publishers, Chennai.

2. Edward Alcamo I. (2001). Fundamentals of Microbiology, Jones and Bartlett Publishers, INC. VI Edition.
3. Kumar H.D. (1995). General Ecology, I Ed. Vikas Publishing House Pvt. Ltd., NewDelhi
4. Pepper W. (1995). Environmental Microbiology. A.P. Publishers.
5. William C. Frazier and Dennis C. Westhoff. (1995). Food Microbiology, Tata McGraw-Hill Publishing Company limited, New Delhi, IVth Edition
6. Odum E.P. (1971). Fundamental Ecology, 5th Ed., Saunders.
7. Kormondy E.J. (1962). Concepts of Ecology, Prentice Hall.
8. Singh H.R. (1989). Animal Ecology and Environmental Biology. Nagin Chand & Co. Shoban Lal (1992). Ecology
9. Eiseth G.D. and Baumgardener K.D. (1981). Population biology, Van Nos Strand Co., N.Y
10. Phillipson F.H. (1980). Ecological Energetics.
11. Michael J. Pelczar. (1986). Microbiology, 5th (Ed) McGraw – Hill Book Co.
12. Michael J. Pelczar. (1994). Microbiology-Concepts and applications, McGraw-Hill Inc.
13. Martin Alexander. (1983). Introduction to Soil Microbiology, 2nd Ed., Wiley Eastern Ltd.
14. Powar C.B and Daginwala H.F. (1985). General Microbiology, Vol. I & II, 2nd Ed., Himalaya Publishing House.
15. Bhattacharya R.N. (1993). Experiments with microorganisms, Reprint, Emkay Publications, New Delhi.
16. Pepper W. (1995), Environmental Microbiology. A.P. Publishers.
17. Oliver S. Owen. (1980). Natural Resources conservation - An Ecological approach, 3rd Ed., Macmillan Publishing Co.Inc. New York.
18. Daniel D. Chiras. (1994). Environmental Science, 4th Ed., The Benjamin /Cummings Publishing Co., Inc.
19. Nandini N, Sunitha N. and Sucharita Tandon. (2007). Environmental Studies, Sapna Book House, Bangalore.

ES 102: ENVIRONMENTAL CHEMISTRY (Core)
4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Atmospheric Chemistry: Chemical composition of air, Classification of elements, chemical speciation. Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermo-chemical and photochemical reactions in the atmosphere. CFC's and Ozone chemistry, chemistry of air pollutants, photochemical smog. **08 hrs**

Unit 2: Soil Chemistry: Soil profile, distribution of inorganic and organic components in soil, Chemical properties of Soil - Saline, Acidic and Alkaline soils. Major micro and macro nutrients of soil, Nutrient Pathways - Nitrogen, Phosphorus and Potassium pathways in the soil. **10 hrs**

Unit 3: Chemical pollution and fundamentals of chemical reactions: Acid-base reaction, oxidation, reduction, precipitation. Reactions of acids and bases reaction on surfaces-toxic chemicals in the environment biochemical aspects of As, Cd, pb, Hg, CO, O_3, PAN, pesticides, MIC and carcinogens in air. **10 hrs**

Unit 4: Water chemistry: properties of water, water pollutants- types sources-heavy metals metalloids-organic, biological and radioactive- types of reactions in various water bodies including marine environment. Chemistry of oil based and water based paints, physicochemical basis of redox processes. Electrochemical theory of corrosion. **12 hrs**

Unit 5: Instrumentation and Analytical Techniques: Theoretical principles of Analytical Techniques – Role and importance of analytical techniques in analysis of environmental samples. Titrimetry; types and applications of neutralization, precipitation, complexometric titrations; gravimetry, Conductometry, pH, Colorimetry, Spectrometry, UV-Vis and IR Spectrophotometer and AAS. Nephelometry, Flame Spectrometry and fluorimetry; Chromatographic techniques: Paper, Thin Layer, GC and Gas – Liquid Chromatography, HPLC, X-ray florescence, X-ray diffraction, Electrophoresis. **12 hrs**

Reference Books:

1. Sharma B.K and Kaur H. (1995). Environmental Chemistry, I Ed., Goel Publishing House.
2. De A.K (1989). Environmental Chemistry, II Ed., Wiley Eastern Limited.

3. Sawyer C.N, Mc Carty P.L and Perking G.F. (1994). Chemistry for Environmental Engineering, IIEd, Mc Graw- Hill.
4. Bailey, R.A. (1978). Chemistry of the Environment, Academic Press.
5. Tyagi O.D. and Mehra M. (1990). Text Book of Environmental Chemistry, I Ed., Anmol Publications.
6. Charles R. Goldman and Alexander J. Horene. (1983). Limnology, Mc Graw- Hill.
7. Roy L. Donahue, Raymond W. Miller and John C. Shickluna. (1987). Soils – An Introduction to soils and plant growth V.Ed., Prentice-Hall of India.
8. Biswas T.D and Mukherjee S.K. (1987). Text book of Soil Science IV Ed., Mc Graw- Hill.
9. Vogel's Textbook of Quantitative Inorganic Analysis. (1978). IV Ed., Longman Group Ltd.
10. Jacobs. (1969). Analytical Chemistry of Industrial poisons. Hazards and solvents, M.B. Inter Science. New York.
11. Sawyer C.N, Mc Marty P.L. and Perkin G.F. (1994). Chemistry for Environmental Engineering (II ed), Mc Graw Hill.
12. Tyagi O.D. and Mehra M. (1990). Environmental Chemistry, Anmol Publications.
13. Manahan S.E. (2000). Environmental Chemistry (7^{th} Ed), Lewis Publications, Florida, U.S.A.

ES103: ENVIROMENTAL GEOLOGY (Core)
4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Earth systems and its interaction: Lithosphere, hydrosphere and biosphere. Earth's Materials – Minerals and their definition. Distribution and abundance of elements in the major units of earth, Geochemical features, Formation and classification of Rocks. Folds, faults, dykes and other geological formations and their environmental significance. **10 hrs**

Unit 2: Mineral resources and Pedology: Resources and reserves, depletion trends of resources. Geological features of India and Karnataka. Land-use planning and Terrain evaluation. Soil characteristics, formation of soil, role of soil organisms in soil formation, soil erosion, types, soil conservation. Elemental Pathways - geochemical cycles. Biogeochemical factors in environmental health and effects of imbalance. **10 hrs**

Unit 3: Water Resources and Environment: Classification of global water resources – Lotic and Lentic system. Global water balance, Ice sheets and fluctuations of sea levels. Origin and composition of seawater, Hydrological cycle, Human usage of surface and ground water. Ground water potential. Global water budget. **10 Hrs**

Unit 4: Geochemical and geological process-exogenic and endogenic – Earthquakes volcanoes, cyclones, Tsunami - their impact on flora and fauna and human beings. River action, wind action and glaciers. Concept of major trace and REE classification and mobility of trace element Geochemical cycle, Human use, trace elements and health, Diseases induced by human use of land. **12 hrs**

Unit 5: Geographical classification and zones of Environment. Energy budget of the earth. Earth's thermal environment and seasons. General relationship between landscapes, biomes and climate. Climate of India. Indian Monsoon, Elnino, droughts, Tropical cyclones and westerly disturbances. **10hrs**

Reference books:

1. Schwab S.O, Frevert R.K, Edimster T.W and Barns K.K. (1975). Soil and water conservation Engineering, John Wiley and Sons.
2. Loehr, R.C.Jesel, W.J.Novak, N.D., Clarkson, W.S. and Friedeman G.S. (1979). Land Application of Wastes (Vol-I and II). Van Nostrand Reinhold Co., New. York.

3. Valdia K.S. (1987). Environmental Geology.
4. Menard H.W., W.H.Freeman and Company, San Francisco. (1969). The nature of Oceanic life, The Ocean – A Scientific American Book.
5. Reed Wicander and James S. Monroe. Essentials of Geology, Wadsworth publishing
6. Roy L. Donahue, Raymond W. Miller and John C. Shickluna. (1987). Soils – An Introduction to soils and plant growth V.Ed., Prentice-Hall of India.
7. Biswas T.D and Mukherjee S.K. (1987). Text book of Soil Science IV Ed., Mc Graw- Hill.
8. Strahler and Strahler. (1970). Environmental Geology, Wiley & Sons, New York.
9. Valdiya K.S. (1985). Environmental Geology Allied Publishers New York.
10. Carla W. Montgomery. (1989). Environmental Geology, Wm C Brown Publishers. Dubuuguo Lowa.
11. Peter T. Flawn. (1970). Environmental Geology, Harper and Row, New York.
12. Khurumi R.S. (1988). Engineering Geology, Dhanpet Rai & Sons, New Delhi.
13. Mahapatra G.B. (1989). A textbook of Geology. CBS Publishers & Distributors NewDelhi.
14. Mukherjee P.K. (1995). A textbook of Geology. The World Press Private Ltd. Calcutta.
15. William D. Thornbury. (1984). Principles of Geomorphology. First Wiley Eastern print.
16. Berry l.G, Mason Brian and R.V Dietrich. (1985). Mineralogy, CBS Publishers & Distributors.
17. Gribbis C.D. (1991). Rutley's Elements of Mineralogy, 27th Ed., Revised by CBS Publishers & Distributors.
18. Edward A Keller. (1981). Environmental Geology, 3rd Edition, Charles E. Merill Pub. Co.
19. Earth Science and the Environment, Richard J.Ordway, D.Van Nostrand and Company, London.
20. Laporte. Encounter with the Earth, L.F. Oxford press, San Francisco.

ES104: METEOROLOGICAL SCIENCES (CORE)
4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Fundamentals of Atmospheric Science: Composition, Structure & Evolution of Atmosphere. Solar radiation and terrestrial radiation; electromagnetic spectrum latitudinal and seasonal variations, effect of atmosphere, greenhouse effect, heat budget. Temperature measurements and controls, Environmental lapse rate, dry and wet adiabatic lapse rate, inversion of temperature and atmospheric stability. **10 hrs**

Unit 2: Climatology: Definition and Scope, Aims and Objectives of Climatology, Insolation-Factors Affecting the Distribution of Insolation. Atmospheric Depletion of Solar Radiation. Process of Heat Energy Transfer- Radiation, Conduction and Convection. Hydrological cycle - Evaporation, Condensation; Forms of Condensation – Dew, Frost, Fog, Mist, Smog. Cloud Formation, Classification of Clouds and Role of Clouds in Weather Forecasting. **10 hrs**

Unit 3: Meteorology: Definition, and Scope, Aims and Objectives of Meteorology. Primary Meteorological Parameters and their Measurement—Temperature, Wind Speed and Direction. Secondary Meteorological Parameters and their Measurement: Humidity, Relative Humidity, Absolute Humidity, Pressure and Solar Radiation. Collection and Analysis of Wind Data, Wind Roses, Plotting of Wind Roses and Pollution Roses. Effects of Meteorological Parameters on weather and climate. **12 hrs**

Unit 4: Global Climate Change: Introduction, Sources and Effects of Greenhouse Gases – Carbon dioxide, Methane, Ozone, Nitrous oxide, Chlorofluoro carbons and water vapour. Stratospheric Ozone, Mechanism of Ozone Depletion, Effects of Ozone Depletion, Climatic Effects and Environmental Disturbances due to Ozone Depletion, Advance Research to Protect the Ozone Layer, Antarctic Ozone Hole and Consequences. **10 hrs**

Unit 5: Greenhouse Effect: Effect on Global Climate, Consequences & Control. Implications of Climate Change, Monitoring, Assessment, Research and Prediction Programs, El-Nino and La-Nino. Atmospheric disturbances: Thunderstorms, Cyclones, lightening, flood, and drought. Impacts, Mitigation and adaptation measures. **10hrs**

Reference Books:

1. General Meteorology: H. R. Byers, Tata McGraw Hill Publications, New Delhi.

2. Climatology: Fundamentals and Applications: Mater J. R.
3. Climatology: Selected Applications: Henry D. Foth.
4. Introduction to weather and climate: Trewartha.
5. The Atmosphere: An Introduction to Meteorology: Fedrik K. Lutgen, E. J.Tarbuck.
6. General Meteorology: H. R. Byers (Tata Mc Grew – Hill Publications, New Delhi).
7. Meteorology: Dr. S.R. Gadekar, Agromate Publishers, Nagpur 2000.
8. Environmental Analysis: M.M. Saxena, Agrobotanical Publisher, Bikaner 1994.
9. Climatology: D.S. Lal, Shraddha Pustak Bhavan Alahabad, 2001.
10. Atmosphere, Weather and Climate: K. Sidddhartha, Kisalaya Publication Pvt. Ltd 2000.

ES 105: ENVIRONMENTAL SAMPLING AND APPLICATIONS OF STATISTICS (SOFT CORE)

2 Credits, 3hrs/Week, 39hrs/semester

Unit 1: Air Sampling: Objective and Criteria of Air Sampling, Selection of Sampling Location, Sampling Methods (Sedimentation, Filtration, Centrifugal and Impingement Method), Instrumental Techniques used in Estimation of Atmospheric Air Pollutant, Dust Fall Jar, SPM and RSPM using Respirable Dust sample/High Volume Air Sampler. **08 hrs**

Unit 2: Water Sampling: Necessity of Water Sampling, Objectives, Selection of Sampling Site, Types of Water Samples, Collection, Handling and Preservation, Sampling Equipment, Classification of Water Quality Parameters (Inorganic, Organic and Nutrient), Parameters analyzed on the Spot, (Field Parameters) Data Interpretation, Basic Concept, Significance and Measurement of DO, BOD, COD, Phenol, Pesticides and Polynuclear Aromatic Hydrocarbon (PAH) in Water and Wastewater. **09 hrs**

Unit 3: Soil and Solid Waste Sampling: Objectives of Soil and Solid Waste Sampling, Site Selection Criteria, Collection and Handling of Soil and Solid Waste Samples, Preparation of Soil Samples for Analysis, Physico-Chemical Parameters and their Significance (Quality and Productivity). **10 hrs**

Unit 4: Application of Statistics in Environmental Analysis: Introduction, Research Problem and Design, Data Collection, Data Representation, Measure of Central Tendency, Measure of Variation, Correlation and Regression, Testing of Hypothesis, Interpretation and Report Writing. Nature of Errors, Types of Errors and Importance of Error, Random Error, Estimation of Standard. Deviation, Confidence Limits of Analytical Results, Combined Effects of Different Random Errors, Comparison of Two Means, Comparison of Two Standard Deviations, Laboratory Quality Control and Assessment, Correction, Limit of Detection, Bias, Precision and Accuracy. **12 hrs**

Reference Books:

1. Biostatistics: P.N. Arora, P.K. Malhan, Himalaya publishing House, Delhi, 2008.
2. Basic concepts of Biostatistics: N.Arumugam, Saras Publications, Kanyakumari, 2003.
3. Biostatistics in theory and Practice: T.K.Saha, Emkay Publications, Delhi, 1992.

4. Biostatistics: P. Ramakrishnan, Saras Publications, Kanyakumari, 1995.
5. Statistical Methods: S.C.Gupta, S.Chand & Sons Publishers, New Delhi, 1997.
6. Evolution Biostatistics AND Computer Applications: A.Gopi, A.Meena, N.Arumugam, Saras Publications, Kanyakumari, 2003.
7. Fundamentals of Computer: V.Rajaraman, Prentice Hall of India, New Delhi, 2008.
8. Computer Fundamentals: Pradeep K.Sinha, Preeti Sinha, BPB Publications, New Delhi, 2007.

II SEMESTER M.Sc ENVIRONMENTAL SCIENCE

E.S 201: ENVIRONMENTAL TOXICOLOGY (Core)

4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Introduction to toxicology, scope of toxicology subspecialties of toxicology, Description and terminology of toxic effects, factors influencing toxicity, drug toxicity, biochemical basis of toxicity – mechanism of toxicity and receptor mediated events, acute and chronic toxicity. Selective toxicity. Concentration and dose, synergism and antagonism. **10 hrs**

Unit 2: Dose – Response relationships – Graded response, quantal response, Time action curves, Threshold Limit Value (TLV); LC50; Margin of safety; Toxicity curves; Cumulative toxicity and LD50 & CTF. Toxicity testing; Bioassay – Definition, purpose, criteria for selection of test organism, methodology, estimation of LC50, Limitation and importance of Bioassay, Acute Toxicity (single); Sub acute Toxicity; Chronic Toxicity; Teratogenicity, carcinogenicity and mutagenicity. Immunotoxicity, histotoxicity, cell toxicity. **12 hrs**

Unit 3: Bioaccumulation and Biomagnifications of toxic materials in food chain, Toxicology of major pesticides - Environmental impacts of pesticides, biotransformation, biomonitoring, programs and parameters of biomonitoring, concept of bioindicator, bioindicator groups and examples. Basic concepts of Environmental forensics. **10 hrs**

Unit 4: Heavy metals toxicology: Bio-chemical cycles of toxic metals, Metabolism, toxicity monitoring and exposure standards for heavy metals such as Cadmium, Lead, Nickel, Mercury, Arsenic in humans - Biomonitoring of Toxic Chemicals - Objectives, programs & parameters, concepts of bio indicators groups with examples. **10 hrs**

Unit 5: Bio-transformation of Xenobiotics (Selective Toxicity); Principles, Receptor sites, absorption and storage of xenobiotics; types of Bio transformations; microsomal oxidations, mixed function oxygenizes, conjugation, biotransformation of organo-chlorine and organo-phosphorous pesticides, Antidotal procedures in Toxicology. Environmental Epidemiology: Pollution related diseases and disorders, Health Hazards. **10 hrs**

Reference Books:

1. Jerome O. Niragu and Lakshminarayana J.S.S. (1989). Aquatic Toxicology and Water Quality Management, John Wiley & Sons.

2. Sharma P.D. (1994). Environmental Biology and Toxicology, Rastoggi and Company.
3. Meera Asthana and Asthana D.K. (1990). Environmental Pollution and Toxicology, Alka Printers.
4. Mettelev V.V, Kanaev A.I and Dzasokhova N.G. (1971). Water Toxicology, Amerind Publishing Co. Pvt. Ltd.
5. Standard Methods for the Examination of water and Waste water, 17th Ed., (1989). APHA-AWWA-WPCF.
6. Guithinier Perry. (1980). Introduction to Environmental Toxicology, Elsevier.
7. Waldron H.A. (1980). Metals in Environment. Academic Press, Toronto.
8. Butter G.C. (1988). Principles of Ecotoxicology. John Wiley and Sons.
9. Moriarty F. (1983). Ecotoxicology. Academic Press, New York.
10. Oehme W.F. (1989). Toxicity of Heavy Metals in EnvironmentMarcel Dakkar Inc., New York.

ES 202: ENVIRONMENTAL ENGINNERING (Core)
4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Environmental Engineering: Introduction and Scope of Environmental Engineering, Water and Wastewater standards for specific applications. Water Demand: Manmade and environmental factors, Population forecasting methods, design period, Quality of water supply. **08hrs**

Unit 2: Wastewater Sources: Domestic and Industrial wastes, Measurement of wastewater. Objectives of wastewater Collection, Systems of collection, sewerage and drainage system, Principle of design for a sewerage system. Storm water and sewage characteristics and quantities estimation method. Physico-chemical and Biological characteristic of sewage, sewage management; disposal on land, sewage sickness; disposal by dilution, self purification/natural treatment of streams, variation of DO, BOD and COD and their importance. Stabilization of organic matter. **10hrs**

Unit 3: Objective of wastewater treatment, Principles of wastewater treatment, Unit Operation and Unit Processes, Different wastewater treatment flow sheets, Physico-chemical and Bacteriological Parameters and their role in water treatment.

06 hrs

Unit 4: Water Treatment Process: Preliminary, Primary, Secondary and Tertiary, Theory, Mechanism and Significance of Aeration, Coagulation, Flocculation, Sedimentation, Filtration and Disinfection. Chlorination, Ozonation; forms and methods of chlorination., Water softening; Hardness treatment - Desalination, Membrane Techniques Removal of Taste and Odour, Miscellaneous Treatment Methods, (Lime, Soda Process, Zeolite Process, Demineralization Process) and their Chemical reactions, Occurrence of Iron and Manganese in water, Occurrence of Fluoride in water, Significance and methods of removal, Role of Ozone and UV as a Disinfectant. Chemical Treatment of Defluoridation and Mechanism Health Effects. **14hrs**

Unit 5: Wastewater treatment methods: Primary, Secondary and Tertiary levels. Principle of Chemical Treatment, Unit Operations involved in Chemical Treatment. Methods of Treatment, Chemical Coagulation, Flocculation, Sedimentation, Filtration, Air Stripping, Ion Exchange Carbon Adsorption, Reverse Osmosis, Clarifiers, Efficiency of Chemical Precipitation, Disinfection of treated sewage, Septic tank design and effluent disposal methods. Design Aspects - Design of biological treatment units. Phytoremediatation technique of sewage. Sludge characteristics, treatment of Sludge, conventional and high rate digesters, Disposal of sludge, gas utilization. **14hrs**

Reference Books:

1. Arcadio P. Sincer and Gregoria. A Sincers Enviromental Enginnering - A design Approach. Prentice Hall of India Pvt. Ltd., New Delhi.
2. Birdie. (1999). Water Supply and Sanitary Engineering Dhanpat Rai Pub. Co. Charotal Publishing House, NewDelhi.
3. Christian R.K. Chemical and Biological Methods for Water Pollution Studies, Prentice Hall of India Press.Company, New Delhi.
4. Nandini N, Sunitha N and Sucharita Tandon. (2007). Environmental Studies, Sapna Book House, Bangalore
5. De A.K. Environmental Chemistry, Wiley Eastern Limited, New Delhi.
6. Sharma B.K. and Kour H. Environmental Chemistry, Villa Publication.
7. Garg S.K. Sewage disposal and air Pollution Engineering Khanna Publication.
8. Gilbert M. Masters. Introduction to Environmental Engineering and Science, Prentice – Hall of India Pvt., Ltd.
9. Hammer M.J. Waste Water Treatment, 2nd Ed., John Wiley and Sons.
10. Mackenize L. Davis and David A. Cornweli. Environmental Engineering,., McGraw – Hill, International Editions.
11. Metcalf and Eddy Inc. Waste Water Engineering: Treatment, Disposal, Reuse, Tata., McGraw-Hill Publishing Company Ltd.
12. Robert A.Corbitt Standard Handbook of Environmental Engineering, McGraw – Hill.
13. Sawyer C.N. Mc Carty P.L. and Perkin G.F Chemistry for Environmental Engineering IV Ed, McGraw-Hill.
14. Waste Water Engineering by Metcalf and Eddy, Tata McGraw Hill Publishing House.
15. Karia G.L. Waste Water Treatment- Concept & Design Approach.
16. Rao M.N and Datta A.K. Wastewater Treatment by, IBH Publishing Company.
17. Soli J. Arceivala. Wastewater Treatment for Pollution Control.
18. Mahida U.N. Water Pollution and disposal of Waste water on Land.
19. Rangwala R.C. and Rangwala S.C. Water Supply and Sanitary Engineering.

ES 203: ENVIRONMENTAL MICROBIOLOGY (Core)

4 Credits, 4hrs/Week, 52 hrs/semester

Unit 1: Introduction, Concepts and scope of environmental microorganisms as components of ecosystem, Classification and characteristics of Microorganisms, Microbial interactions, Role of microorganisms in element cycles – different cycles. **08 hrs**

Unit 2: Microbial diversity of environment- Microbes in air, water, waste water and soil; Introduction, distribution, sampling and measurement techniques and identification. Microbes of extreme Environment. Mechanisms of adaptation by microorganisms to environmental extremes. **12 hrs**

Unit 3: Study of air-borne allergens and air-borne diseases. Microbiological aspects in drinking water and their distribution. Indicator microorganisms and their measurement - MPN and MF technique. Bio-fouling- definition, sources and causes - bio-film and Bio-corrosion. Major antibiotic resistant bacteria in drinking water and their implications. **12 hrs**

Unit 4: Microbes in the degradation of wastes, Bioremediation - Its role in Environmental management, advantages and disadvantages. Control of pests and diseases by microorganisms, Treatment of solid and liquid industrial wastes, Microbial degradation of pesticides. Microbes in metal extraction, mineral leaching and mining, microbes in petroleum product formation Ecological implication of genetically modified microorganisms and transgenic plants on native biota and Environment. **10 hrs**

Unit 5: Food and Medical Microbiology - Introduction to Fermentation Technology. Types of microorganisms in vegetables, meat, poultry, seafood and dairy products. Spoilage of food – factors influencing spoilage - methods of detection - physical, chemical and bioassay methods. Microbial contamination in hospital environmental - Nosocomial infections: salient features and control strategies. **10hrs**

Reference books:

1. Ramesh Vijaya K. (2005). Environmental Microbiology. MGP Publishers, Chennai.
2. Edward Alcamo I. (2001). Fundamentals of Microbiology VIth Edition., Jones and Bartlett Publishers, INC.
3. Pepper W. (1995). Environmental Microbiology. A.P. Publishers.

4. William C. Frazier and Dennis C. Westhoff. (1995). Food Microbiology IVth Edition, Tata McGraw-Hill Publishing Company limited, New Delhi.
5. Michael J. Pelczar. (1986). Microbiology 5th (Ed), McGraw – Hill Book Co.
6. Michael J.Pelczar. (1994). Microbiology-Concepts and applications, McGraw-Hill Inc.
7. Martin Alexander. (1983). Introduction to Soil Microbiology 2nd Ed., Wiley Eastern Ltd.
8. Powar C.B and Daginwala H.F. (1985). General Microbiology, Vol. I &II, 2nd Ed., Himalaya Publishing House.
9. Bhattacharya R.N. (1993). Experiments with microorganisms, Reprint, Emkay Publications, New Delhi.
10. Pepper W. (1995). Environmental Microbiology. A.P. Publishers.

ES 204: ENVIRONMENTAL POLLUTION AND CONTROL (Core)

4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Air pollution: Definition, Sources and Classification of air pollutants. Transport and diffusion of pollutants. Gas laws governing the behavior of pollutants in the atmosphere. Meteorological parameters, scale of meteorology, Effect of pressure temperature, precipitation, humidity, radiation and wind. Heat transferring processes, atmospheric stability, inversions and mixing heights, Plume behavior and Stack dispersion theories & models of monitoring & control of exhaust emissions. Effects of air pollution on man, animal, plants, inanimate objects and climate. Ambient air quality standards and air pollution indices. **10 hrs**

Unit 2: Air sampling and monitoring techniques - settle able and suspended particulate matter - Dust fall jar and Impingement Method, RDS/HVS samplers (Ambient Air monitoring); Stack gas/dust Sampling technique and other techniques of air monitoring for pollutants. Automobile pollution in Indian cities. Monitoring and control of exhaust emissions. Noise Pollution: Definition, Sources and Terminology; types of noise; Measurement of noise; Noise indices; Effect of meteorological parameter on noise propagation. Noise exposure level and Standard Impact on biota and inanimate objects. Noise control and abatement measures. **14 hrs**

Unit 3: Aquatic Pollution: Definition; Sources and classification of aquatic pollutants. Cause and consequences of pollution on surface, subsurface and marine water sources. Coastal water intrusion. Oil leakage and industrial effluents. Water quality indices. Thermal pollution: Sources, causes and effects. Preventive and Control measures. **10 hrs**

Unit 4: Soil Pollution: Definition, sources and classification of soil pollutants and their impacts on physico-chemical and biological properties of soil, plants, animals and man. Physico-chemical and bacteriological sampling and analysis of soil quality. Industrial waste effluents and heavy metals, their interactions with soil components, Soil microorganisms and their function, degradation of insecticides, fungicides and weedicides in soil. Interaction of fertilizer (NPK) with different components of soil. Soil pollution control Measures. **10 hrs**

Unit 5: Radioactive Pollution: Definition, Radioactivity, Radionuclide, Radiation emissions, sources, Radioactive decay and buildup. Biological effects of radiation. Radiation exposure Standards. Radioactive pollution impacts on ecosystem. Pollution control measures. Biological dosimetry. **08 hrs**

Reference books:

1. Nandini N, Sunitha N and Sucharita Tandon. (2007). Environmental Studies, Sapna Book House, Bangalore
2. Stern A.C. (1986). Air Pollution Vol.I-VIII, Academic Press.
3. Henry C. Perkins. (1974). Air Pollution, Mc Graw Hill.
4. William L. Donn. (1975). Meteorology 4th Ed., Mc Graw Hill.
5. Furry R, Baddel.R and Haurker L. (1985). Air Pollution and Lichens.
6. Mansfiels M.R. (1989). Effects of air pollutants on plants.
7. Lodge. (1994). Methods of air sampling and analysis.
8. Trivedy R.K and Goel P.K. (1995). An Introduction to air Pollution, Techno Science Publications Jaipur.
9. Kudesia V.P. (1993). Air Pollution, Pragati Prakashan, New Delhi.
10. Mishra P.C. (1989). Soil Pollution and Soil Organisms.
11. Goel P.K. (1997) Water Pollution-Causes, Effects & Control. Techno Science Pub., Jaipur.
12. Pratap Mowle P and Venkattasubbayya N. (1990). Air pollution and Control. Divyajyothi Prakashan, Jodhpur.

ES 205: OCCUPATIONAL HEALTH HAZARDS (Soft Core)
2 Credit, 3hrs/Week, 39 hrs/semester

Unit 1: Occupational Environment- Physical, Chemical, Biological agent. Occupational hazards- Physical hazards, chemical hazards, Biological hazards. Occupational diseases- Pneumoconiosis- silicosis, Anthracosis, Byssinosis, Bagassosis, Astertosis, Farmers lung, Lead poisoning, Occupational cancer, Occupational Dermatitis, Radiation hazards. **08hrs**

Unit 2: Occupational hazards of agricultural workers- somatic diseases, accidents, toxic hazards, physical hazards, respiratory diseases, accidents in industry, sickness, absenteeism, health problems due to industrialization .Measures for health protection of workers, preservation of occupational diseases medical measures, engineering measures Human health problems due to pollution, public health programs , food poisoning- types of food poisoning prevention and control, indicators of health. **12hrs**

Unit 3: Occupational hazards: Evaluation and control of occupational health hazards; occupational health surveillance, Control programmes in the context of Indian Factories Act - case studies. Epidemiology and Public health - Principles of Epidemiology, Epidemiology and control of diseases caused by important microbes in water, air, milk and soil. Status of communicable diseases in India. Administration of public health in India. **10hrs**

Unit 4: Public health Legislation- The Factories Act, 1948. Industrial safety standards and regulations. Accidents – definitions - prevention and control. Safety management system- concepts of safety management systems- EMS ISO 14000 series and ISO 25000 series. OSHA. Public Liability Insurance Act, Mining Act. **9hrs**

References Books:

1. Benjamin O. Fundamental principles of occupational health and safety.
1. Louis J. Diberardinis. Alli Handbook of Occupational Safety and Health.
2. Keith Smith and David N. Petley. Environmental Hazards: Assessing Risk and Reducing Disaster.
3. Peter H. Wald, Gregg M. Stave Proctor and Hughes. Physical and Biological Hazards of the work place.
4. Gloria J. Hathaway, Nick H. Proctor, James P. Hughes. Chemical Hazards of the Workplace.
5. G. K. Kulakarni. Implementation of occupational health legislation at work place, issues and concerns.

III SEMESTER M.Sc ENVIRONMENTAL SCIENCE

ES 301: SOLID AND HAZARDOUS WASTE MANAGEMENT (Core)

4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Solid Waste: Introduction, Classification and Origin of Solid Waste, Characterisation of Solid Waste, Collection and transportation. Dumping of garbage, commercial, industrial, agriculture, mining and power plant discharges. Methods of Solid Waste Treatment and Disposal- Pyrolysis, Recycling and Reuse of Solid Waste and Management, Solid Waste Handling Methods, Segregation and Salvage, Recovery of the Bio Products, Public Health Aspect Related to Solid Waste, Status of Municipal Solid Waste in Indian cities. **08 hrs**

Unit 2: Solid Waste Management: Introduction, Vermiculture, Composting, Biogas from MSW, Landfill (Site Selection, Site Investigation and Site Characterization), Landfill Planning and Designing, Construction and Operational Practices, Landfill Quality and Control. Indian Scenario and Legislative Control, Municipal Solid Waste (Management and Handling) Rules, 2000. **12 hrs**

Unit 3: Hazardous Waste: Definition, Classification, Identification, Sources and Characteristics of Hazardous Waste, Integrated Approach for Minimization of Air, Water and Solid Pollutants, Collection, Storage, Transportation, Hazardous Waste Testing in Terms of Toxicity, Corrosively, Ignitability and Reactivity, Priority Pollutants, Acute and Chronic Toxicity, Bioaccumulation, Mutagenicity, Teratogenicity, Carcinogenicity and Genotoxicity. **12 hrs**

Unit 4: Hazardous Waste Treatment & Management: Physico-Chemical, Biological and Thermal Destruction of Hazardous Wastes, Incineration, Pyrolysis, Wet Air Oxidation. Containment Technologies, Secured Landfill, Land Farming, Bioremediation, Biodegradation of Recalcitrant, Xenobiotics Treatment. Guidelines for Identification of Landfill for Hazardous Waste Disposal. Leachate Management Waste Minimization, Recycle and Reuse of Hazardous Waste, Recovery of Chemicals from Hazardous Wastes. **10 hrs**

Unit 5: Hazardous Waste Treatment Facility: Planning of Hazardous Waste Incinerator & Management and Handling Rules, India-1989. Categories of Biomedical Waste. Contaminated Site Remediation- *Ex-Situ* and *In-Situ* Approach, Landmark Episodes. Biomedial Waste Management – Characterization, Types, quantity, segregation, treatment and disposal. Biomedical waste management in developed countries and in India – legal

aspects. E-waste, composition, sources. E-waste management in global and national scenario, Recycling and disposal strategies. **10 hrs**

Reference

1. Aradhana Salpekar. Solid waste pollution, Jnanada Prakashan, New Delhi.
2. Lie D.H.F and Liptak B.G. (2000). Hazardous Wastes and Solid Wastes-Lewis publishers, New York.
3. Solid Waste management in Developing countries – Indian National Scientific.
4. Milary Theiren and Samuel A. Solid waste management- George Tehobanaglous-
5. WHO Manual on solid waste management.
6. CPHEEO Manual on solid waste management.
7. La Grega M.D, Buckingham P.L and Evans. Hazardous Waste Management, II Ed,
8. Baker K.M. and Herson, B.S. (1994). Bioremediation Mc. Grqw-Hill Inc.
9. Eweis, J.B, Ergas S.J, Change D.P.Y and Schroeder E.D. Bioremediation-Principles, Mc. Grqw-Hill Inc.
10. Charles A.Wentz. (1996). Hazardous waste Management. McGraw –Hill International Edition.
11. Tandon. (1995). Recycing of crop, Abnimal and Human waste in Agriculture. Mc-Graw Hill Publishing Co.
12. Tchobanaglous, Theisen and Vigil. (1994). Integrated Solid Waste Management- Engineering principles and management issues.

ES 302: NATURAL RESOURCES MANAGEMENT (Core)
4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Natural Resources: Definition, Classification, concepts and distribution of natural resource in India and global level. Importance and applications of natural resources, Conservation and Management- Definition, Broad Classification, Renewable, Non Renewable and Mineral Resources. Renewable (Non Conventional Source of Energy). Solar Energy, Wind Energy, Geothermal Energy, Tidal Energy, Biomass energy (Bio Gas), Ocean Energy and Magneto-hydrodynamic Power (MHD), Impact on Environment and their applications, Energy Production Consumption and Energy use pertain in different part of the world. Non Renewable (Conventional Source of energy): Thermal Power, Hydro Energy, Atomic Energy, Nuclear Energy (Fission and Fusion) and Fossil fuels (Coal, Petroleum Oil and natural Gas). **12 hrs**

Unit 2: Power generation from waste. Biogas plants - principles of generation, designs, application of biomass technology to increase the hydrocarbon chain. Pyrolysis. Biogas from solid waste. Biofuels. Conservation of Energy - Importance, Methods of Conservation, Barriers to Energy Conservation, Measures for Promoting Energy Conservation, Eco-Friendly Energy Sources, Energy Audit. **10 hrs**

Unit 3: Mineral Resource management**:** Resources and reserves. Metals and Non-Metals, Formation of Mineral Deposits, Consequences of over Exploitation and Conservation of Mineral resources of India and their Distribution. Oceans as new areas for exploration of mineral resources. oceans ore and recycling of resources. **08 hrs**

Unit 4: Water Resources Management - Concept and classification, integrated water resource management; Participatory watershed development; rain water harvesting. National Lake and River Conservation Programmes. Wetland management. Coastal zone management- concept, scope, issues and strategies. Implications of National River linking programme on environment. Water Conservation Strategies in India–Rain Water Harvesting. **10 hrs**

Unit 5- Land and Forest Resources: Agricultural Practices in India - Exploitation of Agricultural Land. Range Land Management - Wasteland development – concept scope, issues and strategies. Forest resource Management: Importance of Forestry, forest products, Forest based medicinal & Pharmaceutical Industries. Forest management practices and programmes. Forest – land-use changes in India - future demand of forestlands. Afforestation and Joint Forest Management – Social Forestry, Agro-Forestry, urban forestry.

Protected forest area management – Eco-development committees and Eco-tourism. Gene pool management. Forest Fire and its Control. Wildlife habitat management- In-situ and Ex-situ conservation of Biodiversity in India. Conservation of key wildlife species – project tiger, project elephant, crocodile project. Role of Non Governmental Organizations in wildlife and forest conservation. Salient Features of Forest Act. **12 hrs**

Reference Books:

1. V. P. Agrawal. (1968). Forests in India: Oxford & IBH Publishing Co. Pvt.Ltd. New Delhi.
2. Sitram Rao. Introduction to Social Forestry, Oxford and IBH Pub. Co. Pvt. Ltd.
3. Anand S. Bal. (2005). An Introduction to Environmental Management, Himalaya Publishing House.
4. Prabhakar V.K. Energy Resources and Environment, Anmol Publisher
5. Biomas Energy and Environment: H.R. Ravindranath, Oxford University Press,New York. 1995.
6. Rai G.D. Non Conventional Energy Sources, Khanna Publication, New Delhi.
7. Kothari D.B and Singal K.C. (2011). Renewable Energy Sources and Emerging Technologies: PHI Learning Pvt. Ltd. New Delhi.
8. Satyanaraya, Sitre S.R, Zade S.B, Meshram P.U. A Textbook of Environmental Studies: Allied Publisher.
9. Oliver S. Owen. (1980). Natural resources conservation – An Ecological approach, 3rd edition, Macmillan publishing Co. Inc. New York.
10. Daniel D. Chiras. (1994). Environmental Science. 4th edition.
11. Sapru R.K. (1987). Environment Management in India. Vol. I & II. Ashish Pub. House.
12. The state of India's Environment, The second citizen's report (1984-85). Center for science and environment. New Delhi.
13. Agarwal and Rana S.V.S. (1985). Environment & Natural resources, society of Biosciences.
14. Sharma V.K. (1985). Water resources planning and management, Himalaya Pub. House.
15. Maheshwar Dayal. (1992). Renewable energy. Konark publishers Pvt. Ltd.
16. Shrikande R.P and Varade S.R. (1991). Ecology of water and land management vol 1 & 2, Chugh publishers.

17. Kittredge J. (1978). Forest influences. Dover publishers Inc. New York.
18. Srivastava M.B. (1977). Introduction to forestry. Vikas publishers, New Delhi.
19. Agarwal V.G. (1985). Forests in India. Oxford and IBH, New Delhi.
20. Negi S. S. (1986). Handbook of social forestry. IBH, New Delhi.
21. Singh B. (1992). Social forestry for rural rural development Anmol publication, NewDelhi.
22. Wenger K.E. (1984). forestry Handbook. Jhon Wiley and sons. New York.
23. Berthkur S. and Ghosh A.K. (1987). Biological pest 18. simons, I.J. eds. 1986. The ecology of natural resources.
24. Shafi R. (1992). Forest ecosystem of the World.
25. Nalini K.S. (1993). Environmental resources and management. Anmol publishers.
26. Aradhana P.S. (1991). Environ mental management. Rajat publishers.
27. Singh G. (1996). Manual of soil and water conservation practices.
28. Coppel H.C and Mertins J.W. (1997). Biological insect pest suppression. Springner – Verlag, Heidelberg, New York.
29. Haue R and Freed V.H. (1975). Environmental dynamics of pesticides. Menum press, London.
30. Raymond F. Dasmann. (1984). Environmental conservation, 5th eds. John wiley & Sons.
31. Shrikande R.P and Varade S.R. (1991). Ecology of water and land management vol 1& 11, Chugh publishers.
32. Newson M.M. (1993). Managing the human impact on the natural environment: patterns and processes. International book distributor, Dehradun.
33. Rajagopalan R. (2005). Environmental Studies, Oxford University Press, New Delhi.

ES 303: REMOTE SENSING AND GIS APPLICATION (Core)

4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Satellites and their characteristics – Geo-stationary and sun-synchronous, Earth resource Satellites- Indian Space programme. Basics of remote sensing: Definition, concepts and principle of energy interactions with environmental components. Electromagnetic spectrum, Principles of radiation; radiation transfer; Physics of Remote Sensing; Active and Passive remote sensing. Ideal and Real remote Sensing characteristics. Fundamental of aerial photographic systems; Principle: Types of aerial cameras, aerial photos; ground coverage; radiometric characteristics, Interpretation principles and techniques and Applications of aerial photos. **12 hrs**

Unit 2: Sensors and Scanners- Profiles and geometry of scanners, different types of sensors, their characteristics; Multispectral and thermal scanning. Thermal and Microwave sensing; basic concepts, profiles; SAR, SLAR-operations, characteristic of RADAR signals; earth surface characteristics influencing RADAR returns interpretation of microwave data. **08 hrs**

Unit 3: Digital image processing: Basic concepts and principles; image enhancement; edge enhancement; band rationing classification-supervised and unsupervised classification. Smoothing and filtering techniques; post classification smoothing classification accuracy enhancement; data merging; scale effects. **08 hrs**

Unit 4: GIS - Definitions, Components, History and Development. Concept of space and spatial data: type, characteristics, quality and sources of spatial data. Data input, verification, storage and output. Data stream, Geo-referencing and Map scale. Spatial Data Models - Raster Data Model, Vector Data Model. Database: Different formats for database. Hierarchical, network, relational and object-oriented data models. Linking spatial and nonspatial data. Spatial Data Analysis**:** Measurements, Queries, Overlay, Topology, Buffering. TIN and DEM. Current issues and future GIS. **12 hrs**

Unit 5: Application of Remote Sensing, GPS and GIS for Environmental Planning and Management: Vegetation cover, Agriculture, Surface and Ground water, Watershed, Marine resources, Coastal zones, Wild life Ecology, Mining and Quarrying; Agriculture and range land application; earthquakes and flood mapping assessment. **12 hrs**

Reference Books:

1. Anji Reddy M. (2000). Remote Sensing and Geographical Information Systems: An Introduction. Book Syndicate.
2. Robert G. Reeves (Ed). (1983), Manual of Remote Sensing, Johm Wiley and Sons, New York.
3. Morris M. Thomson (Ed). (1988). Manual of Photography. Tata McGraw-Hill. Publishing Co.
4. Berry. S Siegal and Allen R.Gillspie. (1987). Remote Sensing in Geology, Tata McGraw-Hill. Publishing Co.
5. Miller J.C. (1986). Photography, John wiley and Sons, New York.
6. Smith J.T. (1991). Manual of colour Photography. John Wiley and Sons, New York.
7. Leuderr D.R. (1993). Aerial Photography interpretation – Principles and Applications, McGraw – Hill.
8. Lillesand and Kiefer. (1993). Principles of Remote Sensing
9. Nag P and Kudrat M. (1998). Digital Remote Sensing. Concept Publishing Co., New Delhi.
10. Chouhan and Joshi K.N. (1996). Applied Remote Sensing and Photo interpretation.
11. Rajan M.S. (1991). Remote Sensing and GIS for Natural Resources.
12. Narayana L.R.A (1999). Remote Sensing and its application University Press (India).
13. Lillesand T.M. (1987). Remote Sensing and Image interpretation. John Wiley, Hamburg.
14. Sabins F.F and Floyd F.J.R. (1978). Remote Sensing- Principles and interpretations.
15. Burroguh P.A and Mc Donnell R.A. (1988). Principles of Geographical Information system. Oxford Univ.Press.
16. Jorgevsen S.E. (1996). Applications of ecological modeling in environmental management. Elsevier Sci. Co., London.
17. Muralikrishna I.V. (2001). Spatial Information Technology- RS and GIS. Vol.I and II BS Publications, Hyderabad.
18. Burrough P.A. (1986). Principles of GIS for Land Resource Assessment. Oxford University Press.
19. Elachi C. (1978). Introduction to Physics and Techniques of Remote sensing. John Wiley Publication New York.

ES 304: CLIMATE CHANGE AND CURRENT ISSUES (Open Elective)

4 credits, 4 hrs/week, 52hrs/semester

Unit 1: Global Environmental problems: Ozone depletion, causes and effects. Acid Rain acid rain formation, adverse effects of acid rain. Photochemical smog, Factors Responsible for photochemical smog. **08 hrs**

Unit 2: Global Climate Change: Introduction, Sources of Greenhouse Gases - Carbon dioxide, Methane, Nitrous oxide, Chlorofluoro carbons and water vapour. Atmospheric Ozone, Mechanism of Ozone Depletion, Effects of Ozone Depletion, Climatic Effects and Environmental Disturbances due to Ozone Depletion, Advance Research to Protect the Ozone Layer, Antarctic Ozone Hole and Consequences. **10 hrs**

Unit 3: Greenhouse Effect: Implications of Climate Change, Monitoring, Assessment, Research and Prediction Programs, El-Nino and La-Nino. Green house gases, green house effect and climate change. Global warming facts – Effects of Global warming – control and remedial measures of green house effect, global warming and climate change, impacts of sea level rise. Effect on Global Climate, Consequences & Control. Atmospheric disturbances: Thunderstorms, cyclones, lightening, flood, and drought. **10 hrs**

Unit 4: Man and Ecodegradation of Natural Environment: Present status of wasteland in India. Problems and prospects of wasteland development. Wasteland reclamation through Social Forestry, Bioaesthetic planting for pollution abatement. Eutrophication and restoration of Lakes, Environmental ethics - stewardship ethics and lifeboat ethics of Garret Hardin. Fly ash utilization, wet land conservation, environmental disaster (manmade) episodes; Minamata and Itai-Itai disease, London smog, Los Angeles smog, Bhopal gas tragedy. **12 hrs**

Unit 5: Current Issues and Environmental Problems: Narmada Dam, Tehri Dam, Almatti Dam, Waste lands and their Reclamation, Water Crises-Conservation of Water, Eutrophication and Restoration of Indian Lakes. Scheme of Labeling of Environmentally Friendly Products (Eco Mark). Environmental conferences – importance goals and achievement. International agreements, United Nations conventions on climate change, Stockholm Conferences – Conference of Parties, Earth summit, Copenhagen Conference, Durban Conference and Worldwide Role of NGO in Environmental Management, Concept and Strategies of Sustainable Development, Cost Benefit Analysis, Environmental Priorities in India. **12 hrs**

Reference Books:

1. Nanda. A.N. (1996). Environmental Education.
2. Agarwal K.M, Sikdar P.K. and Deb S.C. (2002). A text book of Environment – MacMiller India Ltd., Calcutta
3. Tyler Miller Jr. Living in the Environment – Principles, Connections and Solutions.
4. Botkin D.B. (1989). Changing the Global Environment, Academic Press, San Diago.
5. Howard J. Critchfield. (1983). General Climatology (Fourth Edition), Phi Learning Pvt Ltd.
6. Mark Maslin. (2013). Climate - a very short introduction, Oxford University Press.
7. Roger G. Barry and Richard J. Chorley. (2007). Atmosphere, weather and Climate, 8th Edition, Routledge Publishers.
8. Oliver. (2002). Climatology: An Atmospheric Science, 1st Edition, Pearson Publishers.
9. Mark Maslin. (2008). Global Warming, 2nd Edition, Oxford University Press Publishers -New Delhi.
10. Manoj Singh. (2012). Climatology: Sonali Publications Publisher.

ES 304: WATER SUPPLY AND RESOURCES (Open Elective)

4 credits, 4 hrs/week, 52 hrs/semester

Unit 1: Sources of Water Supply: Importance and Necessity of Water Supply Scheme, Essential of Water Supply Scheme, Types of Water Sources, Surface Sources- General, Sources of Water, Streams, Lakes, Rivers, Ponds, Impounded Reservoirs, Stored Rainwater, Suitability of Surface Water with Regard to Quality and Quantity, Reservoir Storage Capacity. **08 hrs**

Unit 2: Surface & Ground Water Quality: Infiltration, Porosity, Water Bearing Stratum, Groundwater flow, Groundwater Yield, Permeability, Groundwater Velocity, Springs, Infiltration Galleries, Porous Pipe Galleries', Classification of Wells, Dug Wells or Percolation Well, Yield & Types of Wells, Tube Wells, Specific Capacity of a Well, Infiltration Well, Artesian Well, Yield of a Artesian Well, Yield of an Infiltration Gallery. Parameters of Organic Content of Water Quality, DO and BOD, Transformation and Transport Process in Water Body, Oxygen Transfer by Interphase, Turbulence Mixing in River, Water Quality in Lakes and Rivers and Groundwater. **12 hrs**

Unit 3: Quantity and Quality of Water: Types of Demand, Factor Affecting Rate of Demand, Variations in Rate of Demand, Measurement of Water Quantity, Effects of Variation on Design, Water Requirements for Buildings Other than Residences, Estimating Population, Factors Affecting Estimated Population. Meaning of Pure and Potable Water, Impurities in Water, Analysis of Water, Physical Tests, Chemical Test, Bacteriological Tests, and Maintenance for Purity of Water, Precaution and Preservation, Water Born Diseases. **10 hrs**

Unit 4: Distribution of Water: Method of Distribution System, Requirement of Distribution of Water and their Merits and Demerits, System of Supplying Water, Types of Service Reservoir, Different Layout for Distribution of Water, Design and Maintenance of Distribution System, Analysis of Pipe Network, Detection and Prevention of Leakages, Rectification, Types of Valves, Fire Hydrants, Water Meters. **10 hrs**

Unit 5: Water Softening: Necessity of Water Softening, Types of Hardness, Methods of Water Softening, (Lime, Soda Process, Zeolite Process, Demineralization Process) and their Chemical Reactions, Occurrence of Iron and Manganese in Water. Modern Water Treatment Techniques**:** Introduction, Removal of Colour, Odour and Taste, Aeration, Treatment With Activated Carbon, De-Salinisation of Brackish Waters, Distillation, Reverse Osmosis, Solar Distillation, Mineral Waters, Natural Mineral Water Quality Requirement of Packaged Drinking Mineral Waters. **12 hrs**

Reference Books:

1. Willered Merit and Dean. Instrumental Methods of Analysis, CBS Publication, New Delhi.
2. Soli J. Arceivala. Wastewater Treatment for Pollution Control: Tata McGraw Hill Publishing Company, New Delhi.
3. Birdie G.S. Water Supply & Sanitary Engineering.
4. Husain S.K. Textbook of Water Supply & Sanitary Engineering.
5. Rangwala R.C and Rangwala S.C. Water Supply & Sanitary Engineering: Charotal Publishing House.
6. Rao M.N and Datta A.K. Wastewater Treatment, IBH Publishing Company, New Delhi.
7. Vinayak Gharpure. A Textbook of Sanitary Engineering: Engineering Book Publishing Company, Pune.
8. Kudesia V.P. Water Pollution:, Pragati Prakashan, Meerut.
9. Asthana D.K. Environmental Problems and Solution, S.Chand publications Company, New Delhi.

ES 304: EIA AND ENVIRONMENTAL POLICY (Open Elective)
4 credits, 4hrs/week, 52 hrs/semester

Unit 1: Environmental Impact Assessment: Definition, basic concepts and principles of EIA. Regulatory framework in India. Environmental inventory; Baseline studies. Overview of EIA - Assessment and Methodologies: Physical Assessment, Biological Assessment - Fauna and Flora. Socio-economic and cultural Environmental Assessment. EIA methodologies - Adhoc Approach, Matrix Approach, Checklist Approach, Economic Evaluation of impacts - Cost Benefits of EIA. Public participation in Environmental decision making. Procedures for reviewing EIA analysis and Statement. Decision methods for evaluation of alternatives. **12 hrs**

Unit 2: Application of EIA and EMP to development projects - Site selection criteria for pre and post constructional activities. Carrying capacity based EIA, EIA for selected developmental projects - transportation, water resources, mining and quarrying, industrial, tourism development, nuclear power plants and urban areas. **10 hrs**

Unit 3: Environmental Guidelines and Auditing: Environmental Impact Assessment guidelines 1994 (India), CPCB guidelines (1996). Environmental Management Plan - ISO 14000 series. Environmental indices and indicators for describing the affected environment. **10 hrs**

Unit 4: Planning: Importance of planning, local, regional, state and national planning. Zoning-Physical planning. National policy, sectorial – integration, state level policy and implementation. Organizational structure at state and central governmental levels. Urban and rural land use planning in India. **08 hrs**

Unit 5: Legal control of Environmental pollution in India with special reference to: The Indian Wildlife (Protection) Act, 1972; The Water (Prevention and control of pollution) Act, 1974, amended 1988; CESS Act 1977, amended in 1991; The Forest (Conservation) Act, 1980, amended in1988; The Air (Prevention and Control of Pollution) Act, 1981, amended in 1990; The Environment (Protection) Act, 1986; The Wildlife (Protection) Rules, 1995; The Indian Forest Act, 1927; The Forest (Conservation) Act, 1980; The Forest (Conservation) Rules, 1981; Biomedical waste (Management & Handling) rules, 1998; Hazardous Wastes (Management and Handling) Rules,1989; Municipal waste (Management & Handling) rules, 2000; E-waste (Management & Handling) Rules, 2011. Salient Features of Coastal Zone Regulations (CZR) Notification, the Convention of Biodiversity. (Several Case Studies to be given as Assignment). **12 hrs**

Reference Books:

1. Anjane Yulu. (2011). Environmental Impact Assessment Methodologies 2nd Edition, BSP Books Pvt Ltd.
2. Divan Shyam and Rosencranz Armin. (2002). Environmental Law And Policy In India: Cases, Materials And Statutes 2nd Edition. Oxford University Press
3. Trivedi P.R. (2004). Environmental Impact Assessment, 1st Edition, APH Publishing Corp.-New Delhi.
4. Kailash Thakur. (2005). Environmental Protection, Law and Policy in India, 1st Edition, Deep & Deep Publications Pvt. Ltd.
5. Hosetti. B.B. (1998).Environmental Impact Assessment and Management, Daya Publishing House.
6. Digumarti Bhaskara Rao. (2012). The Theory and Practice of Environmental Impact and Assessment, 1st Edition, Discovery Publishing House Pvt. Ltd.
7. Aruna Venkat. (2011). Environmental Law and Policy. New Arrivals – PHI.
8. Leelakrishnan P. (2008). Environmental Law In India 3rd Edition (English) 3rd Edition. LexisNexis India.
9. Dharmendra S Sengar. (2009). Environmental Law, 1st Edition, Phi Learning Pvt Ltd.
10. Ganesamurthy V. S. (2011). Environmental Status and Policy in India, New Century Publications.

ES 304: NATURAL RESOURCES MANAGEMENT (Open Elective)

4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Natural Resources: Definition, Classification, concepts and distribution of natural resource in India and global level. Importance and applications of natural resources, Conservation and Management- Definition, Broad Classification, Renewable, Non Renewable and Mineral Resources. Renewable (Non Conventional Source of Energy). Solar Energy, Wind Energy, Geothermal Energy, Tidal Energy, Biomass energy (Bio Gas), Ocean Energy and Magneto-hydrodynamic Power (MHD), Impact on Environment and their applications, Energy Production Consumption and Energy use pertain in different part of the world. Non Renewable (Conventional Source of energy): Thermal Power, Hydro Energy, Atomic Energy, Nuclear Energy (Fission and Fusion) and Fossil fuels (Coal, Petroleum Oil and natural Gas). **12 hrs**

Unit 2: Power generation from waste. Biogas plants - principles of generation, designs, application of biomass technology to increase the hydrocarbon chain. Pyrolysis. Biogas from solid waste. Biofuels. Conservation of Energy - Importance, Methods of Conservation, Barriers to Energy Conservation, Measures for Promoting Energy Conservation, Eco-Friendly Energy Sources, Energy Audit. **10 hrs**

Unit 3: Mineral Resource management**:** Resources and reserves. Metals and Non-Metals, Formation of Mineral Deposits, Consequences of over Exploitation and Conservation of Mineral resources of India and their Distribution. Oceans as new areas for exploration of mineral resources. oceans ore and recycling of resources. **08 hrs**

Unit 4: Water Resources Management - Concept and classification, integrated water resource management; Participatory watershed development; rain water harvesting. National Lake and River Conservation Programmes. Wetland management. Coastal zone management- concept, scope, issues and strategies. Implications of National River linking programme on environment. Water Conservation Strategies in India–Rain Water Harvesting. **10 hrs**

Unit 5- Land and Forest Resources: Agricultural Practices in India - Exploitation of Agricultural Land. Range Land Management - Wasteland development – concept scope, issues and strategies. Forest resource Management: Importance of Forestry, forest products, Forest based medicinal & Pharmaceutical Industries. Forest management practices and programmes. Forest – land-use changes in India - future demand of forestlands. Afforestation and Joint Forest Management – Social Forestry, Agro-Forestry, urban forestry.

Protected forest area management – Eco-development committees and Eco-tourism. Gene pool management. Forest Fire and its Control. Wildlife habitat management- In-situ and Ex-situ conservation of Biodiversity in India. Conservation of key wildlife species – project tiger, project elephant, crocodile project. Role of Non Governmental Organizations in wildlife and forest conservation. Salient Features of Forest Act. **12 hrs**

Reference Books:

1. Agrawal V.P. (1968). Forests in India: Oxford & IBH Publishing Co. Pvt.Ltd. New Delhi.
2. Sitram Rao. Introduction to Social Forestry, Oxford and IBH Pub. Co. Pvt. Ltd.
3. Anand S. Bal. (2005). An Introduction to Environmental Management, Himalaya Publishing House.
4. Prabhakar V.K. Energy Resources and Environment, Anmol Publisher
5. Biomas Energy and Environment: H.R. Ravindranath, Oxford University Press,New York. 1995.
6. Rai G.D. Non Conventional Energy Sources, Khanna Publication, New Delhi.
7. Kothari D.B and Singal K.C. (2011). Renewable Energy Sources and Emerging Technologies: PHI Learning Pvt. Ltd. New Delhi.
8. Satyanaraya, Sitre S.R, Zade S.B and Meshram P.U. A Textbook of Environmental Studies: Allied Publisher.
9. Oliver S. Owen. (1980). Natural resources conservation – An Ecological approach, 3rd edition, Macmillan publishing Co. Inc. New York.
10. Daniel D. Chiras. (1994). Environmental Science. 4th edition.
11. Sapru R.K. (1987). Environment Management in India. Vol. I & II. Ashish Pub. House.
12. The state of India's Environment, The second citizen's report (1984-85). Center for science and environment. New Delhi.
13. Agarwal and Rana S.V.S. (1985). Environment & Natural resources, society of Biosciences.
14. Sharma V.K. (1985). Water resources planning and management, Himalaya Pub. House.
15. Maheshwar Dayal. (1992). Renewable energy. Konark publishers Pvt. Ltd.
16. Shrikande R.P and Varade S.R. (1991). Ecology of water and land management vol 1 & 2, Chugh publishers.

17. Kittredge J. (1978). Forest influences. Dover publishers Inc. New York.
18. Srivastava M.B. (1977). Introduction to forestry. Vikas publishers, New Delhi.
19. Agarwal V.G. (1985). Forests in India. Oxford and IBH, New Delhi.
20. Negi S.S. (1986). Handbook of social forestry. IBH, New Delhi.
21. Singh B. (1992). Social forestry for rural rural development Anmol publication, NewDelhi.
22. Wenger K.E. (1984). forestry Handbook. Jhon Wiley and sons. New York.
23. Berthkur S and Ghosh A.K. (1987). Biological pest 18. simons, I.J. eds. 1986. The ecology of natural resources.
24. Shafi R. (1992). Forest ecosystem of the World.
25. Nalini K.S. (1993). Environmental resources and management. Anmol publishers.
26. Aradhana P.S. (1991). Environ mental management. Rajat publishers.
27. Singh G. (1996). Manual of soil and water conservation practices.
28. Coppel H.C and Mertins J.W. (1997). Biological insect pest suppression. Springner – Verlag, Heidelberg, New York.
29. Haue R and Freed V.H. (1975). Environmental dynamics of pesticides. Menum press, London.
30. Raymond F. Dasmann. (1984). Environmental conservation, 5th eds. John wiley & Sons.
31. Shrikande R.P and Varade S.R. (1991). Ecology of water and land management. Vol 1& 11, Chugh publishers.
32. Newson M.M. (1993). Managing the human impact on the natural environment: patterns and processes. International book distributor, Dehradun.
33. Rajagopalan R. (2005). Environmental Studies, Oxford University Press, New Delhi.

ES 401: ENVIRONMENTAL ECONOMICS AND SUSTAINABLE DEVELOPMENT (Core)

4 credits, 4hrs/week, 52hrs/semester

Unit 1: Environmental Economics: Definition, Relation between Economics and environment, environmental quality and environmental costs, economics of natural resources, resource taxonomy – resource scarcity, problem of social costs, economics of exhaustible resources. **08 hrs**

Unit 2: Economics Valuation, concept of economic value – objectives, standard based valuation, indirect and direct method of valuation, cost-benefit analysis. Negative international externalities and global concerns. Methods of site selection and evaluation. **10 hrs**

Unit 3: Sustainable Development: Scope & definition, goals, principles of sustainability. Population stabilization, integrated land use planning, Healthy cropland and grassland, woodland revegetation, conservation of biological diversity, control of pollution, development of non-polluting renewable energy systems. Recycling of wastes, ecologically compatible human settlement and slum improvement, environmental education and awareness. **12 hrs**

Unit 4: Planning: definition and concept, land use policy for India. Urban and rural planning for India. Land use and land cover planning. Arable lands in India. Environmental priorities in India. Sustainable development in practice: sustainable urban and industrial development. Sustainable agriculture and rural development, Sustainable resource management. **10 hrs**

Unit 5: Sustainable agricultural rotations of crops, organic farming. Environmental degradation due to pesticides and chemical fertilizers-Sustainable Management. Environmental movements and role of NGO's in sustainable development. Global policy for sustainable development – world summits. Urbanization and its impact on Environment. Rural and Urban planning for sustainable development. **10 hrs**

Reference Books:

1. Berck Peter and Helfand Gloria. (2011). The Economics of The Environment. Prentice-Hall Publishers.
2. Jhingan M.L. (2009). Environmental Economics - Theory, Management & Policy, 2nd Edition. Vrinda Publications PLT-Delhi Publishers.

3. Anne Bayley and Tracey Strange. (2010). Sustainable Development: Linking Economy, Society, Environment, Academic Foundation Publishers.
4. Sundar I. (2006). Environment and Sustainable Development, 1st Edition, APH Publishing Corporations Publishers.
5. Bhattacharya Rabindranath (Ed). (2002). Environmental Economics : An Indian Perspective, 1st Edition, Oxford University Press Publishers.
6. Karpagam. (1986). Environmental Economics.
7. Anil Shishodia. (2007). Environmental Economics: Theory and Applications, Sage Publications India Pvt. Ltd. Publishers.
8. Maruthi S. (1998). Economic growth and environment. RSBA publishers.
9. David C. (1988). Environmental Economics. EarthScan, UK.
10. Eco-Efficiency: The Business link to Sustainable Development by Livio Desimone.
11. Planning Sustainability by Michael Kenny.
12. Environmentally Sustainable Economic Development by Asayehgn Desta.
13. Sakarama Somayaji. (2011). Environmental Concerns and Sustainable Development: Some perspectives from India. TERI Press.

ES 402: ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL LAW (Core)

4 credits, 4hrs/week, 52hrs/semester

Unit 1: Environmental Impact Assessment: Definition, Basic Concepts and Principles of EIA. Nexus between Development and Environment, Need for EIA, Elements of EIA, Environmental Attributes, Nature of Impacts- Primary, Secondary, Tertiary, Short Term, Long Term, Reversible and Irreversible Impacts. Overview of Impacts, Directly and Indirectly Measurable Impacts of Air, Noise, Water, Land, Biological and Socio-Economic Elements. **10 hrs**

Unit 2: EIA Procedure: Screening and Scoping in EIA, Methodologies of EIA, Checklist, Matrices, Overlays, Cost Benefit Analysis, Computer Aided EIA, Battelle Environmental Evaluation System-Impact Identification Networks, Strategies for Environmental Management Plan and Green Belt Development Role of Mathematical Models in EIA. Environmental Appraisal of Project with Reference to Industry, Mining and water. Resources projects-Critical Issues and Formulation of Strategies for EMP, Strategies. Environmental Impact Assessment, Methods, Benefits, Legislation of EIA in India and Modification. Role of Statutory Agencies in EIA Clearance. **10 hrs**

Unit 3: Environmental Audit and EMS: Definition, Concept of EA, Types of EA, Benefits of Environmental Audits, Scope and Objectives, Procedural Requirements of Conducting EA, Pre-Audit, on-Site Audit and Post Audit Activities, Water Audit, Raw' Materials Audit and Energy Audit, Health and Safety Audit-Reuse and Conservation of Water and Energy, Waste Minimization, Environmental and Economic Benefits of An Environmental Audit, ECO- Audit and its Importance in Environmental Management. Concept of ISO 9000 and ISO 14000 series in Environmental System Management. **12 hrs**

Unit 4: Environmental protection: issues and problems. International and national efforts for environmental protection. Environmental Policies: Need for policies; different policies. Environmental policy resolution. Public policy - strategies in pollution control. **08 hrs**

Unit 5: Environmental Legislation: Constitutional and Statutory Laws in India, Fundamental Duties and Fundamental Rights, Legal Control of Environmental Pollution with Reference to: Biodiversity bill 2006. The Indian Wildlife (Protection) Act, 1972; The Water (Prevention and control of pollution) Act, 1974, amended 1988; CESS Act 1977, amended in 1991; The Forest (Conservation) Act, 1980, amended in1988; The Air (Prevention and Control of Pollution) Act, 1981, amended in 1990; The Environment (Protection) Act, 1986;

The Wildlife (Protection) Rules, 1995; The Indian Forest Act, 1927; The Forest (Conservation) Act, 1980; The Forest (Conservation) Rules, 1981; Biomedical waste (Management & Handling) rules, 1998; Hazardous Wastes (Management and Handling) Rules,1989; Municipal waste (Management & Handling) rules, 2000; E-waste (Management & Handling) Rules, 2011. Salient Features of Coastal Zone Regulations (CZR) Notification, the Convention of Biodiversity. (Several Case Studies to be given as Assignment). **12 hrs**

Reference

1. Environmental Impact Assessment: Principles and Procedures, John Wiley and Sons, New York.
2. Environmental Impact Assessment: A.K.Shrivastav, APH Publishing Corporation, New Delhi.
3. Environmental Impact Assessment: S.A.Abbasi, D.S.Arya,Discovery Publishing House, New Delhi.
4. Environmental Pollution Control: Neelima Rajvidya and Dilipkumar Markandey, APH Publishing Corporation, New Delhi. (2005).
5. Environment Problems and Solutions: D.K.Asthana and Meera Asthana, S.Chand & Co. Ltd. New Delhi.
6. An Introduction to Environmental Management: Dr.Anand S.Bal.
7. John G. Rau and David C Wooten 1980, Environmental Impact Analysis Handbook. Mcgraw- Hill.
8. John Glasson, Riki Therival, Andrew Chdwick. Introduction to Environmental Impact Assessment, Research press. (1994).
9. Canter L. (1996). Environmental Impact Assessment. McGraw Hill.
10. Allarachand. (1985). Environmental Challenges- A global survey, UDH, New Delhi.
11. Newson M.M. (1993). Managing the human impact on the nature al Environment.
12. Nanda. A.N. (1996). Environmental Education.
13. Ulter S.L. (1994). Environmental Risks and hazards, Prentice Hall of India, New Delhi.
14. Peter Calow. (1998).Handbook of Environmental Impact Assessment, Mc Graw Hills Inc., New Delhi.
15. Westman W.E. (1995). Ecology, Impact Assessment and Environmental planning, John Wiley and

ES 403: DISASTER MANAGEMENT (Core)
4 credits, 4hrs/week, 52hrs/semester

Unit 1: Environmental Disasters: Types of Hazards- Natural and Manmade hazards-Nature of Hazards, Environmental security and Hazard zoning. Strategies of hazard mitigation. Concept of residence time and rates of natural cycles. Catastrophic-geological Hazards. Earthquake and seismic Hazards- effects of earthquake, stability of structures and risk evaluation, seismic topography. Prediction of earthquake, Volcanic Hazards- Nature of volcanic hazards, volcanic belt, prediction and mitigation of volcanic Hazards. **10 hrs**

Unit 2: Environmental security and hazard zoning and strategies for hazard mitigation. Landslides and Mud flows- Types of mass movement, strength of materials and instability of slopes, controlling the landslides. Floods and flood management- causes of floods, management of floods. Floods control methods. Avalanches- Types of avalanches monitoring of avalanches. Effects, Prediction, forecasting and mitigation of hazards. **12 hrs**

Unit 3: Manmade Disasters and Hazards: Improper Irrigation, deforestation, Industrial hazards-safety and management of hazardous waste in industry (DMP). Management of dangerous materials in Industry, Safety system in industry. Disaster and accident prevention evaluation of the common and major accidents. Safety versus production. **08 hrs**

Unit 4: Hazard prediction, perception and alteration to hazards: Environmental risks- Developmental project activities. Preparation of onsite and offsite (DMP) activities. Pre disaster, Actual disaster and Post disaster management techniques. Relief Camp Organization; role of voluntary organization and armed forces. **12 hrs**

Unit 5: Risk analysis and assessment: Vulnerability to natural hazards. Tools of risk assessment, hazard models, risk data, risk identification, risk minimization, risk communication and psychology of risks. Economic and evaluation of risks. Risk assessment in developing programmes. Experience of World Bank – risk communication. **10 hrs**

Reference Books:

1. Disaster Management – Shailendera, K Singh, Subash. C Kundu and Shobu Singh, Mittal Publications, New Delhi (1998).

2. Disaster Management – Induprakash, Rasthra Prahari Prakashan, Gaziabad (1994).
3. Industrial Hazards and Safety, Kind. R.W. and Magic J, Handbook, Butterworth (1982).
4. Disaster Prepardness in India – Narendrakumar Jain, Adhytma Sadhan Kendra Mehrauli, New Delhi.
5. Peter Calow (Ed). (1998). Handbook of Environmental Risk Assessment and Management. Blakwell Sciences, London.
6. Management of Disasters and How to prevent them, Wharband O.P. and Stallworthy, E.A. (1986).
7. Quit M.D. David Taylor and Rupert- Prudrare (Eds) (196) Environmental Impact pf Chemicals Assessment and Control. The Royal Society of Chemistry, Cambridge.
8. Petalc W.J. and AIIIssion, A.A (1982), Natural Hazards Risk Assessment and Public Policy - Anticiptating the unexpected, Springer verlag. N.Y
9. Cuttler S.l (1994). Environmental Risk and Hazards, Prentice hall of India New Delhi.
10. Introduction of Safety Science, Khulman A, TUV Rheinland, (1986).
11. Explosion Hazards & Evaluation, Barkey, W.E. Elsevier, Amsterdam (1983).
12. Natural Disasters - A Guide for relief workers - JAC Adhyatme Sadhama Kendra Mehraui, New Delhi-30.1980.
13. Harold D.Foster. (1980). Disaster Panning. The preservation of life and property. Springer-verlag. N.Y.
14. Shailendra K. Singh, Subash C, Kundu and shobu Singh (1998) Disaster Management, Mittal Publications.
15. Parasuraman S and Unikrishnan P.V. (2000). Indian Disasters report towards a policy initiative. Oxford University press.
16. Indu Prakash. (1994). Disaster Management. Rashtra Prahari Prakashan, & 50 Rajendra Nagar, Sector 2, Shababad.
17. Risk Eartquakes and peoples Vulnerability, Sudhiren Sharma; Energy and Environment Group. P.O. Bag 4, New Delhi-24.
18. Girish K. Mishra and G.C Mathur (eds). (1993). Natural Disaster reduction.Reliance Oublishing House, 302/74, Ranjit Nagar, New Delhi.
19. Narendra kumar Jain, Disaster prepardness in India. Joint Assistance centre. Adhyatma sadhana kendram Mehrauli, New Delhi-30.

ES 404: ECOFRIENDLY TECHNOLOGIES AND ENVIRONMENTAL MODELING (Core)

4 Credits, 4hrs/Week, 52hrs/semester

Unit 1: Ecotechnology -Ecological farming system, Integrated Intensive farming system, Organic farming, Advantages of Organic farming. Integrated plant nutrient management (IPNM). Soil Solarization, Genetic resource management and Ecofriendly detergents and Biodegradable plastics. Cleaner Environmental friendly Technologies: Necessity, application in fertilizer & chemical industries, agro based industries, distillery effluents etc. **10 hrs**

Unit 2: Technologies to arrest global warming: Advanced Techniques – new paradigm in business, green business – new marketing stance – CO_2 reduction potential through renewable energy. Carbon sequestration. Energy And Environment - Technology and economics of electric power generation through renewable sources, hydropower and its constraints. Decentralized versus grid electricity for rural India. **08 hrs**

Unit 3: Advanced technology for prevention & control of air pollution – Latest technologies with respect to fuel selection & utilization process design and equipment changes, site selection and zoning.– Scavenging of Particulate Matter – Gravitational Settling, Impaction on Obstacles, Precipitation, Condensation, Particle filtration, Fibrous mat, Filters, packed bed filters, Inertial Collectors, Scrubbers, Electrostatic removal of gaseous pollutants, Absorption, Adsorption, Exhaust Emission Control. **12 hrs**

Unit 4: Environmental Modeling: Definition, Concept, scope and components. Classes of Mathematical Models. Modeling procedures. Analysis of model properties; Approaches to the development of models. Use and limitations of Models Modeling of Streams, Lakes, and ground water and disposal sites. Modeling of Air, Water quality and Noise characteristics. **12 hrs**

Unit 5: Population Models : Lotka – Volterra model, Leslie's matrix model. Exponential growth curve model; Exponential decay model; Fitting model emanations in experimental data. **10 hrs**

Reference Books:

1. Keith J. Beven. Environmental Modelling: An Uncertain Future, 1st Edition, Routledge Publishers.

2. Jo Smith Pete Smith. (2007). Introduction to Environmental Modelling, 1st Edition, Oxford University Press.
3. Bhatia S.C. (2002). Hand book of Industrial Pollution & Control CBS Publishers, New Delhi.
4. Steven L, Erickson and Brain J King, Fundamentals of Environmental Management, John Wiley & sons, New york,1999.
5. Christopher Sheldon and Mark Yoxon. (1999). Installing Environmental Management Systems, Earthscan. London.
6. Sharma B.K and Kaur H. (1995). Environmental Chemistry, I Ed., Goel Publishing House.
7. Chatterji A.K. (2005). Introduction to Environmental Biotechnology, Prentice-Hall of India Private Limited. New Delhi.
8. Jorgevsen S.E. (1996). Applications of ecological modeling in environmental management. Elsevier Sci. Co., London.

PRACTICAL SYLLABUS

I SEMESTER M.Sc. ENVIRONMENTAL SCIENCE

ES 106: ENVIRONMENTAL BIOLOGY AND ENVIRONMENTAL CHEMISTRY

ES 106 - Part A: Environmental Biology

1. Sampling techniques of phytoplankton/invertebrates.
2. Estimation of primary productivity of a pond/lake.
3. Estimation of standing crop (biomass) of phytoplankton in aquatic system.
4. Numerical estimation of standing crop of phytoplankton.
5. Estimation of standing crop and productivity in grassland habitat.
6. Estimation of growth, productivity and characteristics of terrestrial plants.
7. Productivity and biomass estimation of litter fauna.
8. Estimation of standing crop in forest/plantation.
9. Estimation of chlorophyll in terrestrial plants and phytoplankton.
10. Study of Ecological adaptations – a) Hydrophytes and xerophytes

    b) Rocky shore and sandy shore fauna

ES 106 - Part B: Environmental Chemistry

1. Sampling techniques of water and air.
2. Determination of pH, Electrical Conductivity and Turbidity of water sample.
3. Determination of Total Dissolved Solids in water samples.
4. Determination of Total hardness, calcium hardness and magnesium hardness by EDTA complex metric method.
5. Determination of Chloride in water sample by $AgNO_3$ method.
6. Estimation of Phosphates in water by Ammonium Molybdate method.

7. Estimation of Sulphates in water sample.
8. Estimation of nitrates in water sample.
9. Estimation of fluorides in water sample.
10. Estimation of particulate matter, sulphur dioxide and oxides of nitrogen in ambient air.

I SEMESTER M.Sc. ENVIRONMENTAL SCIENCE

ES 107: ENVIRONMENTAL GEOLOGY AND METEOROLOGICAL SCIENCES

ES 107 - Part A: Environmental Geology

1. Study of terrain characteristics using toposheets.
2. Delineation and Morphometric analysis of watershed.
3. Study of geomorphophological models – a) coastal plain b) Volcanoes C) Fault block mountains d) Folded mountains e) Glaciers f) Canyon g) Coast line
4. Mineralogy – Identification of common rock forming minerals.
5. Petrology – Identification of major rock types – Igneous, Metamorphic and Sedimentary.
6. Verification of Lambert-Beers law.
7. Sampling techniques for soil.
8. Determination of pH and Electrical conductivity of soil sample.
9. Determination of water holding capacity, Bulk density and moisture content of soil.
10. Estimation of calcium and magnesium content of soil.
11. Estimation of organic matter in soil.
12. Estimation of available phosphates and total nitrogen in soil.

ES 107 - Part B: Meteorological Sciences

1. Study of meteorological Instruments.
2. Study of Hygrometer - Maximum and Minimum temperature.
3. Determination of relative humidity in ambient atmosphere.
4. Measurement of solar illuminations using Lux meter.
5. Rain gauge and rainfall analysis.
6. Determination of wind speed and direction by anemometers.
7. Estimation of ambient carbon dioxide.
8. Analysis of annual temperature, humidity and wind speed.
9. Study of Clouds and their types.
10. Study of meteorological parameters – collection and analysis of wind data, plotting of wind roses and pollution roses.
11. Meteorological analysis - Relation between humidity, temperatures and rainfall.
12. Community perception studies on climate change – Questionnaire method.

II Semester M.Sc Environmental Science

ES 206: ENVIRONMENTAL TOXICOLOGY AND ENVIRONMENTAL ENGINEERING

ES 206 - Part A: Environmental Toxicology

1. Estimation of dust accumulated on plant parts – leaves and its effects on morphology and anatomy of plants.
2. Detection of some Organochlorine chemicals in vegetables and fruits.
3. Estimation of protein content of biological samples.
4. Determination of total carbohydrates in biological system.
5. Observation on the effects on metal (individual and mixture) on plants.
6. Observation on the effects of metal (individual and moisture) on animals.
7. Study of rate of uptake of metal toxins by different species of plants.
8. Estimation of trace heavy metals in soil, plant and animal material.
9. Estimation of Proline in biological samples.
10. Estimation of reducing sugars.
11. Estimation of lead, zinc, chromium, copper and mercury in biological samples.
12. Observations on plant growth using waste water (industrial and domestic).

ES 206 - Part B: Environmental Engineering

1. Estimation of Total solids, settable solids and suspended solids.
2. Estimation of DO and Biochemical Oxygen Demand in wastewater sample.
3. Estimation of Chemical Oxygen Demand in wastewater sample.
4. Estimation of oil and grease in wastewater.
5. Estimation of optimum dose of coagulants.

6. Estimation of available chlorine in the bleaching powder and residual chlorine.
7. Estimation of rate of run-off.
8. Sludge sampling and characterization.
9. Monitoring performance of water and wastewater treatment.
10. Engineering design of water and wastewater treatment units, water sumps design.

II SEMESTER M.Sc. ENVIRONMENTAL SCIENCE

ES 207: ENVIRONMENTAL MICROBIOLOGY AND ENVIRONMENTAL POLLUTION CONTROL & MANAGEMENT

ES 207 - Part A: Environmental Microbiology

1. Preparation of culture media and study of colony characteristics.
2. Micrometry and Haemocytometer.
3. Biochemical tests a) Indole test b) Methyl red c) Vogues proskaeur test d) Citrate utilization test d) Citrate utilization test e) Catalase test f) Oxidase test g) Urease test h) Sugar fermentation test (Glucose) i) Gelatin hydrolysis j) Casein hydrolysis k) Amylase production starch hydrolysis l) Antibiotic sensitivity tests.
4. Identification of fungal colonies.
5. Identification of Bacteria.
6. Bacterial examination of water – MPN and MF techniques.
7. Isolation of Bacteria and fungi from Air.
8. Isolation of Bacteria and fungi from Soil.
9. Isolation of Bacteria and fungi from spoiled fruits & vegetables.
10. Study of aeroallergens.
11. Study of Phylloplane microflora.

ES 207 - Part B: Environmental pollution control and management

1. Determination of pH and EC in water samples.
2. Estimation of DO, Biochemical Oxygen Demand in water sample.
3. Estimation of Chemical Oxygen Demand in water sample.
4. Estimation of particulate matter in air using RDS/HVS.
5. Determination of SO_2 and NOx in ambient air using RDS/HVS.
6. Modeling of air quality and air quality indices.
7. Determination of Air Pollution Tolerance Index.
8. Air and noise pollution Survey – questionnaire method.
9. Determination of instantaneous noise levels and continuous noise monitoring selected areas using sound level meter and data logger.
10. Computation of water quality index.

III Semester M.Sc Environnement Science

ES 305: SOLID & HAZARDOUS WASTE MANAGEMNET

NATURAL RESOURCES & MANAGEMENT

ES 305 - Part A: Solid & Hazardous Waste Management

1. Sampling techniques of Municipal Waste.
2. Solid waste management-collection and physico-chemical analysis of solid waste characterization and classification of waste.
3. Determination of crude and bulk density.
4. Study of percentage reduction of waste by traditional burning method.
5. Determination of moisture content of the MSW.
6. Collection and characterization of leachate.
7. Estimation of pH of the leachate.
8. Composting methods – Pit/Field/Vermicompost.
9. Design aspects of incinerators, Sanitary landfill site, Biogas plant.
10. Estimation of fluorides/sulphates/phosphates in leachate.
11. Waste generation pattern – questionnaire method.
12. Problem on waste generations and management.
13. Biogas production from the organic waste in the laboratory.

ES 305 - Part B: Natural Resource Management

1. Agro-climatic zones of Karnataka.
2. Community studies using quadrates.
3. Study of selected national park and wildlife sanctuaries in India.
4. Vegetation zones of India.
5. Key areas of conservation in India.
6. Study of selected key wildlife of India.

7. Study of selected exotic species of the Indian subcontinent a) naturalized weeds b) Exotic plantation species.
8. Study of common weeds and pests.
9. Energy content in solid and liquid energy resources A) Petrol and diesel b) Husk, fodder, wood and tree species.
10. Energy consumption pattern in urban and rural areas – Questionnaire method.
11. Design of solar energy trap/ Rain water harvesting.
12. Study of nutrient deficiency in plants.

ES 306 - Part A and B: Application of Remote sensing and GIS

1. Preparation of thematic maps – A) Baseline maps B) Transportation network and settlement maps c) Drainage maps d) Contour maps e) Slope analysis maps f) Land-use/land-cover maps g) Wasteland maps
2. Interpretation of satellite data.
3. Land-use/land-cover classification from satellite data ad toposheets.
4. Calculation of area using planimeter/grid method.
5. Comparative studies of the satellite and toposheet landuse/land cover data.
6. Calculation of latitude and longitude.
7. Delineation of drainage of a given area from satellite data.
8. Study of aerial photographs, photo interpretation for environmental studies and topographical maps.
9. Problems based on remote sensing and aerial photographs.
10. Delineation of lineaments and dykes.
11. Collection of ground truth data.
12. GIS applications - advances softwares of GIS- Arc GIS, ERDAS.
13. DEM models of various topographical features.
14. GIS Data analysis.