

**CURRICULUM  
OF  
ENVIRONMENTAL SCIENCE  
FOR  
B.S/B.Sc.  
M.S/M.Sc.**



**HIGHER EDUCATION COMMISSION  
H-9, ISLAMABAD  
2004**

**CURRICULUM DIVISION, HEC**

Prof. Dr. Altaf Ali G. Shaikh	Member (HRD)
Qazi Riaz Ahmad	Director Curriculum
Malik Ghulam Abbas	Deputy Director
Miss Ghayyur Fatima	Deputy Director
Mr. M. Tahir Ali Shah	Assistant Director
Mrs. Noshaba Awais	Assistant Director

Composed by **Mr. Zulfiqar Ali HEC Islamabad**

**CONTENTS**

1. Preface	4
2. Introduction	7
3. Programmes in Environmental Science	12
4. Degree Programmes	14
5. Graduate Programme	15
6. Outlines of Courses (Graduate)	18
7. Post-Graduate Programme	42
8. Outline of Courses (Post-Graduate)	43
9. Appendix-A	61

## PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum of a subject, one can judge the state of intellectual development and the state of progress of a nation. The world has turned into a global village, new ideas and information are pouring in a constant stream. It is, therefore, imperative to update our curricula by introducing the recent developments in the relevant fields of knowledge.

In exercise of the powers conferred by Sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide Notification NO.D773/76-JEA (Cur.), dated December 4, 1976, appointed Higher Education Commission as the Competent Authority to look after the Curriculum Revision Work beyond Class XII at Bachelor level and onwards to all Degrees, Certificates and Diplomas awarded by Degree Colleges, Universities and other Institutions of higher education.

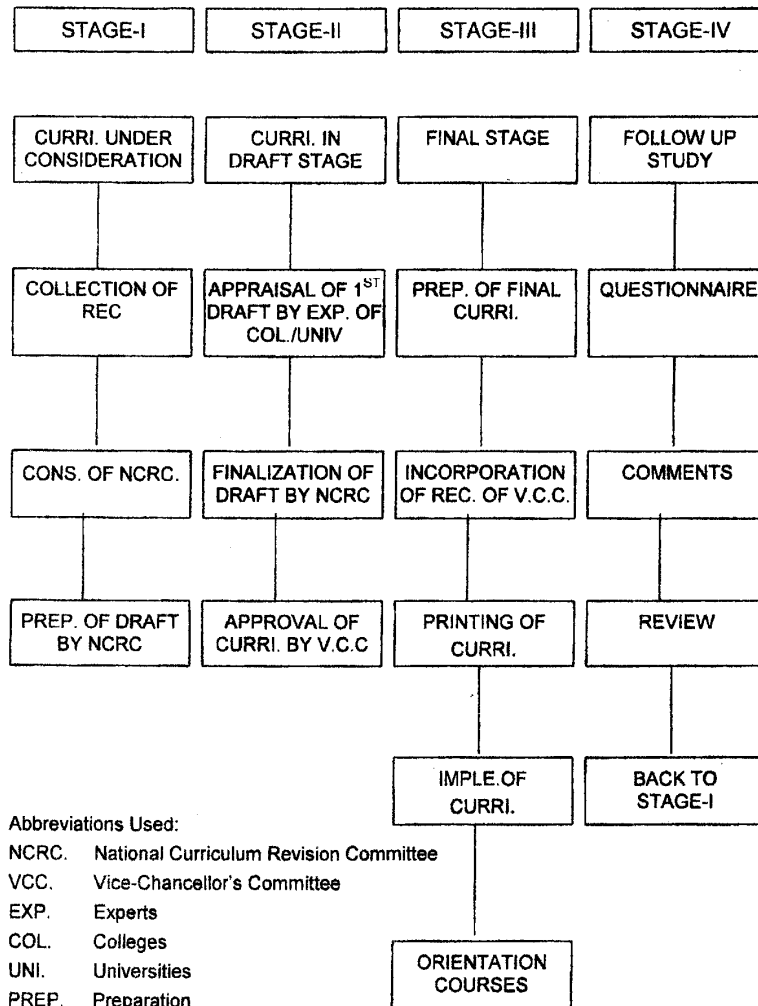
In pursuance of the above decisions and directives, the Commission is continually performing curriculum revision in collaboration with the Universities. According to the decision of the special meeting of Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various Committees are constituted at the national level comprising senior teachers nominated by the Universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these Committees.

The National Curriculum Revision Committee on Environmental Science in its meeting held in April 2004 at the HEC Regional Centre, Peshawar finalized the draft curriculum after due consideration of the comments and suggestions received from the Universities and Colleges where the subject under consideration is taught.

The final curriculum prepared by the National Curriculum Revision Committee duly approved by the Competent Authority is being circulated to the universities for implementation.

**(PROF. DR. ALTAF ALI G. SHAIKH)**  
Adviser (HRD)

### CURRICULUM DEVELOPMENT



## INTRODUCTION

The final meeting of the National Curriculum Revision Committee of Higher Education Commission in Environmental Science was held at Higher Education Commission's Regional Centre at Peshawar from 27<sup>th</sup>–29<sup>th</sup> April 2004 to review the draft curriculum for graduate and post-graduate degree programmes in the discipline and the comments of the foreign expert on the draft curriculum.

Prof. Dr. S. Shafiqur Rehman of Peshawar University and Dr. Muhammad Irfan Khan of Allama Iqbal Open University acted as Convener and Secretary of the Committee respectively in all the meetings held for this purpose. Mr. Muhammad Tahir Ali Shah, Assistant Director (Curriculum) of Higher Education Commission, Islamabad coordinated the meetings. The following were present in the final meeting:

Dr. S. Shafiqur Rehman  
Professor and Chairman  
Department of Environmental Sciences  
University of Peshawar  
Peshawar

Convener

Dr. M.A.Q. Jahangir Durrani  
Professor  
Department of Civil Engineering  
NWFP University of Engineering & Technology  
Peshawar

Dr. Riaz A. Khattak  
Professor  
Department of Soil & Environmental Sciences  
NWFP Agricultural University  
Peshawar

Dr. Muhammad Saleh Soomro  
Professor and Chairman  
Department of Environmental Science  
Sindh Agriculture University, Tandojam

Dr. Ubaidullah Abbasi  
Professor and Director

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Centre for Environmental Science  
University of Sindh  
Jamshoro

Dr. Moazzam Ali Khan  
Coordinator  
Institute of Environmental Studies  
University of Karachi  
Karachi

Dr. Kausar Jamal Cheema  
Professor and Head of  
Environmental Science Department &  
Dean Faculty of Natural Sciences  
Lahore College for Women University  
Lahore

Dr. Himayatullah Khan  
Associate Professor  
(Environmental Economics)  
Institute of Development Studies  
NWFP Agricultural University  
Peshawar

Dr. Muhammad Ali  
Associate Professor  
Department of Zoology  
Institute of Pure and Applied Biology  
Bahauddin Zakariya University  
Multan

Dr. Murtaza Malik  
Program Manager  
Policy Coordination and  
Environmental Governance  
NEAP-Support Programme  
Ministry of Environment  
Islamabad

Dr. Hizbullah Khan  
Lecturer  
Department of Environmental Sciences  
University of Peshawar

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Peshawar

Mr. M. Rizwan Aslam  
Lecturer  
Institute of Environmental Sciences & Engineering  
National University of Sciences & Technology  
Rawalpindi

Dr. Syed Hamidullah  
Professor and Director  
National Centre of Excellence in Geology  
University of Peshawar  
Peshawar

Dr. Mrs. Farrukh Tahir  
House # 1158, Street # 111  
G-9/4, Islamabad

Dr. Muhammad Irfan Khan  
Assistant Professor and Incharge  
Department of Environmental Science  
Allama Iqbal Open University  
Islamabad

Secretary

Mr. Muhammad Tahir Ali Shah, Assistant Director (Curriculum) of Higher Education Commission, Islamabad welcomed the participants on behalf of the Chairman, HEC. He circulated the copies of a letter from Dr. Sohail H. Naqvi, Executive Director, HEC, annexed with that were a specimen model for a 4-year Bachelor's Degree Programme.

The Committee reviewed the comments of foreign expert Dr. Saleem H. Ali of University of Vermont, USA. The House discussed the points raised by the expert, one by one, and incorporated the suggestions where there was consensus in the House.

## Programmes in Environmental Science

### 1. INTRODUCTION

Environmental conservation, alleviation of poverty and sustainable development are high on the agenda of global concerns (UN conferences: Stockholm 1972, Rio de Janeiro, 1992, New York, 1997 and Johannesburg, 2002). Unsustainable management of natural resources hampers the development of humankind and contributes to the unequal distribution of economic welfare. Pollution, depletion of resources and disintegration of ecological functions are of global, regional and local concerns. To prevent continued environmental degradation and the decline of human society, interactions between human and the environment have to be in harmony. This is achievable through an integrated, holistic approach encompassing natural sciences, socio-economic and political factors with technological, economic and socio-cultural interventions.

### 2. THE AIM

The overarching aim of graduate and post-graduate level degree programmes in the discipline of Environmental Science is to develop human resource for achieving the broader objectives of sustainable development.

### 3. THE SCOPE

The programmes have an interdisciplinary scope in which students will learn to address the challenges of maintenance of environmental integrity for sustainable development in relation to human activities.

### 4. TEACHING OBJECTIVES

The teaching objectives of the degree programmes in Environmental Science is to provide students with the knowledge and skills necessary for pollution abatement, conservation and wise use of natural resources for the benefit of society by enabling them to:

- i. learn how to analyze and assess environmental problems;
- ii. carry out independent scientific and technical research on environmental issues; and

- iii. propose sustainable solutions for environmental problems.

## 5. LEARNING OBJECTIVES

After successful completion of these programmes, it is expected that the graduates will be able to understand the natural and socio-economic processes driving environmental systems and will have the scientific and technical expertise to:

- i. make a critical analysis of environmental situations, including natural and societal components;
- ii. solve environmental problems by introducing interventions;
- iii. interact with stakeholders, managers and policy makers in addressing environmental issues.

## 6. RATIONALE

The discipline of Environmental Science is perceived as the systematic study of the world around us, our proper place in it and how it can deal with the issues of socio-economic development on the basis of the principles derived from various disciplines of natural sciences. Keeping in view the above objectives in the local, regional and global contexts, the National Curriculum Revision Committee of Higher Education Commission in Environmental Science in its preliminary meeting, discussed the structure and composition of the graduate and post-graduate degree programmes in the discipline of Environmental Science and outlined this curriculum.

## **DEGREE PROGRAMMES**

Before drawing the structures of the graduate and post-graduate programmes in Environmental Science following principles were agreed by the Committee, with consensus, as guiding principles for the development of the programmes, that:

1. The degree programmes in Environmental Science should be comprehensive in their coverage of the contents.
2. The medium of instruction, assessment and evaluation will be English for degree programmes in Environmental Science.
3. Courses from disciplines of Social Sciences should also be included in the curriculum of Environmental Science along with the courses from disciplines of Natural Sciences in order to integrate the socio-economic aspects of the environment.
4. Environmental Science is an emerging science as a discipline which is highly inter and multi-disciplinary in nature, integrating natural sciences, social sciences and humanities in a holistic study of the world around us.
5. In order to support efficient research in the discipline of Environmental Science skills-oriented courses in information and communication technologies must be included in the degree programmes.
6. The structure of the programmes should be in accordance with international system of higher education in terms of equivalence of credit hours and duration.

## A. GRADUATE PROGRAMME

### Bachelors of Environmental Science (Hons.)

Before drawing the outlines and contents of the courses following principles were agreed by the Committee, with consensus, that:

1. To maintain the equivalence of duration of study at international level, the Bachelors degree programme will be of four years in the annual system and/or eight semesters in the semester system.
2. The nomenclature for this four-year degree programme will be "Bachelors of Environmental Science (Hons.);" consisting minimum of 130 and maximum of 140 credit hours including compulsory courses of English, Islamic Studies and Pakistan Studies.
3. The eligibility for admission to Bachelors of Environmental Science (Hons.) degree will be F.Sc. Pre-medical and Pre-Engineering or equivalent qualification.

The following courses were identified by the Committee to be included in the curriculum of four-year Bachelors of Environmental Science (Hons.) degree. The proposed workload is maximum in the first year and minimum in the final year for the purpose of giving relief for research work and career-oriented activities. The Committee also proposed a semester-wise distribution of courses in a basic to applied order.

### FIRST YEAR

<u>Course Titles</u>	<u>Credit hours</u>
<b>Semester - I</b>	
1. Introduction to Environmental Science	4 (3+1)
2. Biology-I	4 (3+1)
3. Basic Chemistry	4 (3+1)
4. Physics of the Environment	4 (3+1)
5. Functional English	3

**Semester- II**

6. Chemistry of the Environment	4 (3+1)
7. Biology-II	4 (3+1)
8. Fundamentals of Earth Sciences	4 (3+1)
9. Computing Skills	4 (2+2)
10. Remedial English	3

**SECOND YEAR****Semester- III**

11. Fundamentals of Ecology	3
12. Basic Mathematics	4
13. Introductory Economics	4
14. Statistics	4 (3+1)
15. Environmental Microbiology	4 (3+1)

**Semester- IV**

16. Social Theory of Environment	4
17. History and Philosophy of Environmental Thought	3
18. Islamic and Pakistan Studies (Compulsory)	4
19. Environmental Toxicology	3
20. Environmental Policies and Regulations	3

**THIRD YEAR****Semester- V**

21. Applied Ecology	4
22. Environmental Monitoring (Air, water, soil & noise)	4
23. Health and Environment	3
24. Conservation Biology	4
25. Environmental & Natural Resource Economics	4

**Semester- VI**

26. Environmental Technology	4
27. Environmental Management Systems	3
28. Environmental Impact Assessment	3
29. Research Methodology	2
30. Remote Sensing and GIS	4

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**FOURTH YEAR****Semester- VII**

31. Water Resource Management	4
32. Report Writing Skills	4
33. Natural Resource Management	4
34. Participatory Management	4

**Semester- VIII**

35. Occupational Health and Safety	4 (3+1)
36. Dissertation/Thesis	8

## OUTLINES OF COURSES

The suggested contents of each course are given below in the same sequence as listed above.

### COURSE 1

#### INTRODUCTION TO ENVIRONMENTAL SCIENCE

Definitions, history, movements, environmental systems; atmosphere, lithosphere, hydrosphere and biosphere, origin and inter-relationship. Environmental factors; chemical, physical and biological. Environmental pollution, types, sources, causes, effects. Environmental dilemmas; deforestation, waterlogging, salinity, drought and desertification. Issues of environment and sustainable development. Issues of the social environment; population growth, urbanization, migration and poverty. Environment and life style.

#### RECOMMENDED BOOKS

1. Botkin, D and Keller, E, 2000. *Environmental Science: Earth as a Living Planet*. 8<sup>th</sup> ed. John Wiley and Sons, Inc.
2. Cunningham, W P, Saigo, B W, 2001. *Environmental Science*. 6<sup>th</sup> ed. McGraw-Hill.
3. Enger, E D and Smith, B F, 1997. *Environmental Science: A Study of Interrelationships*. McGraw-Hill.
4. Kupchella, C E and Hyland, M C, 1986. *Environmental Science: Living within the System of Nature*. Prentice Hall.
5. Nebel, B J and Wright, R T, 1999. *Environmental Science*, 6<sup>th</sup> ed. Prentice Hall. Upper Saddle River, New Jersey.

### COURSE 2

#### BIOLOGY-I (Basis of life: structural and functional modifications)

Introduction; Definition and concept of life. Chemical basis of life; Structure and the basis of function, Chemical diversity, the molecules of life; carbohydrates, lipids, Proteins, Enzymes, Nucleic acids. Fundamental observations of heredity, the molecular basis of inheritance. Origin of life; historical background, concepts, evolutionary novelty. Diversity in life (classification and phylogenetic relationships); overview with salient features of each category, possible course of evolution.

**RECOMMENDED BOOKS**

1. Campbell, N A, 1998. *Biology*, The Benjamin/Cummings Publishing Company Inc. Menlo Park California, USA.
2. Mader, S, 1998. *Biology*, 1<sup>st</sup> ed. McGraw-Hill New York, USA.
3. Emiliani, C, 1997. *Planet Earth (Cosmology, Geology and the Evolution of Life and Environment)*, 3<sup>rd</sup> ed. Cambridge University Press UK.

**COURSE 3  
BASIC CHEMISTRY**

Basics of chemistry, aqueous solution and concentration units. Vapour pressure, chemical equilibrium, solubility equilibrium and chemical kinetics, dissociation of water, thermo chemistry and electrochemistry, Weak acid base Equilibrium, alkalinity determination, water hardness: causes and effects and determination & removal of hardness. Precipitation titration, electromagnetic radiation, Redox Reactions, Electrode potentials, Ion Selective electrodes, Determination of DO, COD, BOD, Amino acids, Proteins and enzymes, Nucleic Acids: DNA and RNA. Nuclear chemistry.

**RECOMMENDED BOOKS**

1. Clair N. Sawyer, Perry L, McCarly & Geve F Partern, 1994. *Chemistry for Environmental Engineering*. McGraw-Hill, Inc.
2. Harrison R M, De Mora S J, 1996, *Introductory Chemistry for the Environmental Sciences*, Cambridge Environmental Series No. 17, Macmillan Press Ltd.

**COURSE 4  
PHYSICS OF THE ENVIRONMENT**

The Essentials of Environmental Physics, Basic Environmental Spectroscopy; Introduction to the Solar Spectrum, Interaction of Light with Matter, Bio-molecules, Ozone and UV Light. The Global Climate, Energy for Human Use; Heat Transfer, Energy from (mainly) Fossil Fuels, The Price of Energy Conversion, Nuclear Energy. Transport of Pollutants, Diffusion, Conservation of Mass, Flow in Rivers, Ground Water Flow, the Equations of Fluid

Dynamics, Turbulence, Turbulent Diffusion, Gaussian plumes in the Air, Turbulent Jets and Plumes, Particle Physics. Noise, Basic Acoustics, Human Perceptions and Noise Criteria, Reducing the Transmission of

Sound, Active Control of Sound. Spectra and Examples of Environmental Spectroscopy; Atomic Spectra, Molecular Spectra, Scattering, Spectroscopy of the Inner Electrons of Atoms and Molecules, Examples of Environmental Analysis. The Context of Society; Risk Estimation, Limits on Cheap Resources, Saving Energy Resources and Nature.

#### RECOMMENDED BOOKS

1. Boeker, E, 1999. *Environmental Physics*, 2<sup>nd</sup> ed., England: John Wiley & Sons.
2. Guyot, G, 1998. *Physics of the Environment and Climate*, Praxis: England.

#### COURSE 5 FUNCTIONAL ENGLISH

Essay writing; Descriptive, Narrative and Discursive. Report writing. Research paper writing. Showing of documentaries, Reviews of the same in writing. Business letters, Memos etc. Writing of CVs and Job applications. Writing of the minutes of meetings. Discussions and Public address on current affairs.

#### RECOMMENDED BOOKS

1. Khan, Z R, 2000. *Simple English Grammar and Composition for BA Students*. Simple Publications Lahore, Pakistan.
2. Shafi, S, Mansoor, S and Irfan, H, 1994, *Skill Worker: Student Activity Book (BA English for Paper B)*. 1<sup>st</sup> ed. Caravan Book House Lahore, Pakistan.

#### COURSE 6 CHEMISTRY OF THE ENVIRONMENT

Material cycling in the environment; Micro and macronutrients, Cycling of water, carbon, nitrogen and phosphorus, Cycling and balance of nature. Pollution; Definition, Types of pollutants, Origin, transport, reactions and effects of chemicals in water, air, soil, and biotic environment, fate of pollutants in an ecosystem, treatment methods for pollutants. Instrumental Methods of environmental analysis; Principles of sampling, Sampling techniques for chemical analysis of air, water, soil and food, Principles of filtration, titration, distillation, paper chromatography, gas chromatography etc., Absorption spectroscopy and atomic emission spectroscopy, Determination of NEQS parameters,

Lake Water quality, eutrophication of lakes and water and waste water characteristics, chemical coagulation, disinfection of water, smog formation and acid rain, green house effect, pollution of the sea and water desalinization. Soil Biological Activity and Soil Conservation. Pesticides and Herbicides. PCBs. PAHs and Dioxins etc. and Persistent Organic Pollutants (POPs)

### RECOMMENDED BOOKS

1. Manahan, S E, 2000. *Environmental Chemistry*, Lewis Publishers London.
2. Sawyer, C D, 1999. *Chemistry for Environmental Engineers*

### COURSE 7

#### BIOLOGY-II (BIODIVERSITY)

Introduction; Biosphere and biological resources. Evolution of biosphere; Origin of life, Protocell formation, Unicellularity, Multicellularity, Life in sea, Invasion of life on land, Geological time chart with biodiversity. Evolution as a force in diversity of life; Overview of earlier theories, Lamarckism, Darwinism, Modern concepts. Diversity of life and ecological factors; Homeostasis, Crucial for organisms sustainability, Environmental changes and the basis of homeostasis in organisms, Examples of adjustments in varied environment, Interactions among diversified life. Origin of taxonomy; Origin of species, Taxonomic categories, Modern criteria of classification, Different classification systems. Biodiversity: Elements of biodiversity, Molecular basis of biodiversity, Measuring biodiversity, Geographical aspects of biodiversity. Extinction: Ecological extinction and extirpation, Causes of extinction, Population loss and decline, Biodiversity crises, Consequences of losing biodiversity.

### RECOMMENDED BOOKS

1. Primack, R B, 2000. *A Primer of Conservation Biology*. 2<sup>nd</sup> ed. Sinauer Associates Inc. Publishers Sunderland, USA.
2. Gaston, K J and Spicer, J I, 2000. *Biodiversity (An Introduction)*. 2<sup>nd</sup> ed. Blackwell Science Ltd. UK.
3. Bradbury, I K, 1998. *The Biosphere*. 2<sup>nd</sup> ed. John Wiley and Sons Inc. UK.
4. Pandey, A K, 1995. *Taxonomy and Biodiversity*. 1<sup>st</sup> ed. CBS Publications and Distributors Delhi, India.

5. Campbell, N A, 1998. *Biology*. The Benjamin/Cummings Publishing Company Inc. Menlo Park California, USA.

#### **FURTHER READINGS**

1. GoP, 1998. Biodiversity Action Plan.
2. McKinney, M L and Schoch, R M, 1998. *Environmental Science (Systems and Solutions)*. 1<sup>st</sup> ed. Jones and Bartlett Publications Inc. USA.

#### **COURSE 8 FUNDAMENTALS OF EARTH SCIENCES**

Overview of Earth, its environment and resources. Man-environment interaction. Geological framework of Earth; Structure and Composition of Earth, Assessing geological hazards. Frame work of Atmosphere; Composition and structure of atmosphere, Solar radiation and energy balance in atmosphere, Air pressure, wind circulation, Solar radiation and ozone layer, Greenhouse effect and global warming. Human Demography; Human population distribution, Population growth, Current population trends, Causes of population growth, Overpopulation and consequences. Earth Resources; Energy resources their use and alternatives, Mineral resources, Soil resources, Water resources, Biological resources, Resource management.

#### **RECOMMENDED BOOKS**

1. Montgomery C W, 1995. *Environmental Geology*. Wm, C Brown; USA
2. Keller E, 1992. *Environmental Geology*. McMillan, New York.
3. Barbara W, Brian J, Stephen C, Porter, 1996. *Environmental Geology*. John Wiley and Sons, Inc.

#### **COURSE 9 COMPUTING SKILLS**

Definition. Types and classification of computers. Hardware; Input Hardware, Storage Hardware; Processing Hardware, Output Hardware. Software; Application Software, System Software, Software Packages. Operating System (Windows), Internet, e-mail; Local Area Network, Wide Area Network, Configurations. Introduction to MS-Word, MS-Excel, MS-PowerPoint, MS-Access.

**RECOMMENDED BOOKS**

1. Long L, Long N, Fundamentals of Computer, 6<sup>th</sup> ed.
2. Courter G, Marquis A, 1999, Microsoft Office 2000, BPB Publications.

**COURSE 10****REMEDIAL ENGLISH**

Consulting a dictionary for Spelling, Pronunciation and Meanings. Reading skills: Skimming, Scanning, Intensive reading and improving reading speed. Library resources. Listing books (Bibliography). Sentence; Subject and predicate, Kinds, types and parts of speech, Use of articles, Practice in writing a unified correct sentence, Punctuation and spellings, Analysis of sentence structure. Clauses, Verbs (Transitive and Intransitive). Translation (Urdu into English). Paragraph writing; Practice in writing a good, unified and coherent paragraph. Comprehension; Answer to questions on a given text, Summary and précis making. Showing of documentaries; Reviews of the same.

**RECOMMENDED BOOKS**

1. Shafi, S, Mansoor, S and Irfan, H, 1994. *Skill Worker: Student Activity Book: B A English for Paper B*. 1<sup>st</sup> ed. Caravan Book House Lahore, Pakistan.
2. *Polymer English Grammar and Composition for BA/B.Sc.* 1994. 1<sup>st</sup> ed. Polymer Publication Lahore, Pakistan.

**COURSE 11****FUNDAMENTALS OF ECOLOGY**

Concept and framework of ecosystem. Energy and material flow within ecosystem. Succession: (only basic concepts). Types of Terrestrial and aquatic ecosystems and their interrelationship with special emphasis on Pakistan. Communities; concept and structure of ecosystem, Global distribution, Patterns of diversity. Populations; Population distribution and abundance, Distribution limits, patterns, population density, rarity and extinction, Population dynamics, Interaction. Food webs; Community webs, Keystone species, Exotic predators, Humans as keystone species.

Effects of human activities on ecosystem; Exploitation of natural resources, Pollution, Global warming, Ozone depletion, Acid rain, Overpopulation.

**RECOMMENDED BOOKS**

1. Chapman, J L and Reiss, M J, 1992. *Ecology (Principles and applications)*. 1<sup>st</sup> ed. Cambridge University Press UK.
2. Odum, E P, 1971. *Fundamentals of Ecology*. 3<sup>rd</sup> ed. Saunders Company Philadelphia, USA.
3. Moles, M C J, 1999. *Ecology (Concepts and applications)*. 1<sup>st</sup> ed. WCB/McGraw-Hill New York, USA.

**FURTHER READINGS**

1. Cox, C B and Morre, P D, 2000. *Biogeography (An Ecological and Evolutionary Approach)*. 6<sup>th</sup> ed. Life Sciences King's College London, UK.
2. Slingsby, D and Cook, C, 1986. *Practical Ecology*. 1<sup>st</sup> ed. McMillan Education Ltd. UK.

**COURSE 12****BASIC MATHEMATICS**

Elementary concepts, Special Products (Binomial Expression), Factors, Fractions, Simple Equations (Linear equations), Simultaneous Equations, Quadratic Equations, Coordinate Geometry and Trigonometry, Matrices and Determinants, Exponential and Logarithmic Functions, Derivatives, Anti-derivatives (Integration), Sequence and Series.

**RECOMMENDED BOOK**

1. Anton, H, 2000, *Calculus with analytical Geometry*, 5<sup>th</sup> ed., John Wiley & Sons, Reprint National Book Foundation.

**COURSE 13****INTRODUCTORY ECONOMICS**

Introduction: Nature and Scope of Economics. Economics and Environmental Economics, Environment and its Functions, Environmental resources and their types. Natural resources and the economy, Man-environment relationship, Economic system and the environment. Utility analysis, Indifference curves analysis and Demand, elasticity of demand. Factors of production, Production function, Cost and cost curves, Market structures. Equilibrium of the firm and industry under perfect competition, monopoly, and monopolistic competition in

the short and long run. National Income, concepts and measurement, Growth and Development, Poverty, growth and environment.

#### RECOMMENDED BOOKS

1. Samuelson, P and W D Nordhaus, 1998. *Economics* (16<sup>th</sup> edition), McGraw-Hill.
2. Hardwick, P 1986. *An Introduction to Modern Economics* (2<sup>nd</sup> edition), ELBS/Longman.

#### FURTHER READINGS

1. Perman, R, Y Ma, and M Common 1999. *Natural Resource and Environmental Economics*. 2<sup>nd</sup> edition. Longman.
2. Field, B C, 1994, *Environmental Economics: An Introduction*, McGraw Hill, Inc.

#### COURSE 14 INTRODUCTORY STATISTICS

Basic concepts in Statistics; Descriptive statistics; sample, parameter, variables. Collection of primary and secondary data; presentation of data. Measure of central tendency; mean, median and mode of the distribution, population and sample. Sampling techniques and distribution, mean and standard error of distributions. Measure of dispersion; Variance, Standard deviation. Linear regression and correlation. Probability; events, sample space, probability laws, binomial, Poisson and normal distribution; properties and uses. Hypothesis testing; Level of significance, Testing mean (Z-test, t-test, Chi-square test, F-test) and Variance test for association; analysis of variance. Excel, SPSS, Minitab.

#### RECOMMENDED BOOKS

1. Wheeler, C P and Cook, P A, 2000. *Using Statistics to Understand the Environment*. 1<sup>st</sup> ed. Taylor and Francis Group (Routledge) London, UK.
2. Linardakis, N M and Khatchatrym, A, 1988. *Biostatistics and Epidemiology*. 1<sup>st</sup> ed. McGraw-Hill International UK.
3. Levin R I and Rubin D S, 1999, *Statistics for Management*, 11<sup>th</sup> ed. Reprint National Book Foundation.
4. Chuadhary S M, 1978, *Introduction to Statistical Theory*, IImi Kitab Khana, Lahore.

5. Muhammad F, Statistical Methods and Data Analysis, Kitab Markaz, Faisalabad.

### **COURSE 15 ENVIRONMENTAL MICROBIOLOGY**

History of microbiology, Microbial classification, growth and nutrition. Microbes as a component of Environment, Microbial communities, Growth of Micro-organisms, Batch, Continuous and Mixed cultures. Influence of environment on growth and Measurement of growth, DNA structure and replication, Protein synthesis, Energy mechanism in microbial metabolism, Transfer of Genetic information, control of micro-organisms, interaction among microbial population. Water, wastewater, soil and airborne micro-organisms. Biodegradation and bioaccumulation.

### **RECOMMENDED BOOKS**

1. Prescott L M, Harley G P, Klei C A 1992. *Microbiology (4<sup>th</sup> edition)*. McGraw-Hill Inc.
2. Telear M A, Chan E C S *Microbiology: Concepts and Applications*. McGraw-Hill Inc.
3. Mitches R, *Environmetnal Micobiology*, McGraw-Hill Inc.
4. Denyer S P, Gorman S P *Microbial Bioskills: Formation and Control*. McGraw-Hill Inc.

### **FURTHER READINGS**

5. Donaldhold, J *Microbial Enhance Oil Recovery*. McGraw-Hill Inc.

### **COURSE 16 SOCIAL THEORY OF ENVIRONMENT**

Introduction to Social Theory; Environment and Societies, Contemporary Social Theory; Environmental degradation and politics, Classical Social Theory: Politics, Culture and Socialism. Social Interactions; Feminism, Population and Environment. Modernity and Environment; Capitalism, Industrialism and Transformation of Nature. Globalization. The Political Ecology of Capitalism. Social and Cultural Origins of Environmental Movements. The Sociology of Risk. Social Theory, Socialism and the Environment. The Ecology of Unemployment, War and Health.

**RECOMMENDED BOOKS**

1. Barry, J, 1999. *Environment and Social Theory*. Routledge Group.
2. Goldblatt, D, 1996. *Social Theory and the Environment*. Polity Press.

**COURES 17****HISTORY AND PHILOSOPHY OF ENVIRONMENTAL THOUGHT**

The foundations of history. Ways of thought: human and natural world relationship, pursuit of economic growth. Abuse of the world; destruction of wild life, history of exploitation, idea of conservation, creating the third world, changing face of death, weight of numbers; population explosion, expansion of agricultural land, green revolution, ecological disaster of the world, second great transition; sources of energy, first energy crisis, transition to fossil fuels, growth of energy sources and consumption, rise of the city, creating the affluent society, polluting the world, shadow of the past; ecological interpretation of human history-stability and sustainability of human society-lessons of the past.

**RECOMMENDED BOOKS**

1. Ponting C, 1991. *A Green History of the World*, Sinclair-Stevenson Ltd, UK.
2. Simmons, I G, 1989. *Changing the Face of Earth: Culture, Environment, History*. Basil Blackwell, Oxford.
3. Worster D, (ed.), 1988. *The Ends of the Earth: Perspective on Modern Environmental History*. Cambridge University Press, Cambridge.
4. Van De Veer D, Pierce C, 1998. *The Environmental Ethics and Policy Book*, 2<sup>nd</sup> ed. Wadsworth Publishing Company.

**COURSE 18****ISLAMIC AND PAKISTAN STUDIES (COMPULSORY)**

Already approved curriculum of HEC for graduate level

**COURSE 19****ENVIRONMENTAL TOXICOLOGY**

Introduction, Dose response relationship, Bioaccumulation and biomagnifications, Threshold limit for toxins, Toxicological Agents and their types, Toxicant Metabolism and accumulation in body organs and pathways, Response of the body systems to toxicological agents,

immunological considerations in toxicology, toxicity screening using microbial systems, risks and their characterization, risk assessment

### RECOMMENDED BOOKS

1. Botkin D and Keller E, 1995. *Environmental Science: Earth as a Living Planet*. John Wiley & Sons, Inc.
2. Lippmann, M, 1992. *Environmental Toxicants (Human exposure and their Health Effects)*, 1<sup>st</sup> ed. Van Nostrand and Reinhold New York, USA.
3. Yassi, A, Kjellström, T, de Kok, T and Guidotti, T L, 2001. *Basic Environmental Health*. 1<sup>st</sup> ed. Oxford University Press New York, USA.
4. Ballantyne, B, Marrs, T and Turner P (editors), 1993, General and Applied Toxicology, Vol.1 & 2, Macmillan Press Ltd.

### COURSE 20

#### ENVIRONMENTAL POLICIES AND REGULATIONS

Basic concepts (definitions and objectives of policies, plans, strategies, laws, rules and regulations); policy formulation process; environmental policy of Pakistan; Introduction and salient features; National Conservation Strategy (NCS); provincial and district conservation strategies; National Environmental Action Plan (NEAP); forestry and wildlife related policies; integration of environment in sectoral policies; International environmental policy; multilateral environmental agreements, Agenda 21; millennium development goals; WSSD; WEHAB framework; environmental laws, rules, regulations and guidelines in Pakistan; environmental policy instruments, environmental institutional framework in Pakistan. NEQS. WTO and Environment.

### RECOMMENDED BOOKS

1. Barrow, C J, 1995. *Problems and Management*. Essex, Longman.
2. Ball, S and Bell, S, 1994. *Environmental Law – The Law and Policy relating to the Protection of the Environment*. 2<sup>nd</sup> Ed. London Black Stone Press Ltd.
3. Mackenzie, F T Mackenzie J A, 1995. *Our Changing Planet – An Introduction to Earth System Science and Global Environmental Change*, Englewood Cliffs Prentice Hall.

**FURTHER READINGS**

1. The World Commission on Environment and Development: *Our Common Future*, 1987. Oxford University Press.
2. GoP and IUCN. 1992. *The Pakistan National Conservation Strategy (PNCS)*, Islamabad.
3. Draft Environmental Policy of Pakistan.

**COURSE 21  
APPLIED ECOLOGY**

Introduction; Concept of applied ecology, Background and scope, Principles of applied ecology, Basic concepts in applied ecology. Carbon-energy balance and climate change; Solar radiation and primary production, Energy resources for now and for future, Carbon dioxide and global climate change, Effect of carbon dioxide concentration on photosynthesis. Ecological concepts in food production; Efficient use of resources in farming system, Cutting of forests for agricultural purposes, Sustainable agricultural practices, Sustainable livestock management practices. Aquaculture practices. Pollution control through Ecology, Basic concepts about pollutant transfer in plant and animals, Species response to pollutants, Using microcosms and mesocosms to study effects of pollutant on communities, Phytoremediations and bioremediations. Conservation and Management of Wild Species; Coexistence of species, Specie-area relationship, Influence of vegetation structure on animal diversity, Interaction between consumers and affect of specie abundance, Human influence on biodiversity extinction, Biodiversity conservation: aim and approach.

**RECOMMENDED BOOKS**

1. Newman I, 1993, *Applied Ecology*, Blackwell Scientific Publications, Oxford.
2. Odum E D, 1971, *Fundamentals of Ecology*, W B Saunders Company.

**COURSE 22  
ENVIRONMENTAL MONITORING (AIR, WATER, SOIL & NOISE)**

Introduction. Objectives of sampling and monitoring programme. Design and types of samples; pre-sampling requirements/information, sampling and design purposes, regulatory purposes for NEQS compliance, EIA requirement, NOC for plant operation, determination of concentration

and distribution of a specific pollutant. Environmental sampling techniques. Quality assurance and quality control; planning analytic protocols quality assurance programmes, quality control sampling considerations, quality assessment, field custody, laboratory custody. Preservation methods including pH control, chemical addition, refrigeration and freezing methods. Biological indicators for environmental monitoring; role of biomarkers in environmental assessment.

#### RECOMMENDED BOOKS

1. Peakall D, 1992. *Ecotoxicology Series 1: Animal Biomarker as Pollution Indicators*, Chapman and Hall.
2. Bonotto, R, Nobili and Revoltella, R P, 1992. *Biological Indicators for Environmental Monitoring*, Ares-Serono Symposia Via Ravenna, 8-Rome, Italy
3. Lawren H Keith, *Environmental Sampling and Analysis: A Practical Guide*
4. P Patniak (Lewis), *Handbook Of Environmental Analysis*.
5. Mark E Byrnes, *Field Sampling Methods for Remedial Investigations*.
6. Standard Methods for the Examination of Water and Wastewater, A Greenberg (American Public Health Association).

#### COURSE 23 HEALTH AND ENVIRONMENT

Introduction; concept, Basic requirements for a healthy environment, Measuring environmental quality, Human exposure and health Impact, Impact of environmental factors on health, Role of environmental health professional. Nature of environmental hazards, Risk assessment, Risk management, Air, Water and sanitation, Food and agriculture, Health and disease. Human settlement and urbanization, Health and energy use. Health and development, Health indicators, Industrial pollution and chemical safety, Trans-boundary and global health concerns, Action to protect health and the environment. Epidemiology of infectious diseases, Communicable diseases, Non-communicable diseases, Introduction to Immunology, Pathology, Epidemiology.

**RECOMMENDED BOOKS**

1. Yassi, A, Kjellström, T, de Kok, T and Guidotti, T L, 2001. *Basic Environmental Health*. 1<sup>st</sup> ed. Oxford University Press New York, USA.
2. Nebel, B J and Wright, R T, 1998. *Environmental Science (The Way the World Works)*. 1<sup>st</sup> ed. Prentice Hall International Inc. London, UK.
3. Lippmann, M Van Nostrand and Reinhold, 1992. *Environmental Toxicants (Human Exposure and their Health Effects)*. 1<sup>st</sup> ed. New York, USA.
4. Park K, 2002. *Park's Textbook of Preventive and Social Medicine*, 2<sup>nd</sup> ed. M/s Banarsid.
5. Khan, A M, 2001. *Medical Microbiology*. 1<sup>st</sup> ed. Time Publishers Karachi, Pakistan.

**COURSE 24****CONSERVATION BIOLOGY**

Conservation biology, philosophical background, need and approach, Threats to Biological Diversity. Conservation at the population and species level; natural history and ecology, Gathering ecological information, Monitoring populations, Establishment of new populations, Considerations for successful programmes, Social behaviour of released animals, Ex-situ conservation strategies, Overview of conservation categories of species, Legal protection of species, National laws, International agreements, Conservation at the community level; Protected areas, Designing protected areas, Managing protected areas: Habitat management, Park management and people, Outside protected areas: Traditional societies and sustainable development, International approaches to conservation and sustainable development, An agenda for the future.

**RECOMMENDED BOOKS**

1. Primack, R B Sinauer, 2000. *A Primer of Conservation Biology*, 2<sup>nd</sup> ed. Associates Inc. Publishers Sunderland, USA.
2. Cox, C B and Morre, P D, 2000. *Biogeography (An Ecological and Evolutionary Approach)*, 6th ed. Life Sciences King's College London, UK.
3. Mirza, Z B, 1998. *Illustrated Handbook of Biodiversity of Pakistan*, 1<sup>st</sup> ed. Saad Printopack Rawalpindi, Pakistan.

4. Gaston, K J and Spicer, J I, 1998. *Biodiversity (An Introduction)*, 1<sup>st</sup> ed. Blackwell Science Ltd. UK.
5. Chapman, J L and Reiss, M J, 1992. *Ecology (Principles and Applications)*. 1<sup>st</sup>ed. Cambridge University Press UK.

#### **FURTHER READINGS**

1. McKinny, M L and Schoch, M R, 1998. *Environmental Science (Systems and Solutions)*, 1<sup>st</sup> ed. Jones and Bartlett Publications US.
2. Hussain, S S, 1992. *Pakistan Manual of Plant Ecology*, 1<sup>st</sup> ed. National Book Foundation, Pakistan.
3. Bradbury, I K, 1998. *The Biosphere*, 2<sup>nd</sup> ed. John Wiley and Sons Inc. UK.

#### **COURSE 25**

##### **ENVIRONMENT AND NATURAL RESOURCE ECONOMICS**

Introduction to natural resource and environmental economics, concepts of sustainability, valuating environment, market failures, cost benefit analysis, discounting and present value of net benefit. Efficient and optimal use of environmental resources: non-renewable and renewable resources. Pollution control, targets and instruments, instrument. Accounting for the environment. The economics of sustainable development.

#### **RECOMMENDED BOOKS**

1. Tietenberg, T, 1996. *Environmental and Natural Resource Economics*. 4<sup>th</sup> ed. Harper Collins Publishers.
2. Perman, R, Ma, Y, McGilvray, J, 1996. *Environmental and Natural Resource Economics*. Longman, London and New York.
3. James R K, 1998. *The Economic Approach to Environmental and Natural Resources*. Harcourt Brace College Publishers.
4. Hanley, N, J F Shogren and B White, 2002, *Environmental Economics in theory and practice*, Palgrave Macmillan.

#### **COURSE 26**

##### **ENVIRONMENTAL TECHNOLOGY**

Collection, treatment and distribution of drinking water supply; low cost water treatment and sanitation techniques; cleaner production techniques; waste re-use and recycling; collection, treatment and

disposal of municipal and industrial wastewater; solid and hazardous waste management; waste site investigation and remediation; air and noise pollution control.

#### RECOMMENDED BOOKS

1. Metcalf and Eddy, 1994. *Wastewater Engineering*. McGraw-Hill.
2. N D Nevers, 1995. *Air Pollution Control Engineering*. McGraw-Hill.
3. H C Perkins. *Air Pollution* (latest edition). McGraw-Hill.
4. M D Lagrega, P B Buckingham and I C Evans, 1994. *Hazardous Management*. McGraw-Hill.

#### COURSE 27

#### ENVIRONMENTAL MANAGEMENT SYSTEMS

Introduction to Environmental Management System; principles and elements of the process of EMS. Sources of data, data collection and interpretation. Related Environmental regulations, Principles of cleaner production. Application of environmental management principles and tools of environmental management. Introduction of ISO14000 series of standards and its role in environmental management. Environmental Auditing. Corporate Social Responsibility (CSR).

#### RECOMMENDED BOOKS

1. EMS — an implementation Guide for Small and Medium sized Organizations NSF International Ann Arbor, Michigan-January 2001.
2. ISO 14000 – Meet the whole family, ISO Central Secretariat, Switzerland, 1998.
3. North K, 1997. *Environmental Business Management: An Introduction*, Oxford & IBH publishing Co Pvt Ltd.
4. UNEP/IE (Industry and Environment), 1990b, *Environmental auditing*, Paris.
5. Sayre, D, 1997, *Inside ISO 14000: The Competitive Advantage of Environmental Management*, St Luice Press.
6. Khan M I, Tahir B A, and Akhtar N, 2004, *Integrated Environmental Management*, Allama Iqbal Open University.
7. Whitelaw K, 1997, *ISOs 14001 Environmental System Handbook*, Botlerworth Heinemann Ltd.
8. Hillary, R (editor), 1997, *Environmental Management Systems and Cleaner Production*, John Wiley and Sons, Inc.
9. Khan, A B, Khan H N, and Qasmi M F, 1998, *EMAS Environmental Management and Auditing Systems; A Practical Guide for the*

## **COURSE 28 ENVIRONMENTAL IMPACT ASSESSMENT**

Introduction. Principles and purposes of IEE and EIA and its significance for the society. Cost and benefits of EIA. Main stages in EIA process. Public consultation and participation in EIA process. EIA methods and techniques for impact prediction and evaluation. EIA involvement during project life cycle. EIA review and post project analysis. EIA process management. National Environmental Quality Standards for air, liquid, solids, and noise, role of quality assurance and quality control in environmental analysis. EIA Regulations 2000 of Pakistan. One case study to be completed by the students as practical work.

### **RECOMMENDED BOOKS**

1. Wood, C, 1995. *Environmental Impact Assessment (A Comparative Review)*. Longman Scientific and Technical. Longman House. Burnt Hill, Harlow Essex. UK.
2. Petts, J and Eduljee, G, 1994. *Environmental Impact Assessment for Waste Treatment and Disposal Facilities*. John Willey & Sons Inc. UK.
3. North K, 1997. *Environmental Business Management: An Introduction*, Oxford & IBH Publishing Co. Pvt. Ltd.
4. Khan M I, Tahir B A, and Akhtar N., 2004. *Integrated Environmental Management: Urban and Rural*, Allama Iqbal Open University.
5. Asian Development Bank. A Manual for Environmental Impact Assessment.

### **FURTHER READINGS**

1. GoP, 2000, IEE/EIA Regulations, Ministry of Environment, Government of Pakistan.

## **COURSE 29 RESEARCH METHODOLOGY**

Purpose of Research; Research Project Conceptualization, Choice of Methods; Elements of a Research Proposal, Operationalization choices and illustrations.

Research Design: formulation of research design, pretesting of research instruments and procedures, units of Analysis, time dimension; Experimental design and use of indicators in research, Survey Research: Guidelines for asking question and questionnaires construction, Self-administered questionnaires, Interview and other survey methods; their strength and weaknesses. Sampling: the logic of sampling, concepts and terminologies, population and sampling frames, types of sampling design. Field Studies: Steps in the conducting field study; Evaluation Research: How to carry out evaluation research; Analytical tools in research: qualitative and quantitative methods; Statistical analyses: Univariate, Bivariate and Multivariate analyses.

### RECOMMENDED BOOKS

1. Wheater, C P and Cook, P A, 2000. *Using Statistics to Understand the Environment*, 1<sup>st</sup> ed. Taylor, Francis Group (Routledge) London, UK.
2. Prace, B and Loyzos, P 1992. *Choosing Research Methods: Data Collection for Development Work*, Oxfam, Oxford, UK.
3. Babbie E R, 1989. *Survey Research Methods*. Wadsworth Publishing Company, Belmont California.
4. Babbie E R, 1989. *The Practice of Social Research*. Wadsworth Publishing Company, Belmont California.
5. Rosenberg M, 1993. *The Logic of Survey Analysis*. Basic Book Company New York.

### COURSE 30

#### REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

Fundamentals of Remote Sensing. Energy Sources, Characteristics of electromagnetic radiation and spectrum, Spectral reflectance of land covers. Remote Sensing system, Aerial Photography, Interpretation, Photogrammetry, Satellite Imageries, Image Processing, Interpretation, Preparation of thematic maps.

Fundamentals of Geographic Information System (GIS), Data analysis and output, Organizational setup, evaluation and implementation; GIS applications in: Environmental protection and resource conservation, Environmental Impact Assessment (EIA), Agriculture, Forestry, Fishery and Wildlife. Introduction to relevant Pakistani Institutions working in GIS.

**RECOMMENDED BOOKS**

1. Lulla, K and Dessinov, L V, 2000. *Dynamic Earth Environment Remote Sensing Observations from Shuttle Mission*. John Wiley and Sons. Inc.
2. Rancez, A Z, 1999. *Remote Sensing for the Earth Sciences*. John Wiley and Sons. Inc.
3. Foody, G M and Curran, P J, 1994. *Environmental Remote Sensing from Regional to Global Scales*. John Wiley and Sons. Inc.
4. Murai, S (ed.), 1996. *Remote Sensing Note*, 2<sup>nd</sup> edition. Japan Association on Remote Sensing, Tokyo.
5. Lillesand, T M and Kiefer, R W *Remote Sensing and Image Interpretation*. John Wiley and Sons Inc.
6. Luder D R *Aerial Photographic Interpretation* (latest edition).
7. Bernhardsen, T, 1992. *Geographic Information Systems*. Vivak IT Publishers, Norway.
8. Taylor, D R F, 1991. *Geographic Information Systems, The Microcomputer and Modern Cartography*. Pergamon Press, Toronto.

**COURSE 31  
WATER RESOURCE MANAGEMENT**

Introduction; hydrological cycle, water resources and their role, limits to water availability, water losses, water consumption, water pollution, water shortage problem and solution, improving water productivity, water conservation practices, integrated management of coastal and marine resources, wetlands resources, irrigation resources, sustainable aquaculture practices, flood and draught management, government Policies and Programmes. Dams, barrages and their environmental impacts on farm water management. Recycling and re-use of wastewater as a resource. Indus Water Treaty 1960, Indus Water Accord 1991, relevant intuitions and authorities.

**RECOMMENDED BOOKS**

1. Botkin D, Keller E, 1995. *Environmental Science: Earth as a Living Planet*, John Wiley and Sons, Inc.
2. Chua T E 1993. *Essential Elements of Integrated Coastal Zone Management. Ocean and Coastal Management*.
3. Linsley. *Water Resource Management*. McGraw-Hill.

4. Dr. Khan M I, Tahir B A, and Akhtar N, 2004. *Integrated Environmental Management*, Allama Iqbal Open University.
5. Dr. Khan M I, Tahir B A, Amir S, and Akhtar N, 2004. *Participatory Management*, Allama Iqbal Open University.

### **COURSE 32 REPORT WRITING SKILLS**

Introduction to report writing, components of a report, choosing title, references and bibliography, abstract writing, introduction writing, materials and methods writing, results and discussions writing, stating the acknowledgment, citation, effective data presentation.

Introduction of presentation skills, planning your presentation, benefits of a good presentation, presenting oral reports, group presentation skills, do's and don'ts in using visual aids, before and during presentation, creating colour visuals, medium of presentation, building rapport; body language, handling questions, assertion theory, argumentation skills, preparing presentation; oral presentations, AV aids, checklist on presentation effectiveness, guidelines for question and answer session. Evaluation of presentation skills.

### **RECOMMENDED BOOKS**

1. De Bono, E, 1987. *The CoRT Thinking Programme*, 2<sup>nd</sup> ed. Pergamon, New York.
2. Frank, Milo O, 1986. *How to Get Your Point Across in 30 Seconds or Less*. Corgi, London.
3. Hunt, Garry T, 1980. *Communication Skill in the Organization*. Prentice Hall, New Jersey.
4. Robert A D, 1989. *How to Write and Publish a Scientific Paper*, 3<sup>rd</sup> ed. Cambridge University Press.

### **COURSE 33 NATURAL RESOURCE MANAGEMENT (Uni. Of Peshawar)**

Natural resources and sustainable management of natural resources, Development of Management Plan, Watershed Management, Rangeland Management, Wildlife Management, Water Resource Management, Fisheries Management, Agricultural Resource Management, Energy (coal, hydrocarbon, hydel) and Mineral Resource (Metallic and non-metallic deposits) Management, Land use Planning and Management.

**RECOMMENDED BOOKS**

1. Goldsmith, F B and Warren, A, 1983. *Conservation in Progress*. John Willey and Sons; New York, USA.
2. Pearce and Turner, 1990. *Economic of Natural Resources and the Environment*. Harvester Wheat Sheaf, London.
3. Dasmann, R F, 1984. *Environmental Conservation*. John Wiley and Sons, New York.
4. GoP and IUCN. 1992. *The Pakistan National Conservation Strategy (PNCS)*, Islamabad.
5. Hansen, P E and Jorgensen, S E, 1991. Introduction to Environmental Management – Development in Environmental Modelling. 18; Amsterdam, Elsevier.

**COURSE 34  
PARTICIPATORY MANAGEMENT**

Towards Participatory Management: A New Paradigm, Concepts and Philosophy, Historical Perspectives; Models of Participatory Management in South Asia; Participatory Approaches to Environment and Development; A Model for Urban Development “Orangi Pilot Project”; Women Participation in Development; Youth Participation in Development; Participatory Management of Mountain Ecosystems, Coastal and Forest Resources, Wetland Conservation; Participatory Irrigation Management (PIM).

**RECOMMENDED BOOKS**

1. Chambers R, 1997. *Whose Reality Count Putting the First Last*, Intermediate Technology Publications.
2. Shepherd A, 1998. *Sustainable Rural Development*, St. Martin Press, Inc.
3. Uphoff, N, Learning from Gal Oya: Possibilities for Participatory Development and Post-Newtonian Social Science, Cornell University Press, Ithaca, 1992.
4. Burkey, S, *People First, A guide to self-reliant participatory rural development*, Zed Books, London & New York, 1993.
5. Dr. Khan M I, Tahir B A, Amir S, and Akhtar N, 2004. *Towards Participatory Management*, Allama Iqbal Open University.

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**COURSE 35**  
**OCCUPATIONAL HEALTH AND SAFETY**

Introduction; concept, importance and principles of occupational health and safety, Cost of accidents, Hazards and risks at work place and causes, Plant and mines safety and safe work practices; fire fighting techniques, Emergency response protocols, Spill response protocols, risk assessment approaches, Occupational Health and Safety Management System 18001, Occupational health and safety in Pakistan; Labour code of Pakistan (1986), Industrial and occupational rules and regulations in Pakistan, Agricultural Pesticides Rules, 1973, Agricultural Pesticide Ordinance, 1971

**RECOMMENDED BOOKS**

1. Occupational Health and Safety Management Systems-Specification 18001, British Standards Institute.
2. Occupational Health and Safety Management Systems-Guidelines for Implementation 18002, British Standards Institute.

## **B. POST-GRADUATE PROGRAMME**

### **Masters in Environmental Science**

Regarding postgraduate degree programme, the committee agreed on the following principles, that:

1. The nomenclature of the degree will be "Masters in Environmental Science".
2. The Masters degree programme will be of one-year duration after four years Bachelors degree in Environmental Science that may spill over to one and a half year due to research thesis.
3. The Masters degree will be a taught programme based on course work along with a mandatory research thesis to be submitted at least after one year in partial fulfilment of the requirement of the Masters degree.
4. The Masters degree programme will not be of more than 36 credit hours with certain core courses and some elective courses directed to a specialized area preferably in accordance with the area of research thesis in order to provide a theoretical support to the research.
5. The research thesis will comprise not less than one third of the total credits. Therefore, it was agreed that the thesis would be of 10 credits.
6. There should be some areas of specialization for students to support their research work. For this purpose at least four courses of 2 credit hours from the list of elective subjects in consultation with the supervisor.
7. The areas of specialization may be offered according to the geographic location of the institutions, availability of the faculty and other facilities.

The Committee proposed the following courses as Core Courses for the degree of Masters in Environmental Science.

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**OUTLINES OF POST-GRADUATE COURSES**
**CORE COURSES**

<u>Course Titles</u>	<u>Credit Hours</u>
1. Environmental Policy	3
2. Environmental Analytical Techniques	3
3. Environmental Impact Assessment	3
4. Project Management	2
5. Health, Safety and Environment	2
6. Population Dynamics and the Environment	2
7. Pollution Control Technologies	3

**Elective Courses**

The Committee proposed the following elective courses:

1. Environmental Management
2. Environmental Chemistry
3. Environmental Microbiology
4. Freshwater Ecology (Limnology)
5. Environmental Sociology
6. Environmental Geology
7. Marine Pollution
8. Epidemiology
9. Environmental Biotechnology
10. Wildlife, Forestry and Wetland Management
11. Watershed Management
12. Environmental Auditing
13. Alternative Energy Sources/Energy Technology
14. Cleaner Production Technology
15. Solid and Hazardous Waste Management

16. Environmental Economics
17. Remote Sensing & GIS Applications in Environment
18. Environmental Risk Assessment

## **OUTLINES OF POST-GRADUATE CORE COURSES**

### **CORE COURSES**

#### **COURSE 1 ENVIRONMENTAL POLICY**

Meaning and Scope of Environmental Planning and Management, development of concepts, Carrying capacity and sustainable development. Man-Environment Interaction in time and space. Relationship of culture, technology and resource use. Conservation Strategies; WCS, NCS, Provincial and Local Strategies. A detailed study of Environmental Problems of Pakistan, status of Terrestrial, Aquatic and Atmospheric Ecosystems. Treaties, Conventions and Protocols in Global, Regional and International Environmental Issues. Legislation and Environmental Protection with particular reference to Pakistan. Environmental control Policies, Instruments and methods. Role of Public awareness and community participation in environmental conservation and management. Organizational and Institutional Framework for Environmental Protection and Management: Scope and Status in Pakistan. Draft National Environmental Policy.

#### **RECOMMENDED BOOKS**

1. Ball, S and Bell, S, 1994. *Environmental Law – The Law and Policy relating to the Protection of the Environment*. 2<sup>nd</sup> Ed. London Black Stone Press Ltd.
2. Mackenzie, F T Mackenzie J A, 1995. *Our Changing Planet – An Introduction to Earth System Science and Global Environmental Change*, Englewood Cliffs Prentice Hall.
3. Hansen, P E and Jorgensen, S E, 1991. *Introduction to Environmental Management – Development in Environmental Modeling*, 18; Amsterdam, Elsevier.
4. Money, D, 1994. *Environmental Issues – The Global Consequences*, Hodder and Stoughton, London.

**FURTHER READINGS**

1. The World Commission on Environment and Development: *Our Common Future*, 1987. Oxford University Press.
2. GoP and IUCN. 1992. *The Pakistan National Conservation Strategy (PNCS)*, Islamabad.
3. Khan K F, 1991. *Geography of Pakistan, Environment People and Economy*. Oxford University Press, Karachi.

**COURSE 2****ENVIRONMENTAL ANALYTICAL TECHNIQUES**

Introduction; Principles of physical, chemical and microbiological analysis of environmental pollutants, Sampling Procedure for the examination of Water, Wastewater, Air and Solid Waste; sampling rules, sample collection and preservation. Laboratory Techniques and Field Monitoring for parameters of importance causing environmental pollution. Environmental Chemical Analysis; role and importance, classical methods: volumetric and gravimetric analysis. Instrumental Techniques using Atomic Absorption and Emission Analysis Spectrophotometry, Gas Chromatography etc. Assessment and Interpretation of Results using Statistical Tools.

**RECOMMENDED BOOKS**

1. Ahmed, K, *Environmental Engineering Laboratory* (latest edition). A one Publishers Lahore.
2. Standard Methods for Examination of Water and Wastewater, ed. A. Greenberg (American Public Health Association).

**COURSE 3****ENVIRONMENTAL IMPACT ASSESSMENT**

Introduction to principles and process of EIA. Introduction to EIA tool and techniques. Role of bio-geo-chemical cycles in Trans-conversion of aspects to environment. Risk management process in terms of hazard management. Assessment of environmental impacts; Impacts upon the physical environment, ecological impact assessment, social impact assessment, economic impact assessment. Cost benefit analysis of projects. Sectoral guidelines for EIA. Environmental Impact Statement. Case Studies and review. Cumulative effects assessment.

**RECOMMENDED BOOKS**

1. Wood, C, 1995. *Environmental Impact Assessment (A Comparative Review)*. Longman Scientific and Technical. Longman House. Burnt Hill, Harlow Essex. UK.
2. World Bank (1993) *Public involvement in environmental assessment: requirements, opportunities and issues, Environmental Assessment Sourcebook Update*, Environment Department, W B, Washington, DC.

**FURTHER READINGS**

1. Sectoral Guidelines of Environmental Impact Assessment, Ministry of Environment, Government of Pakistan.

**COURSE 4  
PROJECT MANAGEMENT**

Introduction: What is a Project, Project Life Cycle, Writing Project Proposal, Defining Project objectives. Project Planning. Project Initiation; Need identification, feasibility study, economic evaluation. Logical Framework: Explanation of Vertical Logic; inputs, activities, outputs, specific objectives, development objectives, work breakdown structure. Explanation of Horizontal Logic; indicators, means of verification, assumptions. Stakeholders Analysis and Participation. Participatory project monitoring and evaluation. Reasons for Project success or failure. Planning Commission Performas, Project Planning and Approval Processes, Resource Mobilization. MS Project

**RECOMMENDED BOOKS**

1. A Guide to Project Management; Body of Knowledge PMBOK Guide, 2000, Project Management Institute
2. Meredith J R, Mantel S J, 1997, Project Management: A Managerial Approach, John Wiley and Sons, Inc.

**COURSE 5  
HEALTH SAFETY AND ENVIRONMENT**

Definition and Concept of Environment related Human health problems, Public health concept, communicable and non-communicable diseases water borne, air borne, food borne and sanitation related diseases and control measures, Occupational Health: problems and issues, prevention and control. Accident prevention and safety plans, safety

techniques. Ergonomic and Safety. Primary health care services; principles and practices. Government Policies and Programmes.

#### RECOMMENDED BOOKS

1. Caeneross, S, 1993. *Environmental Health Engineering*. Wiley Interscience.
2. Yassi, A, Kjellström, T, de Kok, T and Guidotti, T L, 2001. *Basic Environmental Health*. 1<sup>st</sup> ed. Oxford University Press New York, USA.
3. Nebel, B J and Wright, R T, 1998. *Environmental Science (The Way the World Works)*. 1<sup>st</sup> ed. Prentice Hall International Inc. London, UK.
4. Lippmann, M Van Nostrand and Reinhold, 1992. *Environmental Toxicants (Human Exposure and their Health Effects)*. 1<sup>st</sup> ed. New York, USA.
5. Park K, 2002. *Park's Text book of Preventive and Social Medicine*, 2<sup>nd</sup> ed. M/S Banarsid.

#### COURSE 6

##### POPULATION DYNAMICS AND THE ENVIRONMENT

Population: Is really a problem? The Population Concept. Population Problem and Population Debates. World Population: Current Scenario and Future Growth Projection. The Demographic Transitions: Population Growth and Decline. Population and Environment Nexus: Population and Natural Resource Sustainability, Population and Poverty, Unplanned Migrations and Urbanization, Unhealthy Living Environment. Population and Development Nexus: Population and Development in South Asia, Environment and Development Relatedness, Population-Development-Environment Nexus: South Asia Situation, Technology as Solution of Population Problem. Response to Population Problem: The Politics of Population Control, Government Responses: Programmes and Policies, Individual Responses: Attitudes and Perceptions, Sustainable Approach to Population Control.

#### RECOMMENDED BOOKS

1. Botkin, D and Keller, E, 2000. *Environmental Science: Earth As a Living Planet*. John Wiley and Sons, Inc.
2. Nebel, B J and Wright, R T, 1998. *Environmental Science*. 6<sup>th</sup> edition. Prentice Hall.

3. Engr, E D and Smith, B F, 2000. *Environmental Science: A Study of Inter-relationships*. 7<sup>th</sup> edition. McGraw-Hills.

## **COURSE 7 POLLUTION CONTROL TECHNOLOGIES**

Introduction; Pollution Concept, Types of Pollution, solid waste minimization techniques, air pollution control technologies, water pollution control technologies, water treatment technologies, soil pollution control technologies, noise pollution control technologies, Biotechnology for environment, industrial pollution control, Occupational safety devices.

### **RECOMMENDED BOOKS**

1. Nevers, N D, 1995. *Air Pollution Control Engineering*. McGraw-Hill.
2. Felder, E, 1989. *Industrial Water Pollution Control*, 2<sup>nd</sup> edition. McGraw-Hill.
3. Cheremisinoff, N P, 1996. *Biotechnology for Waste and Wastewater Treatment*. Prentice Hall India.
4. Botkin, D and Keller, E, 1995. *Environmental Science: Earth As a Living Planet*. John Wiley and Sons, Inc.
5. Freeman and Harry, M, 1995. *Industrial Pollution Prevention Handbook*. McGraw-Hill.

## **Elective Courses**

### **COURSE 1 ENVIRONMENTAL MANAGEMENT**

Fundamental concepts of Environmental Management, Historical Development of environmental concerns, sustainable development concept, environmental management of agriculture, forest, water, land resources, social, ethical and religious economic and technological dimensions, policy and legal instrument for environmental management, institutional framework, role of private sector and civil society: greening manufacturing, marketing, green consumerism, global efforts for managing environment: Agenda 21, WSSD, WEHAB. Local actions: NCS, NEAP, Environmental policy

**RECOMMENDED BOOKS**

1. Cunningham, W P and Saigo, B W, 1995. *Environmental Science: A Global Concern*, Wm C Brown Communication, Inc.
2. Khan M I, Tahir B A, and Akhtar N, 2004. *Integrated Environmental Management*, Allama Iqbal Open University.
3. Carley, M and Christie, I, 2000. *Managing Sustainable Development*. 2<sup>nd</sup> ed. Earthscan Publications Ltd. UK.
4. TERI, 2000, *Global Sustainable Development: directions and innovation for change*. Tata Energy Research Institute, New Delhi.
5. Dwivedi, O P, 1997. *India's Environmental Policies, Programmes and Stewardship*, Macmillan Press Ltd, London.

**FURTHER READINGS**

1. Qadar S, Dogar A R, Khan A S, 2003. *Pakistan Environmental Laws and their Compliance*, Lahore Law Times Publications.

**COURSE 2****ENVIRONMENTAL CHEMISTRY**

Material cycling in the environment; Micro and macronutrients, Cycling of water, carbon, nitrogen and phosphorus, Cycling and balance of nature. Pollution; Definition, Types of pollutants, Origin, transport, reactions and effects of chemicals in water, air, soil, and biotic environment, fate of pollutants in an ecosystem, treatment methods for pollutants. Instrumental Methods of environmental analysis; Principles of sampling, Sampling techniques for chemical analysis of air, water, soil and food, Principles of filtration, titration, distillation, paper chromatography, gas chromatography etc., Absorption spectroscopy and atomic emission spectroscopy, Determination of NEQS parameters, Lake Water quality, eutrophication of lakes and water and waste water characteristics, chemical coagulation, disinfections of water, smog formation and acid rain, green house effect, pollution of the sea and water desalinization. Soil Biological Activity and Soil Conservation.

Chemistry and dynamics of pollutants in the environment; effects of pollutants: synergistic effects, antagonistic effects, and additive effects on biotic and abiotic components of environment. Detail analysis of agrochemicals in relation to natural runoff persistence in the environment. Pollution prevention decision-making using life cycle analysis (LCA). Industrial ecology, ecology of polluted water.

**RECOMMENDED BOOKS**

1. Manahan, S E, 2000. *Environmental Chemistry*, Lews Publishers London.
2. Sawyer, C D, 1999. *Chemistry for Environmental Engineers*.

**COURSE 3  
ENVIRONMENTAL MICROBIOLOGY**

Biological characteristics of wastes. Microbiological quality of water, food and soil. Effects of disinfectants on water and food borne microorganism. Techniques for the control of microbiological pollution. Environmental hygiene and sanitation. Health problems and issues related to different occupation. Primary health care and practice. Host pathogen interaction. Communicable and non- communicable diseases. Nosocomial infection.

**RECOMMENDED BOOKS**

1. Ford E Timothy (editor), 1993, *Aquatic Microbiology: An Ecological Approach*, Blackwell Scientific Publications.
2. Telear M A, Chan E.C.S. *Microbiology: Concepts and Applications*. McGraw-Hill Inc.
3. Prescott, L M, Harley G P, Klei C.A. 1992. *Microbiology (4<sup>th</sup> edition)*. McGraw-Hill Inc.

**COURSE 4  
FRESHWATER ECOLOGY**

Definition, importance, lentic and lotic series, origin of lentic and lotic series, size, depth, elevation, margin, bottom; sources of bottom materials; stratification of bottom deposits; physical features of water, density, water turbidity, chemical features of water; dissolved gases; pH, alkalinity, hardness, salinity; nitrogen cycle; phosphorus cycle; sulphur cycle; trace elements.

**RECOMMENDED BOOKS**

1. Goldman, C R and Horne, A J, 1983. *Limnology*. McGraw-Hill, International Book Company, Japan.
2. Welch, P S, 1968. *Limnology (4<sup>th</sup> edition)*. McGraw-Hill Book Co. Inc. New York.
3. Allen S E, 1990. *Chemical Analysis of Ecological Materials*. Scientific Publishers, London.

## **COURSE 5 ENVIRONMENTAL SOCIOLOGY**

Introduction to sociology, Individualistic, Naturalistic and sociological features, Environment and sociology: Relationship between society and nature, Giddens's theory of structuralism and its suitability as a tool for sociological investigation of environmental issues, Co-evolution concept; relationship between society and nature. Environmental sociology: History and development, Concepts: "Socio-Environmental Relations"; "Co-evolution"; "Societal metabolism"; "Human expansionism", Interdisciplinary approach to environmental issues, Constructive approaches in environmental sociology, Social commitments. Environment and development: Development, Environmentalism and conservation in developed and developing countries, Sustainable development, Political economy and political ecology. Environmental social movements, Gender and environment: Women and environment, Gendered nature of environmental issues, Environmental degradation and women, Eco-feminism. Environment and societies: International and national perspectives; e.g. America; Asia; Africa; Europe and Pakistan. Environmental management, Public policy, Behaviour.

### **RECOMMENDED BOOKS**

1. Cooper, D. E. and Palmer, J. A. (ed.) *The Environment in Question: Ethics and Global Issues*. Routledge London, UK.
2. Irwin, A. A., 2001. *Sociology and the Environment: A Critical Introduction to Society, Nature and Knowledge*. Polity and Blackwell Publishers Ltd. UK.
3. Stark, L. S., 2002. Editors *State of the World 2002: Progress Towards a Sustainable Society. A World Watch Institute Report on Progress Towards Sustainable Society*. Earthscan Publications Ltd. London, UK.

### **FURTHER READINGS**

1. Barry, J and Frankland, E G (ed.), 2002. *International Encyclopaedia of Environmental Politics*. Routledge London, UK.

## **COURSE 6 ENVIRONMENTAL GEOLOGY**

Introduction: our place in the environment, Geologic framework: the home planet, earth systems and cycles, earth structure and materials. Hazardous geologic processes: assessing geologic hazards and risks, earthquakes, volcanic activity, tsunamis, landslides, mass wasting,

subsidence, floods, hazards of ocean and weather and meteorite impacts. Using and Caring for Earth Resources: the nature of earth resources, energy from fossil fuels, energy alternatives, mineral resources, soil resources and water resources. Human Impact on the environment: managing waste disposal contaminants in the geologic environment and atmospheric change. Medical Geology: the role of geologic materials in health; trace elements in natural waters, radon and trace elements in soil. The effects of radioactivity on human health, and its remedial measures. Contamination of air and ground water resources by nuclear wastes and nuclear explosions. Environmental Law: History, development and protection of environment, some case histories, environmental legislations: water law and land use planning laws.

#### RECOMMENDED BOOKS

1. Barbara W M, Brain J S, Stephen C P, 1996, *Environmental Geology*, John Wiley and Sons Inc. New York.
2. Montgomery C W, 1999, *Environmental Geology*, 4<sup>th</sup> ed. William C. Publisher, Brown USA.
3. Blatt H, 1997, *Our Geologic Environment*, Prentice Hall Inc. Eagle Wood Cliffs. New Jersey, USA.
4. Akhtar R, 1991, *Environment and Health: Themes in Medical Geography*, Pak Book Corporation.

#### COURSE 7 MARINE POLLUTION

Characteristics of marine water and sediment. Sources and effect of marine pollution. Marine pollution and ecological changes. Effects of pollution discharges, oil spills, coastal development, beach erosion, eutrophication channel dredging and changing sea-level on marine environment and control measures, modelling for pollution dispersion, study of marine biology (organism, fisheries and mangroves), coastal geology and estuarine ecology, marine resources management. Seawater intrusion. Coastal management.

#### RECOMMENDED BOOKS

1. Mackenzie, F, 1998. *Introduction to Earth Systems Science and Global Environmental Change*. Printice Hall.
2. Brows, G and Engela, 1991. *Case Studies in Oceanography and Marine Affairs*. Open University, UK.

3. Ocean Chemistry and Deep Sea Sediments, 1995. Open University, UK.
4. Brown, E and Collings, E, 1995. *Sea Water: Its Composition, Properties and Behaviour*.

### **COURSE 8 EPIDEMIOLOGY**

Basic concept of Epidemiology, epidemiological approach and intervention, Dynamics of Disease and interventions, measuring the occurrence of disease, cohort cases, case control and cross sectional studies, Epidemiology models, ecological triad, wheel model and web causation, host and pathogen interaction: concept of cause, establishing the cause of a disease, environmental risk assessment, association and causation in environmental Epidemiology, survival of pathogen in the environment, Epidemiology of communicable and non-communicable diseases, Epidemiology and prevention. Field investigation for Epidemiology; designing studies in the field, developing interventions, The scope and level of prevention, Water and food borne disease and their spread, environmental and occupational Epidemiology, epidemiological aspects of environmental hazards to reproduction; risk factors for cancer in different occupational environment, epidemiological analysis using computer EP11NFO-5 for micro computer use. Epidemiology and public policy

### **RECOMMENDED BOOKS**

1. Gordis I, 2000, *Epidemiology*, W B Saunders Company.
2. Rothman K J, 2002, *Epidemiology; An Introduction*, Oxford University Press Inc.
3. Gregg M B, (editor), 2002, *Field Epidemiology*, Oxford University Press.
4. Brian M, Dimitrios T, 1996, *Epidemiology: Principles and Methods*, Little, Brown and Company.
5. Benenson A S, (editor), 1990, *Control of Communicable Diseases in Man*, 15<sup>th</sup> ed. American Public Health Association.

### **COURSE 9 ENVIRONMENTAL BIOTECHNOLOGY**

Biotechnology: definition, principal and process, Recombinant DNA. technology: genetics of bacteria, Methods of gene transplantation in bacteria.

Biosensors: development and use for pollution monitoring, Bioabsorption and bioaccumulation of heavy metals, Biodegradation of toxic chemicals, genetics of biodegradation, Phytoremediation,

Bioreactor: types and construction, Immobilization and biofilm formation.  
GEMS: construction and use.

### RECOMMENDED BOOKS

1. Rattledge C, *et al*, 2001, *Basic Biotechnology*, Cambridge University Press.
2. McEldowney S, Hardman D J, Waite S, 1993, *Pollution: Ecology and Biotreatment*, Longman Scientific & Technical.

### COURSE 10

#### WILDLIFE, FORESTRY AND WETLAND MANAGEMENT

Introduction to wildlife and their relationship with population. Concepts of wildlife conservation, sustainable development and ecosystem. Effects of Industrial and Agricultural development and urbanization on wildlife. National Parks. Wildlife sanctuaries and game reserves of Pakistan, their management and environmental problems. Modern techniques for control of environmental pollution in wildlife areas. Endangered species causes and measures for the conservation. International Conventions.

### RECOMMENDED BOOKS

1. Rigger, P G, 1991. *Long Term Ecological Research: An International Perspective*. John Wiley.
2. Sexena, M M, 1990. *Applied Environmental Biology*. Agro Botanical Publishers, India.
3. Sheehun, P J, 1984. *Effect of Pollution on the Ecosystem*. John Wiley.

### COURSE 11

#### WATERSHED MANAGEMENT

Introduction: what is watershed, how watershed works, parts of watershed, natural changes within watershed, current issues in water management, characteristics of effective management, watershed.

Inventory: Physical features and landforms, climate, soil, infiltration and runoff, stream flow, groundwater, water quality, plant and animal communities, land use, social and economic systems, valued features and activities. Problem Definitions and Scoping, identifying current users, need for public involvement, public involvement techniques and processes, developing workable management options, simple and detailed assessment methods, costing and financing, quantifying intangibles, legal and institutional administrative concerns, planning for watershed, choosing and implementing the best plan, case studies.

**RECOMMENDED BOOKS**

1. Heathcote I W, *Integrated Watershed Management*, 1998, John Wiley & Sons. Inc.
2. Beck G, Dobson C, *Watersheds; A Practical Handbook for Healthy Water*.
3. Reimold R J, 1998, *Watershed Management; Practice, Policies and Coordination*, McGraw-Hill Companies.

**COURSE 12  
ENVIRONMENTAL AUDITING**

Background and history of Environmental audit, principles of environmental auditing, types of environmental audit, definition and basic concepts, scope of environmental audit, initiating an environmental audit; planning, team selection, preparation, carrying out the data, reporting, terms of reference for Environmental auditor, environmental audit protocol.

**RECOMMENDED BOOKS**

1. Khan, A B, Khan H N, and Qasmi M F, 1998, *EMAS Environmental Management and auditing Systems; A Practical Guide for the Development and Implementation of an Effective Environmental Management System*, WWF Pakistan.

**COURSE 13  
ALTERNATE ENERGY SOURCES AND TECHNOLOGY**

Fossil fuels and their environmental effects; Green house effect and acid rain etc. Renewable energy principles; essential Physics (fluid mechanics, thermodynamics etc.); Solar radiation characteristics, measurements and local data; Passive use of solar energy (water heating, air heating, crop dryers, space heating, water desalination, solar ponds and solar concentrators etc); Photovoltaic; Micro-hydro electric plants; Wind power; Biofuels; Ethanol from Biomass; Wave and tidal and ocean thermal energy; Geothermal energy; Energy storage (batteries and fuel cells etc.); Hydrogen from renewable energy sources.

**RECOMMENDED BOOKS**

1. Walisiewicz, M and Gribbin, J (ed.), 2002. *Alternative Energy (Essential Science Series)*. D K Publishing.

2. Hoffmann, P., 2002. *Tomorrow's Energy: Hydrogen, Fuel Cells and the Prospects for a Cleaner Planet*. MIT Press.
3. Twidell, J. and Weir, T., 1986. *Renewable Energy Resources*. E & F.N.Spon Ltd.
4. Cassedy, E.D., 2002. *Prospects for Sustainable Energy: A Critical Assessment*. Cambridge University Press.
5. Trivedi, P.R. and Raj, Gurdeep., 1992. *Environmental Energy Resources*. Akashdeep Publishing, New Delhi.

#### **COURSE 14 SOLID AND HAZARDOUS WASTE MANAGEMENT**

Sources, Classification, Characteristics, Generation, onsite handling and storage, collection, transfer, recycling and disposal techniques of municipal Solid Waste, land filling, thermal conversion, composting, concept of integrated solid waste management, existing practices and their hazards. Economic evaluation of the systems, Hospital waste Management, Hazardous waste management.

#### **RECOMMENDED BOOKS**

1. Tehobanoglous G, 1993, Integrated Solid Waste Management, McGraw-Hill

#### **COURSE 15 ENVIRONMENTAL ECONOMICS**

Introduction, definitions, Distinction between natural resource economics and environmental economics. The Economy and the Environment. First and second laws of thermodynamics. The fundamental balance. Willingness to pay and aggregate demand/willingness to pay. Benefits and costs, the equilibrium principle, marginal cost and supply. Economic efficiency and markets. Markets and social efficiency, external costs and external benefits. Pollution control – a general model. Pollution damages and abatement costs. The socially efficient level of emissions. Valuing the Environment and Benefit-cost Analysis: Measuring environmental benefits: contingent valuation, the travel cost method and the hedonic approach. Benefit-cost analysis. The value of life, health, risk and safety. Economic Development and the Environment: The Global Environment: Ozone Depletion, global warming and biological diversity. International environmental agreements. The economics of international agreements. International Trade and the environment.

**RECOMMENDED BOOKS**

1. Field, B C and M K Field, 2002. *Environmental Economics: An Introduction*, 3<sup>rd</sup> edition, New York: McGraw-Hill.
2. Chapman, D, 2000. *Environmental Economics: Theory, Application and Policy*, Massachusetts: Addison-Wesley.
3. Goodstein E S, 2002, *Economics and the Environment*, 3<sup>rd</sup> ed., John Wiley & Sons. Inc.
4. Markandya A, and Richardson J, (editors), 1992, *Environmental Economics: A Reader*, St. Martin's Press, USA.

**COURSE 16****REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENT**

Image interpretation and identification of features from photographs and satellite images, Land Use mapping, environmental monitoring of natural and man-made processes such as floods, land sliding, ozone layer depletion, water pollution, deforestation, soil erosion, waterlogging and salinity. Resource inventories, techniques to carry out surveys and inventories, Mapinfo, ER Mapper, Autocad.

**RECOMMENDED BOOKS**

1. Lillesand, T M and Kiefer, R W *Remote Sensing and Image Interpretation*. John Wiley and Sons Inc.
2. Bernhardsen, T, 1992. *Geographic Information Systems*. Vivak IT Publishers, Norway.

**COURSE 17****ENVIRONMENTAL RISK ASSESSMENT**

Environmental risk assessment and management; historical perspective. Risk assessment to human health from chemicals in the environment. Risk assessment to ecological systems from chemicals, from biological introductions, Evaluation of the likelihood of major accidents in industrial processes. Assessing risks to ecosystems and human health from genetically modified organisms. Retrospective assessment, eco-epidemiology and ecological monitoring. Epidemiology and environmental risk assessment. Risk assessment in legislation: Application of risk assessment in policy and legislation in the European Union and in the United Kingdom. Application of risk assessment in policy and legislation in North America. Application of risk assessment in policy and legislation in developing countries. Balancing risks with other considerations: The psychology of risk and uncertainty. The economics

of risk. Valuing risks. Natural hazards, risk analysis and risk management. Risk management: Principles, approaches and concepts: Corporate chemical management; a risk-based approach. Environmental risk assessment in business. Risk assessment and management for water treatment and disposal. Risk assessment and management in the exploitation of the seas. Risk assessment and management for inland waters. Environmental risk assessment in development programmes, the experience of World Bank. Risk communication. A framework for sustainable product development.

#### RECOMMENDED BOOKS

1. Calow, P (Ed.), 1998. *Hand Book of Environmental Risk Assessment and Management*: Black Well Science Ltd. UK.
2. Larche, I and Paleologos, E K, 2001. *Environmental Risk Analysis*. McGraw-Hill NY, USA.
3. Patnaik, P, 1997. *Hand Book of Environmental Analysis: Chemical Pollutants in Air, Water, Soil and Solid wastes*. CRC Press Inc., USA.
4. Mohapatra, R, 2002. *Occupational Health Hazards and Remedies*. Jaypee Brothers Medical Publishers Pvt. Ltd., India.
5. Cutter, S L, (ed.), 1999. *Environmental Risks and Hazards*. Prentice-Hall of India. New Dehli, India.
6. Tarynor, P L, 2000. *Biosafety Management: Principles and Applications*. Virginia Polytechnic Institute Publications. USA.
7. Riviere, J, 2000. *Environmental Risk Evaluation of Polluted Soils*. Oxford and IBH Publishing Company Pvt. Ltd. India.
8. Iqbal, M, Srivastava, P S and Siddiqi, T O, 2000. *Environmental Hazards: Plants and People*. CBS Publishers and Distributors, India.

Suggested Bachelors Degree Programme Structure  
APPENDIX-A

KEY TO SUBJECTS			
University Requirements (student has no choice)	Core Subjects (choose 5 courses)	Subjects Required for Major (choose 15 courses from the following)	Electives Subjects (choose 4 courses of not more than 12 credits in total from other departments)
1. English I 2. English II 3. Functional English 4. Remedial English 5. Islamic and Pak Studies or Ethics 6. Research Methodology 7. Report Writing Skills	1. Introduction to Environmental Science 2. Basic Chemistry 3. Environmental Chemistry 4. Biology I 5. Biology II 6. Physics of the Environment 7. Basic Mathematics 8. Fundamentals of Ecology	1. Social theory of environment 2. History and philosophy of environmental thoughts 3. Environmental Toxicology 4. Environmental policies and regulations 5. Applied Ecology 6. Environmental Monitoring 7. Health and Environment 8. Conservation Biology 9. Environmental and natural resource economics 10. Environmental Technology 11. Environmental Management Systems 12. Environmental Impact Assessment 13. Remote Sensing and GIS 14. Water Resource Management 15. Natural Resource Management 16. Participatory Management 17. Occupational Health and Safety 18. Environmental Microbiology 19. Sustainable Development	1. Fundamentals of Earth Science 2. Basic Statistics 3. Introductory Economics 4. Introductory Sociology 5. Computing skills 6. Principles of Management 7. Fundamentals of Public Administration

