

CURRICULUM
OF
ENVIRONMENTAL SCIENCE
BS/MS

(Revised 2013)



HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

| | |
|-------------------------|----------------------------|
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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “Supervision of Curricula and Textbooks and Maintenance of Standard of Education”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

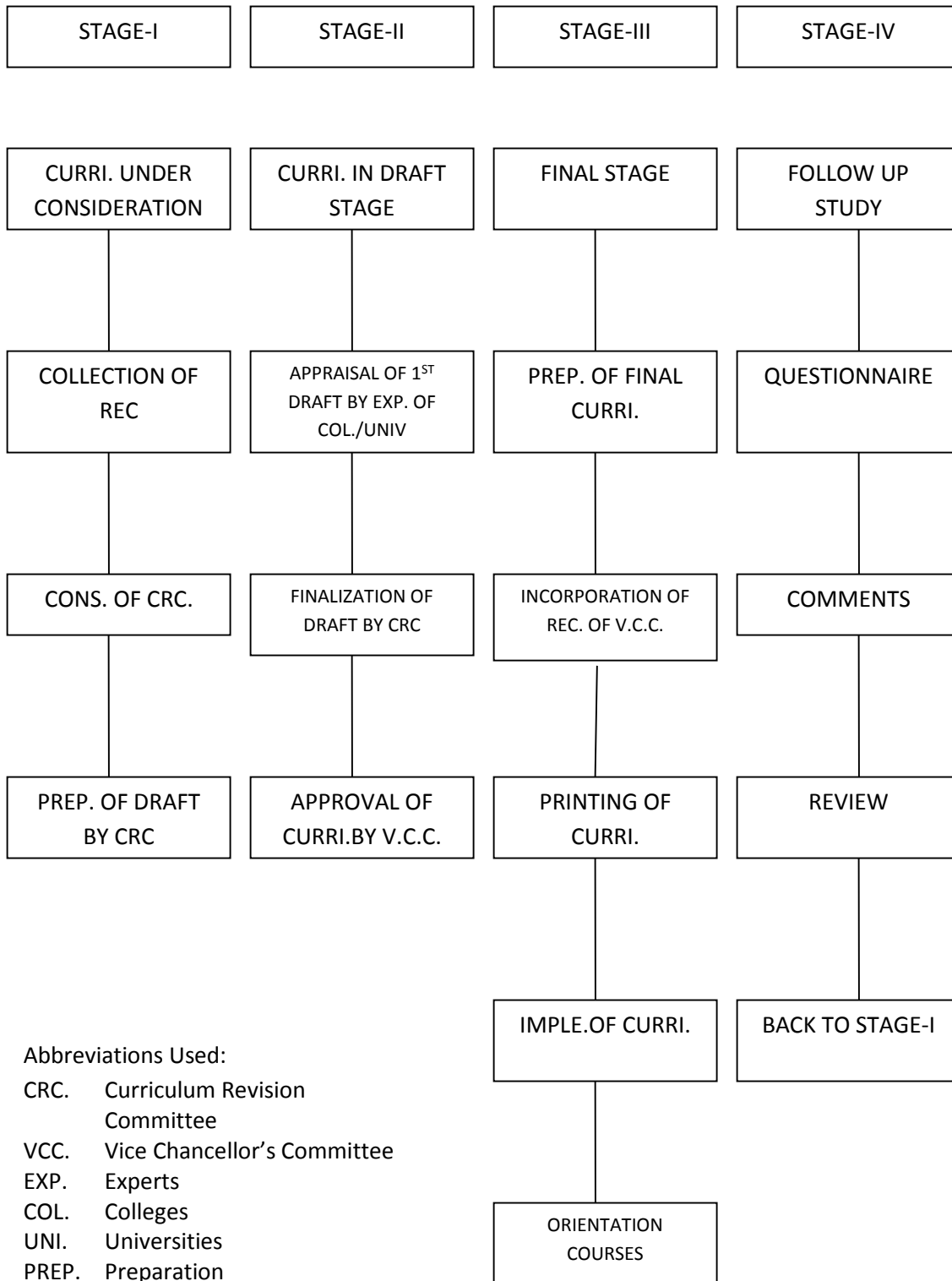
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC’s, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

- CRC. Curriculum Revision Committee
- VCC. Vice Chancellor's Committee
- EXP. Experts
- COL. Colleges
- UNI. Universities
- PREP. Preparation
- REC. Recommendations

Minutes of the Final Meeting of NCRC

The Final meeting of National Curriculum Revision Committee (NCRC) in Environmental Science was held from June 19-21, 2013 at HEC Regional Centre, Peshawar to finalize the 2nd revision of the curriculum of environmental science based on suggestions discussed in its preliminary meeting held from December 10-12, 2012 and input received thereafter from various sub-committees and institutions. The purpose of the meeting was to finalize the draft revision of curricula of undergraduate level Bachelor Studies (BS) and graduate level Masters Studies (MS) programmes in the discipline of Environmental Science.

Following Members attended the meetings:

1. **Dr. Muhammad Irfan Khan** Convener
Professor & Chairman
Department of Environmental Science
International Islamic University, Islamabad.
2. **Dr. Shahid Amjad** Member
Professor & Chairman
Department of Environment & Energy
Management
Institute of Business Management, Karachi
3. **Dr. Muhammad Ullah** Member
Professor & Chairman
Department of Environmental Science
Northern University, City Campus, Nowshera
4. **Dr. M. Faheem Malik** Member
Professor & Chairman
Department of Environmental Science
University of Gujrat
5. **Dr. Shahida Zakir** Member
Associate Professor & Chairperson
Department of Environmental Sciences
Peshawar University, Peshawar
6. **Dr. Moazzam Jamil** Member
Associate Professor
University College of Agriculture and
Environmental Sciences
The Islamia University of Bahawalpur,
Bahawalpur

7. **Dr. Nadia Ghani** Member
Assistant Professor
Department of Environmental Science
Lahore College for Women University,
Lahore
8. **Dr. Mirza Habib Ali** Member
Principal Scientific Officer
Pakistan Science Foundation, Islamabad
9. **Dr. Rohama Gill** Member
Assistant Professor
Department of Environmental Science
Fatima Jinnah Women University, Rawalpindi
10. **Dr. Muhammad Usman** Member
Assistant Professor,
Institute of Soil & Environmental Sciences
University of Agriculture, Faisalabad
11. **Dr. Said Rahman** Member
Manager
Environmental Monitoring & Modeling Division
SUPARCO, Head Quarters,
Karachi
12. **Dr. Sohail Yousaf** Member
Assistant Professor,
Department of Environmental Science
Quaid-i-Azam University, Islamabad
13. **Dr. Abdul Qadir** Member
Assistant Professor
College of Earth & Environmental Sciences
University of the Punjab, Lahore
14. **Dr. Muhammad Wahab** Member
Assistant Professor
Centre of Botany and Biodiversity
Conservation
University of Swat
15. **Dr. Audil Rashid** Member
Assistant Professor
Department of Environmental Sciences
PMAS-Arid Agriculture University, Rawalpindi

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| 16. Dr. Islamuddin Assistant Professor Department of Environmental Science International Islamic University, Islamabad | Member |
| 17. Syed Muhammad Yahya Director, Sindh EPA, Karachi | Member |
| 18. Fareed Ahmad Yasin Lecturer, Department of Environmental Science Bahauddin Zakariya University, Multan | Member |
| 19. Dr. Faiza Sharif Assistant Professor Sustainable Development Study Center G.C. University, Lahore. | Member/ Secretary |

Following Members could not attend the final meeting due to other engagements but attended the preliminary meeting and sent their representatives in the final meeting:

1. **Dr. Noor Jehan**
Professor and Vice Chancellor
Swabi University, Swabi
2. **Dr. Muhammad Anwar Baig**
HoD, Environmental Science
Institute of Environmental Science and
Engineering,
National University of Sciences and
Technology, Islamabad
3. **Dr. Kausar Jamal Cheema**
Professor & Dean
Faculty of Natural Sciences
Lahore College for Women University, Lahore
4. **Dr. Humera Farah**
Associate Professor
Department of Earth & Environmental
Sciences
Bahria University, Islamabad

5. **Dr. Azra Yasmin**
Associate Professor/Chairperson
Department of Environmental Science
Fatima Jinnah Women University,
Rawalpindi
6. **Dr. Ghulam Murtaza**
Associate Professor
Institute of Soil & Environmental Sciences
University of Agriculture, Faisalabad
7. **Dr. Asif Ali Memon**
Assistant Professor
Department of Energy & Environment
Engineering
Quaid-e-Awam University of Engineering
Science and Technology, Nawabshah
8. **Dr. Muhammad Arshad**
Assistant Professor
Institute of Environmental Science and
Engineering
National University of Sciences and
Technology, Islamabad.

The meeting started with the name of Almighty Allah and the welcome remarks by Mr. Fida Hussain, Director General (Academics), HEC. He explained the aims and objectives of the meeting with particular focus on revision and development of the curriculum so as to bring it in line with the international standards keeping in view the national needs. This was followed by introduction of the participants. Then he requested the Convener and Secretary to conduct further proceeding of the meeting.

The NCRC in its preliminary meeting, unanimously elected by consensus Prof. Dr. Muhammad Irfan Khan, Chairman of the Department of Environmental Science, International Islamic University, Islamabad as *Convener* and Dr. Faiza Sharif, Assistant Professor, Sustainable Development Study Center, GC University, Lahore as *Secretary* of the NCRC.

The Secretary of the NCRC already circulated the minutes of the Preliminary Meeting of the NCRC held from December 10-12, 2012 before the start of the meeting. The Convener asked, if there is any missing point or correction of record. Prof. Dr. Shahid Amjad, Chairman, Department of Environment and Energy Management, Institute of business Management confirmed that the minutes have been recorded correctly.

The Convener started the meeting with the remarks that the feedback from members of NCRC on the existing curriculum, which was revised in 2008 and the purpose and need of revision after five years was discussed at length in the first meeting, where members have also shared their perspectives on the implementation of curriculum in their respective university/institution. The Convener further apprised that we have agreed on a framework structure of the BS and MS programmes in December, 2012 meeting. For development of contents of courses, sub-committees were constituted in the previous meeting, which provided the revised contents during the last six months or so, therefore, in this meeting we will finalize the contents of the course and finally, we will give some general recommendations.

The Convener also updated the NCRC about the input received from National Impact Assessment Programme (NIAP) of Planning Commission of Pakistan for which financial and technical assistance was provided by Government of Netherlands and IUCN respectively. Under NIAP, the curriculum of “Environmental Impact Assessment”, which is one of the core courses in environmental science, environmental engineering and environmental design degree programmes has been revised by national and international experts through a nation-wide consultative process and will be appended with this document, which may also be used as a template for development of other courses by faculty members.

Another important aspect discussed in the meeting was admission criteria at undergraduate and graduate degree programmes in Environmental Science. It was agreed that admission to BS Environmental Science degree programme will remain the same as it was, i.e. HSSC pre-medical and pre-engineering or equivalent qualification. Whereas, admission to MS Environmental Science programme will only be given to candidates with BS four years degree in Environmental Science. However, the graduates of other allied disciplines like Agriculture, Biology, Botany, Chemistry, Forestry, Soil Science, Wildlife and Zoology may be admitted after passing at least four major courses of BS level without credit towards MS degree.

The NCRC further discussed various arguments about giving admission to graduates of other disciplines which are crosscutting in nature and important for understanding human relationship with environmental problems, perceptions and practices; and help in making policies and taking decision towards the environment and management of its resources. The Committee agreed that the door should not be closed for such graduates but at the same time the basic scientific character of Environmental Science programmes must remain intact. It was pointed out that like for design for pollution abatement and environmental improvement the discipline of Environmental Engineering was established. On the same line, keeping in view the importance of governance of environment and its linkages with socio-economic aspects, the discipline of Environmental Management has been established. Therefore, the committee agreed that to cater the need of the market which demands management oriented human resource a separate management oriented degree

programme may be developed as **Environmental Management**, which may be started as a Master level programme. This will provide an opportunity of value added qualification to graduates in Social and Management Sciences.

It was observed that many universities have started programmes in Environmental Science without requisite infrastructure, human and technical resources. Therefore, it was agreed that there must be some inspection or certification from some accreditation body for which there is a need to establish **National Environmental Education Accreditation Council (NEEAC)** like other disciplines, which will verify the availability of necessary human and technical resources, infrastructure and facilities for running a degree programme. Most of the universities running Environmental Science programmes are in short of funds for purchasing books and providing basic practical facilities to the students that are essential requirements for running these programmes. The committee strongly recommended that sufficient funds for these facilities should be arranged or provided by the HEC.

The committee also recommended that the principles of environmental science should be included at school level in Social Science that will not only create awareness among the children and develop responsible social behaviour but will also provide opportunities for induction of graduates of Environmental Science in teaching profession. For this purpose, HEC should coordinate with education departments in the provinces.

The Convener informed the NCRC that Federal Public Service Commission has included environmental science as a 100 marks optional subject in CSS curriculum. The committee recommended that from HEC platform provincial Public Service Commission should also be contacted to take the similar steps and include Environmental Science in the curriculum of various competitive examinations. It was also realized that most of the organizations in public sector do not employ environmental science graduates for environment related jobs, they should also be asked to provide opportunities to graduates of environmental science for environment related jobs. It was also observed that environmental contents have already been included in the science subjects at elementary, secondary and higher secondary level but the environmental graduates are not being employed as teachers.

Subsequently, after a general discussion on the NIAP programme, the inputs from the sub-committees constituted in the preliminary meeting were discussed and revised course contents of courses programmes for an in-depth critique and recommendations. Sub-committees also proposed the reading materials for newly introduced courses and proposed some new core courses and elective courses.

With consensus of all members, the NCRC revised the schemes of studies at undergraduate and graduate levels, which are presented below.

PROGRAMMES IN ENVIRONMENTAL SCIENCE

1. Introduction:

The 21st century promises for both an exciting time and a challenging world to live in. Many of the most complex challenges will be environmental forcing people to divert their attention towards this field. Meeting these challenges will require problem solving abilities based in natural, social and management sciences, and other disciplines. Environmental Science is the application of a combination of scientific disciplines to issues and questions regarding environmental and socio-economic problems. Environmental degradation, energy crisis, water scarcity, food security; mitigation and adaptation to climate change impacts are the major areas of concern in today's world. The economy is moving towards "Green or low Carbon Economy" based on Carbon neutrality and valuation of ecosystem services.

Environmental protection and conservation along with alleviation of poverty and sustainable development remained high on the global agenda in UN conferences at Stockholm 1972, Rio 1992, New York 1997, Johannesburg 2002, Bali 2007 and recently Rio 2012. Environmental 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, social and management sciences with political support and technological, economic and social interventions. This will require qualified and trained human resource.

Some of the environmental problems are global whose solutions will require international cooperation. Most of them are complex problems whose solution will require people able to grasp the big picture, able to appreciate and deal with complex problems and able to support strategies having long-way of impacts. We don't have many of these kinds of people; and there is a dire need and we anticipate that the academic programmes in environmental science are justifying that national need.

2. The Scope

Environmental Science is a decision support science, which has emerged as a result of convergence of a wide range of disciplines, therefore, its scope is wide as inter and multi-disciplinary field of knowledge. Its ambit is as wide as environment itself.

3. The Aim and objectives

The aim of undergraduate and graduate degree programmes in the discipline of Environmental Science is sustainable development and the objectives are to develop human resource equipped with knowledge to support decisions,

skills needed to mitigate impacts of climate change or adapt necessary measures and attitude to contribute in development of sustainable life style in the society and to develop green economy.

a. Teaching Objectives

The teaching objectives of the degree programmes in Environmental Science are to:

- enable students to learn how to analyze and assess environmental problems, its interrelationships with other systems of the society;
- equip student with the knowledge and skill necessary for pollution abatement, environmental conservation, management of natural resources and making path to sustainable development; and
- to impart skills to carry out independent scientific and technical research on various crosscutting aspects of environmental issues.

b. Learning Objectives

The degree programs are expected to equip the graduates with an ability to understand the linkages between various bio-physical and socio-economic components of environment and with an expertise of:

- demonstration of capabilities to understand the natural and socio-economic processes driving environmental systems;
- learning of scientific and technical expertise to solve environmental problems by introducing interventions; and
- development of interactions with stakeholders, managers and policy makers in addressing environmental issues.

4. Rationale for revision of curriculum

The environmental education at tertiary level has gain importance in the last 10 years in Pakistan as 40 universities in public sector and 8 universities in private sector have started offering degree programmes; about four times increase since 2003-4, when there were only 11 universities were offering degree programmes on environment. Secondly, there has been a rapid change in the worldview about environment and perspectives of dealing with environmental issues. Initially, the environmental science was considered as amalgam of many disciplines but now it has become a visionary science of informed decision-making, strategic planning and leadership, there is a complete paradigm shift from growing economy to greening economy. Thirdly, it is the policy of HEC to revise curriculum after three to five years to abreast with new developments in the knowledge domain worldwide.

Keeping in view the above facts, the Higher Education Commission of Pakistan appointed a National Curriculum Revision Committee in Environmental Science. This committee, in its preliminary and final meetings, discussed the

structure and composition of the existing undergraduate and graduate programmes in the discipline of Environmental Science and suggested appropriate changes to keep the graduate abreast with new developments in the discipline of Environmental Science and recommended a revised syllabus as a guidance for development of curricula by individual institutions with concurrence of their own statutory bodies for implementation.

5. Guiding Principles for Degree Programmes

Before drawing the structure 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. Environmental Science is an emerging science as a discipline which is highly inter and multi-disciplinary in nature. Integration of natural sciences with social sciences and humanities in a holistic study of the world around us is required to achieve its objectives by supporting decisions for sustainable development.
2. The degree programmes in Environmental Science must be comprehensive in coverage of the contents and consistent with contemporary state of knowledge.
3. The medium of instruction, assessment and evaluation will be English for all degree programmes in Environmental Science.
4. Courses from disciplines of social and management sciences must 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 with management orientation.
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. UNDERGRADUATE PROGRAMME

BS Environmental Science

Before drawing the outlines and contents of the courses the NCRC unanimously agreed on the following principles.

1. To maintain the equivalence of duration of study at international level, the Bachelors degree programme (BS) will be of four years i.e., eight semesters in the semester system.
2. The nomenclature for this four-year degree programme will be Bachelor Studies (BS) in Environmental Science consisting minimum of 124 and maximum of 136 credit hours including compulsory courses of English, Islamic studies and Pakistan studies.
3. The eligibility for admission to Bachelors of Environmental Science degree will be Higher Secondary School Certificate (HSSE) or equivalent qualifications after 12 years of schooling from other countries with pre-medical or pre-engineering subjects studied in English.
4. The course load should be minimum in the final year for the purpose of giving relief for final year's project work and career-oriented activities.
5. The Committee also proposed a semester wise distribution of courses in a basic to applied order. The committee recommended the following structure of the scheme of studies of BS degree and identified the courses for inclusion in the curriculum of BS in accordance with HEC's unified template.

Scheme of Studies of 4-year BS degree in Environmental Science

| Sr. | Categories | No. of courses | Credit Hours |
|--------------------------|---|----------------|--------------|
| | | Min-Max | Min-Max |
| 1. | Compulsory Requirement (No Choice) | 9-9 | 25-25 |
| 2. | General Courses to be chosen from other departments | 7-8 | 21-24 |
| 3. | Discipline Specific Foundation Courses | 9-10 | 30-33 |
| 4. | Major Courses including research project / Internship | 11-13 | 36-42 |
| 5. | Electives within the major | 4-4 | 12-12 |
| Total Credit Hour | 40-44 | 124-136 | |

- Total numbers of Credit hours 124-136
- Duration 4 years
- Semester duration 16-18 weeks
- Minimum semesters 8
- Course load per Semester 15-18 Cr hr
- Number of courses per semester 4-6
- Not more than 4 lab /practical courses
- No research thesis/dissertation instead a Final Year Project (FYP) is mandatory

4 YEARS BS PROGRAMME LAY OUT

| Compulsory Courses <i>(the student has no choice)</i> | General Courses <i>(to be chosen from courses offered by other departments)</i> | | Foundation Courses <i>(Discipline Specific)</i> | | |
|---|---|-----------------|---|-----------------------------|-----------|
| 9 courses | 7- 8 courses | | 9 -10 courses | | |
| 25 Credit hours | 21 - 24 Cr. Hours | | 30 - 33 Credit hours | | |
| Subject | Cr. Hr | Subject | Cr. Hr | Subject | Cr. Hr. |
| ENGLISH I | 3 | Biology I | 3 | Introduction to | 3 |
| ENGLISH II | 3 | Biology II | 3 | Environmental Science | |
| ENGLISH III | 3 | Basic Chemistry | 3 | Introduction to Earth | 3 |
| ENGLISH IV/ UNIVERSITY OPTIONAL* | 3 | Sociology | 3 | Sciences | |
| PAKISTAN STUDIES | 2 | Anthropology | 3 | Environmental Chemistry | 3 |
| ISLAMIC STUDIES / ETHICS | 2 | Introductory | 3 | Environmental Physics | 3 |
| MATHEMATICS | 3 | Economics | | Fundamentals of Ecology | 3 |
| STATISTICS <i>(in lieu of Mathematics II)</i> | | Psychology | 3 | Environmental Microbiology | 3 |
| | | Philosophy | 3 | Environmental Pollution | |
| | | International | 3 | Climatology | 3 |
| | | Relations | | Environmental Profile of | 3 |
| | | Globalization | 3 | Pakistan | 3 |
| | | | | Analytical Techniques in ES | 3 |
| INTRODUCTION TO COMPUTER | 3 | | | Population and Environment | 3 |
| | | | | Research Methods in | 3 |
| | | | | Environmental Science | |
| * University has the option to offer any other course in lieu of English IV. | 3 | | | | |
| | 25 | | 21 | | 36 |

| Major Courses <i>(including final year project/internship)</i> | | Elective Courses <i>(within the major discipline)</i> | |
|--|-----------|---|-----------|
| 11-13 courses | | 4 courses | |
| 36-42 Credit hours | | 12 Credit hours | |
| Subject | Cr. Hr. | Subject | Cr.Hr |
| Applied Ecology | 3 | Water Resources Management | 3 |
| Environmental Toxicology | 3 | Soil and Environment | 3 |
| Environmental Economics | 3 | Urban Environmental Management | 3 |
| GIS & RS | 3 | Disaster Risk Management | 3 |
| Environmental Management | 3 | Pollutant Movement in Soil | 3 |
| Biodiversity and Conservation | 3 | Energy and Environment | 3 |
| Environmental Monitoring | 3 | Hydrology | |
| Climate Change | 3 | Agro-ecology | 3 |
| Environmental Impact Assessment | 3 | Occupational Health and Safety | 3 |
| Natural Resource Management | 3 | Solid Waste Management | 3 |
| Environmental Governance | 3 | Coastal Environmental Management | 3 |
| Public Health and Environment | 3 | Ecotourism | |
| Pollution Control Technologies | 3 | Air and Noise Pollution | 3 |
| Final Year Project | | Environmental Biotechnology | 3 |
| OR | 3-6 | Project Management | 3 |
| Internship | | | |
| | 42 | | 12 |

Proposed Scheme of Studies for (4-Years) BS Degree in ENVIRONMENTAL SCIENCE

FIRST YEAR

| Course Titles | Credit Hours |
|---------------|--------------|
|---------------|--------------|

Semester-1

| | |
|--|-----------|
| 1. Introduction to Environmental Science | 3 (3-0) |
| 2. Biology-I | 3 (2-1) |
| 3. Basic Chemistry | 3 (2-1) |
| 4. Mathematics | 3 (3-0) |
| 5. English-I | 3 (3-0) |
| 6. Pakistan Studies | 2 (2-0) |
| Semester Credit Hours | 17 |

Semester-2

| | |
|-----------------------------------|-----------|
| 7. Introduction to Earth Sciences | 3 (2-1) |
| 8. Biology-II | 3 (2-1) |
| 9. Statistics | 3 (3-0) |
| 10. Sociology/Anthropology | 3 (3-0) |
| 11. English-II | 3 (3-0) |
| 12. Islamic Studies/Ethics | 2 (2-0) |
| Semester Credit Hours | 17 |

SECOND YEAR

Semester – 3

| | |
|------------------------------|-----------|
| 13. Introduction to Computer | 3 (2-1) |
| 14. Environmental Chemistry | 3 (3-0) |
| 15. Environmental Physics | 3 (2-1) |
| 16. Introductory Economics | 3 (3-0) |
| 17. English-III | 3 (3-0) |
| 18. Philosophy | 3 (3-0) |
| Semester Credit Hours | 18 |

Semester – 4

| | |
|--------------------------------|-----------|
| 19. Fundamentals of Ecology | 3 (3-0) |
| 20. Environmental Microbiology | 3 (2-1) |
| 21. Environmental Pollution | 3 (3-0) |
| 22. Climatology | 3 (3-0) |
| 23. Psychology | 3 (3-0) |
| 24. English-IV/ Univ. Opt. | 3 (3-0) |
| Semester Credit Hours | 18 |

THIRD YEAR

Semester – 5

| | |
|--|-----------|
| 25. Applied Ecology | 3 (3-0) |
| 26. Environmental toxicology | 3 (2-1) |
| 27. Environmental Profile of Pakistan | 3 (3-0) |
| 28. Population and Environment | 3 (3-0) |
| 29. Analytical Techniques in Environmental Science | 3 (1-2) |
| 30. ELECTIVE-I | 3 (3-0) |
| Semester Credit Hours | 18 |

Semester – 6

| | |
|--------------------------------------|-----------|
| 31. Environmental Economics | 3 (3-0) |
| 32. GIS and Remote Sensing | 3 (2-1) |
| 33. Environmental Management Systems | 3 (3-0) |
| 34. Biodiversity & Conservation | 3 (2-1) |
| 35. Environmental Monitoring | 3 (2-1) |
| 36. ELECTIVE-II | 3 (3-0) |
| Semester Credit Hours | 18 |

FOURTH YEAR

Semester – 7

| | |
|---|-----------|
| 37. Climate Change | 3 (3-0) |
| 38. Environmental Impact Assessment | 3 (2-1) |
| 39. Natural Resource Management | 3 (3-0) |
| 40. Research Methods in Environmental Science | 3 (3-0) |
| 41. ELECTIVE-III | 3 (3-0) |
| 42. ELECTIVE –IV | 3 (3-0) |
| Semester Credit Hours | 18 |

Semester – 8

| | |
|------------------------------------|-----------|
| 43. Environmental Governance | 3 (3-0) |
| 44. Public Health and Environment | 3 (3-0) |
| 45. Pollution Control Technologies | 3 (2-1) |
| 46. Final Year Project/Internship | 3 |
| Semester Credit Hours | 12 |

Elective Courses:

Courses from the following list may be offered by different departments depending upon their human and technical capacity, geographical location and need.

1. Water Resource Management
2. Soil and Environment
3. Urban Environmental Management
4. Disaster Risk Management
5. Pollutant Movement in Soil
6. Energy and Environment
7. Hydrology
8. Agro-ecology
9. Occupational Safety, Health and Environment
10. Solid Waste Management
11. Ecotourism
12. Project Management
13. Environmental Biotechnology
14. Air and Noise Pollution

Total Degree Credit Hours **124-136**

The NCRC agreed and further recommended that:

- *At last four courses must include practical work in the Laboratory and/or in the Field*
- *There will be no research thesis/dissertation at BS level; instead a FYP-final year project may be given to students, individually or in a group of 2-3 students.*
- *Universities can choose courses to offer as elective from the above list of Elective Courses.*
- *There should be at least one study/exposure tour in a year to some sites of ecological importance/industry/some project sites etc.*
- *The students should be encouraged to participate in public hearings of EIA of various projects and in seminars/conferences on environmental issues.*
- *The students should also be encouraged to organize events on various internationally recognized days of environmental importance.*

Outlines of Courses for BS Degree in ENVIRONMENTAL SCIENCE

SEMESTER 1

COURSE 1: INTRODUCTION TO ENVIRONMENTAL SCIENCE 3 (3-0)

Objectives:

The objective of this course is to provide orientation on the evolution and scope of this emerging discipline and to motivate them to think beyond basic sciences to decision sciences. After completing this course, the students are expected to learn the importance of Environmental Science in human life, its relationship with various segments of society and sectors of development. The students are also expected to become familiar with current national, regional and global challenges for sustainable development.

Course Outline:

Basic principles: about convergence of ecology with economic and sociology to evolve as environmental science, its nature, history, scope and the contribution to society. Environmental aspects: physic-chemical, biological, socio-economic, socio-cultural, moral and ethical, and philosophical thinking.

Environmental problems: local, regional and global level. Environmental challenges: Sustainability of resources for development: efficiency of energy and water resources, current and future trends in growth and resultant environmental pollution, poverty and resource depletion, development in industry, agriculture and urbanization.

Recommended Books:

1. *Environmental Science: Earth as a Living Planet*, Botkin, D.B & Keller, E.A. 9th Ed. John Wiley & Sons, 2013.
2. *Environmental Science: systems and solutions*, McKinney, M.L., Schoch, R.M. & Yonavjak, L. 5th Ed. Jones & Bartlett Publishers, 2013
3. *Environmental Science: Toward a Sustainable Future*, Wright, R.T. & Nebel, B.J. 10th Ed. Pearson Educational, 2007.
4. *Environmental Science: working with the Earth*. 11th Ed. Miller, G., Tyler. Cengage Learning, 2005.

**COURSE 2:
BIOLOGY-I**

3 (2-1)

Objectives:

The objective of this course is to provide knowledge the molecular basis of life to give a foundation for understanding the biochemical principles of structure and function of a living system as unity of life.

Course Outline:

Introduction: Definition and concept of life, chemical basis of structure and function of cell, chemical diversity of functional groups. Molecular basis of life: carbohydrates, lipids, proteins, phospholipids in membrane systems, polypeptides in protein diversity, and enzymes as molecular tools in chemical transformations nucleic acids the molecule of genetic information, replication and protein synthesis. Overview of structure and function of cell organelles and cell cycle.

Practical Work:

Identification of chemical nature of different animal and plant materials. Cytochemical demonstration of DNA and RNA in Avian blood and Protozoa. Biochemical tests for carbohydrates, proteins and lipids. Protein digestion by enzyme pepsin. Study of mitosis in onion root tips. Study of meiosis in Grasshopper's testis.

Recommended Books:

1. Campbell Biology. Reece, J.B., Urry, L.A., Cain, M.L. and Wasserman, S.A., 9thEdition, Pearson/ Benjamin Cummings Publishers, USA. 2010.
2. Biology' Campbell, N. A. 8thEdition, The Benjamin / Cummings Publishing Company Inc. New York. USA, 2008.
3. Cells, Lewis, B., Cassimeris, L., Lingappa, V. R., Plopper, G. Jones and Bartlett Publishers. Canada, 2007.

**COURSE 3
BASIC CHEMISTRY**

3(2-1)

Objectives:

The main objective of this course is to provide a basic knowledge and understanding of chemistry and principles of chemical reactions as well as extend the fundamental knowledge of various pollutants and their interactions with environment. The course not only provides excellent practice in basic chemistry, but also allows the rigorous development of experimental schemes and analytical methods.

Course Outline:

Periodic Table, chemical bonding: ionic, covalent, coordinate covalent bond. Solution chemistry. Surface chemistry. Colloids chemistry. Thermodynamics and chemical kinetics. General chemistry of functional groups of organic compounds (alcohols, carbonyls, esters, carboxylic acids, amines). Aromatic compounds, ions, radicals. Photochemical reactions. Radioactivity. Weak Acids & Bases; Water Hardness; Redox Reactions, Chemical Kinetics; Radioactivity.

Practical Work:

Preparation of molar, molal, normal solutions and buffers. Osmosis and Diffusion. Measurement of pH, EC, DO and TDS in waste water. Use of titrimetric and gravimetric analysis. Use of spectrophotometric techniques. Paper Chromatography (one and two dimensional), Thin layer chromatography, Column chromatography.

Recommended Books:

1. Chemistry for Environmental Engineering and Science, Clair Sawyer, Perry McCarty, Gene Parkin, McGraw-Hill 2009.
2. Principles of Environmental Chemistry, Girard, J.E., 1stEdition, Jones and Barlett, USA, 2005.
3. An Introduction to Environmental Chemistry, Andrews, J.E., Brimblecombe, P., Jickells, T.D., Liss, P.S. and Reid, B.J., 2ndEdition. Blackwell Science, UK, 2004.
4. Fundamentals of Analytical Chemistry, Skoog, D.A., West, D.M. and Holler, F.J., 8thEdition. Thomson and Brooks, Canada, 2004.
5. Understanding Environmental Pollution, Hill, M.K., 2ndEdition. Cambridge University Press, UK, 2004.
6. Qualitative Chemical Analysis, Harris, D.C., 6thEdition. W.H. Freeman and Company, USA, 2003.

COURSE 4

Mathematics-I

3(3-0)

Objectives:

The objective of this course is to impart knowledge, logic and skills to students necessary to explore, conjecture, reason logically, and use a variety of mathematical methods to solve problems, develop self-confidence and the ability to use quantitative and spatial information in problem solving and decision making, learn to enjoy and value mathematics, to think analytically, and to understand and appreciate the role of mathematics in everyday life, be prepared for the demands of both further education and the workplace.

Course Outline:

Sets, well known sets, operations on sets, Fundamental properties and operations of union and intersection, De Morgan's Law, Functions, types of functions, the graph of a function, Polynomial function, Algebra of polynomial function, Algebraic functions, Estimating using ratios, Arithmetic mean for grouped and ungrouped data, Matrices: types & algebra of matrices, Determinant of a square & transpose matrix, Inverse of a matrix, Determinant as a sum of products of elements, Characteristics of Binomial Theorem, Application of Binomial theorem, Limits of functions, Properties of limits of functions, Limit at infinity, Continuity of a function at a number, Limits and one sided limits, Properties of continuous functions, Continuity on an interval, Derivatives: Rates of change & slopes of tangent lines, Slope of a tangent line to a graph, The derivative of a function Basic algebraic rules for differentiation, Rules for differentiating trigonometric functions, The chain rule, Implicit differentiation, Partial Derivates of functions of two variables, Indeterminate forms $0/0$, ∞/∞ , Increasing and decreasing functions, Monotone functions, critical numbers, relative extrema, First derivative test, Concavity Point of inflection and second derivative test, Absolute extrema, Indefinite Integration, Basic algebraic rules for integration, The method of substitution or change of variable, Definite integral, Basic properties of definite integral, Trapezoidal Rule, Simpson's Rule

Recommended Books:

1. Calculus with Analytic Geometry, 4th Ed, 2000, M.A Munem, D. J. Foulis. Worth Publishers, Inc.
2. Calculus with Analytic Geometry, 8th Ed, 2002, George B. Thomas, Jr. Ross L. Finney. Addison-Wesley Publishing Company.
3. Calculus with Analytic Geometry, 6th Ed, 2002, Dr. S.M. Yusaf, Prof Muhammad Amin. Ilmi Kitab Khana, Lahore Pakistan.
4. Mathematical Methods, 4th Ed, 2000, Dr. S.M. Yusaf, Dr. Abdul Majeed, Prof Muhammad Amin. Ilmi Kitab Khana, Lahore Pakistan.

NOTE: *Annex-E* is outlines of four courses of Mathematics for different levels are available, outline of Course-I and Course-IV may also be useful. one of that may also be adopted.

COURSE 5

English-I (Functional English)

3(3-0)

To be adopted from HEC's course contents (Annex-A)

COURSE 6

Pakistan Studies (Compulsory)

2 (2-0)

To be adopted from HEC's course contents (Annex-B)

SEMESTER 2

COURSE 7 INTRODUCTION TO EARTH SCIENCES

3(2-1)

Objectives:

This course aims to provide knowledge about the basic concepts of geology and geography. This will help the student to get the knowledge about different types of rocks and minerals, the processes of their formation, different earth processes like mountain buildings, earthquakes, weathering and erosion. The students will also be introduced to work with different type of maps and GPS system.

Course Outline:

Major components of Earth Systems: earth systems and their characteristics, Geologic Time and processes, Geology as an historical science, scientific methods and study of Earth's evolving systems.

Earth Systems: Processes and Interactions-Earth Solid System: components and processes, Rock cycle: Igneous rocks, Sedimentary rocks and Metamorphic rocks. The Hydrosphere–hydrologic cycle, Ocean circulations, the Biosphere–Biogeography, Energy relationships, biogeochemical cycles. Sedimentary rocks and fossils, processes of weathering, Biogenic sedimentary rocks, Chemical sedimentary rocks, Marine environments, Coral Reefs, Continental Shelves.

Terrestrial Environments: Forests, Deserts, Glaciers and Lakes. Time and Stratigraphy: Introduction, Relative ages, Absolute ages, Evolution of Geologic time scale, why sea level is so important. Plate tectonics, structure of earth, hypothesis of continental drift, continental margins and plate boundaries types, features and behaviours, tectonic cycles.

The Dynamic Earth and Natural Hazards: Earth Quake and Volcanoes, Land instability, Weather Hazards, Fires and Costal Hazards, Humans and the Environment: introduction to Holocene, sea level rise, Rapid climate change: at Millennial time scale, at Continental time scale and at Multidecadal time scales.

Practical and Field Work:

Study of earth relief features with the help of topographical models and thematic maps. Identification of samples of rocks and minerals. Use of Brunton compass and GPS. One study tour in the field.

Recommended Books:

1. Earth Evolving System: The History of Planet Earth by Ronald Martin, Jones & Bartlett Learning: LLC an Ascend Learning Company USA 2013
2. Earth: An Introduction to Physical Geology, Tarbuck, E. J., Lutgens, F. K., and Tasa, D., 9th Edition, Prentice Hall; 2007
3. Historical geology: Evolution of Earth and Life Through Time, Wicander, R., and Monroe, J., 5th Edition, Brooks/Cole, 2007
4. Earth Science, Tarbuck, E. J., Lutgens, F. K., and Tasa, D., 11th Edition, Prentice Hall, 2005.

COURSE 8 BIOLOGY-II

3(2-1)

Objectives:

The objective of this course is to introduce the students with biosphere and its evolution to understand diversity of life. Upon completion of this course students will be able to identify plants and animals of different taxonomic categories.

Course Outline:

Introduction: Biosphere and biological resources. Evolution of biosphere: Origin of life, chemical evolution, origin of metabolism. Systematics of life: Protobionts, Origin of prokaryotic and eukaryotic cells, unicellularity, multicellularity. Adaptation of organisms on land. Geological time scale. Evolution as a force in diversity of life: overview of earlier theories, Lamarckism, Darwinism, modern concepts and origin of species. Nomenclature and classification Systems (Artificial, Natural and Phylogenetic): Classification of Prokaryotes, Protoctista, Fungi, Plants and Animals.

Lab Work:

Study of representatives of Kingdom Prokaryotae, Kingdom Protoctista and Kingdom Fungi with preserved specimens, prepared slides and fresh specimens. Study of salient features of Kingdom Plantae (Bryophytes, Tracheophytes, Pteridophytes, Gymnosperms and Angiosperms) with examples. Study of salient features of Kingdom Animalia (Invertebrates and Chordates) with preserved and fresh specimens. Morphological characters of root, leaf, flower and fruit types. Collection and identification of local plants and animals.

Recommended Books:

1. Campbell Biology. Reece, J.B., Urry, L.A., Cain, M.L. and Wasserman, S.A., 9th Ed., Pearson/ Benjamin Cummings Publishers, USA. 2010.
2. Biology. Campbell, N. A. 8th Ed. The Benjamin / Cummings Publishing Company Inc. New York. USA, 2008.

3. Advanced Level Practical Work for Biology (Advanced Level Practical Work Series). Morgan, S. Hodder & Stoughton. 2002.

**COURSE 9
STATISTICS**

3 (3-0)

To be adopted from HEC's course contents (Annex-D)

**COURSE 10
ANTHROPOLOGY**

3 (3-0)

Objectives:

Environmental Anthropology is the study of applied action and/or advocacy research to address practical environmental problems, and concerns. The course will emphasize how anthropologists work and the students will also learn the use of anthropology in handling some of these issues and therefore application will frame much on class discussions.

Course Outline:

Relationship between environment, culture and society. Goals and expectations. Scope and application. Conceptualizing environment. Tripartite nature of environment. Understanding the environment-human relationship. Chronological. Perspective of human-environment evolution. Contemporary environmental status. Consumption, globalization and environmental issues. Science and the globalization of environmental discourse. The Ecology of global consumer culture. Ecotourism's impact on the environment. Contemporary environmental issues and debate. Use of environment for vested interest, power and hegemony.

Recommended Books:

1. *Nature across cultures: Views of nature and the environment in non-western cultures*. Selin, H. Ed. Kluwer Academic Publishers. 2003.
2. *Environmental Risks and the Media*, Adam, Allan & Carter., Routledge, UK, 2009.
3. *The Environment in Anthropology: A Reader in Ecology, Culture, and Sustainable Living*. Hannen, Nora and Wilk, R. (editors). New York: New York University Press, 2006.
4. *Environmental Anthropology: From Pigs to Policies*. Townsend, P.K. Prospect Heights, IL:Waveland Press, Inc. 2005.
5. *New Directions in Anthropology and Environment: Intersections*, Crumley, C. L. (editor). Walnut Creek, CA: AltaMira Press, 2001.

COURSE 11
English-II (Communication Skills) 3(3-0)

To be adopted from HEC's course contents (Annex-A)

COURSE 12
ISLAMIC STUDIES (Compulsory) 2 (2-0)

Course contents of HEC will be adopted (Annex-C)

SEMESTER 3

COURSE 13
INTRODUCTION TO COMPUTER 3(3-0)

Objectives:

This objective of this course is to impart basic computing skills necessary for use of digital support to modern education for acquiring knowledge through offline and online resources, analysis of data, composition of data and presentation of data in the in efficient and effective way.

Course Outline:

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, Configurations, Introduction to MS-Word, Ms-Excel, Ms-Power Point, Ms-Access.

Recommended Books:

1. *Fundamentals of Computer*. Long, I and Long, N. 6th Ed. 2001.
2. *Microsoft office 2000*. Courter, G and Marquis, A. BPB publication. 1999.

COURSE 14
ENVIRONMENTAL CHEMISTRY 3 (3-0)

Objectives:

This course aims to extend the fundamental knowledge of various pollutants and its interactions with environment. After reviewing basic chemical concepts of environmental chemistry, it can have more advanced and contemporary applications including ozone depletion, physiochemical and biological treatment of pollutants and green chemistry. The chemistry of processes of the atmosphere, lithosphere and hydrosphere are covered in detail and the effects of pollutants on each of these chemical processes are extensively considered, as are their effects on the biosphere.

Course Outline:

Concept and scope of environmental chemistry. Chemical reactions, kinetics and mechanism concerning to organic and inorganic pollutants. Fundamentals of aquatic, atmospheric and soil chemistry. Fate of pollutants in environment; their sources and toxic actions. Acid rain and chemistry of stone cancer. Greenhouse effect, its causes and impacts. Ozone depletion, its causes and effects. Environmental impact of various industries.

Recommended Books:

1. *Environmental Chemistry*. Ibanez, J.G., Hernandez-Esparza, M., Doria-Serrano, C., Fregoso-Infante, A. and Singh, M.M., Springer, Germany, 2008.
2. *Principles of Environmental Chemistry*, Girard, J.E., 1st Edition. Jones and Barlett, USA, 2005.
3. *An Introduction to Environmental Chemistry*, Andrews, J.E., Brimblecombe, P., Jickells, T.D., Liss, P.S. and Reid, B.J., 2nd Edition. Blackwell Science, UK, 2004.
4. *Environmental Science*, Miller, G.T., Thomson-Brooks, Canada, 2004.
5. *Environmental Chemistry*, Samir, K., Banerji Prentice Hall of India, India, 1999.

COURSE 15

ENVIRONMENTAL PHYSICS

(2-1)

Objectives:

The course will provide an introduction to the physical principles that underlie environmental issues and their relationship with different types of interactions with energy and matter.

Course Outline:

Introduction to environmental physics, Scientific notations and mathematical hints for basic concepts. Solar spectrum, interaction of light with matter, Ozone and UV light, Energy, Entropy, Energy conversion. Heat radiation and heat transfer, Nuclear energy, Transport of pollutants, Diffusion, Conversion of mass, Solids, Liquids and Gasses, Equations of fluid dynamics, Turbulence, Turbulent diffusion, Gaussian plumes in the air, Turbulent jets and plumes, Particle physics, Sound and Noise, Basic acoustics, Human perceptions and noise criteria, Reducing the transmission of sound, Active control of sound, Radioactivity and nuclear physics, Isotopes and radioactive decay, Electromagnetic radiation.

Lab Work:

Study of the spectrum of light. Structure and function of spectrophotometer for absorption and transmission of light. Measurement and comparison of the light intensity at different locations and times using lux meter. Measurement of noise

level at different location to assess the noise pollution using sound level meter.
Collection of particulate matter and its measurements by gravimetric methods.
Field visit.

Recommended Books:

1. *Introductory Environmental Physics*, Boeker, E. and Van Grondelle, R. John Wiley and Sons Inc. New York, 2nd Edition. USA, 2001.
2. *Environmental Physics*, Smith. C. Routledge, 1st Edition. Kentucky USA; 2001.
3. *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, Seinfeld, J. H. and Pandis, 2nd Edition. S. N. John Wiley and Sons Inc. USA, 2006.
4. *Physics of the Environment and Climate*, Guyot, G. Praxis publishing. UK, 1998.

COURSE 16

INTRODUCTORY ECONOMICS

3(3-0)

Objectives:

The objective of this course is to provide an orientation to the students about the basic concepts and principles of Economics in order to build the foundation to understand the economic aspects of environmental protection, conservation, cost of environmental degradation. This course will laid the foundation for any advance course on environmental economics.

Course Outline:

Introduction to economics; scope and fundamental concepts of Economics: Consumer behavior, Producer behavior, and Resource allocation. Optimum utilization of resources from consumer, producer and community point of view. Economic development, economic progress, economic growth, economic welfare and difference among all. Man environmental relationship, Impact of economic activity on environment, Sustainable development, Measures for sustainable development. Sustainable development in developed and developing countries. Pakistan economic context: National income, concepts and measurement, Growth and development, poverty, Growth and Environment.

Environmental economics, Economic management and environmental quality, economic growth and its measurement, population and environmental quality, Natural resources and the economy, interaction between ecology and economic management. Economic functions of environment.

Recommended Books:

1. *Economic Development*. Todaro, M. P. 7thEd. Wesley Publishers, USA. 2008.

2. *Development Economics through the Decades: A Critical Look at 30 Years of the World Development Report*. Yusuf, S. World Bank Publications, USA. 2008.
3. *World Development Report 2009: Reshaping Economic Geography*. World Bank Publications. USA, 2008.
4. *Environmental Economics in Theory and Practice*. Hanley, N., Shogren, J. and White, B. Palgrave Macmillan, USA. 2007.
5. *Economics*. Michel Parkin. 5th Ed. Addison Wesley. 2004.
6. *Economics*. Samuelson and Nordhaus. 18th Ed. McGraw-Hills, Inc. 2004.
7. *Economics*. Lipsey and Crystal. Oxford University Press. 1999.

COURSE 17

English-III (Technical Writing & Presentation Skills)3(3-0)

To be adopted from HEC course contents (Annex-A)

COURSE 18

PHILOSOPHY

3(3-0)

There are compelling reasons for teaching a philosophy of science course to undergraduate life science students. The main reason is to help them understand that modern science is not based upon a single, consistent philosophical system; nor is it based upon common sense, or a method, set of rules or formulas that can be used to make unerring predictions. Rather, science is a dynamic process that is constantly being modified and refined to reflect and encompass an ever-expanding set of hypotheses, observations, and theories.

Objectives:

To illustrate these points, this course has been developed, which examines the history and philosophical underpinnings of modern science, and discusses famous experiments that challenged the prevailing norm and led to revolutions in scientific thought. Building upon this knowledge, students will investigate how different philosophical systems address controversial social issues in environmental sciences. Exploration of such topics will help them become better prepared for the inevitable public debates that they will face as environmental scientists, researchers and leaders of society.

Course Outline:

Basic problems and methods of philosophy. Historical and logical analysis of various types of scientific hypotheses and the data that support or undermine them. Topics such as the nature and scope of human knowledge, the existence of God, and the relationship between mind and body. Morality, personal identity, free will and determinism, and the meaning of life. Tools for dealing with both everyday and more technical arguments and concepts. Analysis and resolution of confusions, ambiguities, and fallacies.

Recommended Books:

1. Grounding Concepts: An Empirical Basis for Arithmetical Knowledge by *Carrie Jenkins*, Oxford University Press, 2008.

SEMESTER 4

COURSE 19

FUNDAMENTALS OF ECOLOGY

3 (3-0)

Objectives:

To develop an understanding about ecology, its fundamental concepts, description of population, community, ecosystem and its types, biogeography and systems' ecology.

Course Outline:

Introduction and branches of ecology. Levels of ecological organization: species, population, community and ecosystem. Abiotic and biotic factors. Concepts of limiting factors, habitat and niche. *Populations*: distribution and abundance, population dynamics and distribution limits. *Community*: organization and various concepts, community dynamics. *Ecosystem*: structure and function, energy flow and material cycling within ecosystem and carrying capacity. Biomes of the world. Ecological production: primary and secondary productivity, productivity of different ecosystems.

Recommended Books:

1. Ecology (Concepts and Applications.) Moles, M C J 6th Edition. WCB/McGraw-Hill. New York, 2012.
2. Elements of Ecology. Thomas M. Smith and Robert L. Smith. 8th Ed. Benjamin Cummings, 2012.
3. Ecology. Michael L Cain, William D. Bowman and Sally D. Hacker. 2nd Ed. Sinauer Associates, 2011.
4. *Ecology (principles and applications)*. Chapman, J.L and Reiss, M J. 1st Ed. Cambridge University Press, UK, 1992.
5. *Fundamentals of Ecology*. Odum, E P. and Baret, G.W. 5th Ed.
6. Thomson Brooks/Cole, 2004.

COURSE 20

ENVIRONMENTAL MICROBIOLOGY

3(2-1)

Objectives:

This course will provide an awareness and understanding to the students about the role of microorganisms in the environment. After completion of this course, students will be able to understand the significance, role and applications of microorganisms in the environment.

Course Outline:

Introduction and history of environmental microbiology. Groups of microorganisms: protozoans, algae, fungi, bacteria and viruses (general characteristics). Bacterial cell structure and metabolism. Eubacteria and archaea. Characterization of bacterial colonies and cells. Environmental factors affecting the microbial growth. Microbial genetics (Conjugation, transformation and transduction). Microbial interactions. Role of microbes in environment/industry: biogeochemical cycles, biodegradation and bioremediation, food and health, biological warfare agents.

Lab Work:

Introduction to basic techniques for sterilization/disinfection, isolation, purification and characterizations, Dilution plate technique, Mean plate count, microscopy. Measurement of bacterial growth.

Recommended Books:

1. *Environmental Microbiology*, Maier, F.M., Pepper, I.L. and Gerba, C.P. 2nd Edition, Academic Press, London, UK, 2009.
2. *Principles and Applications of Soil Microbiology*, Sylvia, D.M., Fuhrmann, J.J., Hartel, P.G. and Zuberer, D.A. Prentice Hall, New Jersey, USA, 2005.
3. *Microbiology*, Prescott, L.M., Harley, J.P. and Klein, D.A. McGraw-Hill Inc., USA, 2007.
4. *Microbiology*. Pelczar M.J., Chan, E.C. and Krige, N.R. McGraw-Hill, Inc. New York. 1986
5. *Environmental Microbiology: A Laboratory Manual*, pepper, I.L., Gerba, C.P. and Brendecke, J.W. and Jeffery, W.B. Academic Press, USA, 1995.

COURSE 21

ENVIRONMENTAL POLLUTION

3 (3-0)

Objectives:

The course is focused on introducing environmental pollution and its sources. It will also cover the existing laws related to pollutants in Pakistan and the conventions ratified internationally.

Course Outline:

Environmental Pollution, sources, types and causes. Types of pollutants: Physical, chemical and biological; Characteristics of domestic & industrial effluents; Effects of Pollutants on human & other living organisms; Industrial and Municipal Solid Waste. Principles of Waste Management & Disposal; Fate of pollutants; Factors affecting movement of pollutants in soil, air and water. Monitoring of Environmental Pollution; Pollution Control Strategies; Environmental Laws: Pollutants Guidelines; International Protocols; Case Studies.

Recommended Books:

1. *Understanding Environmental Pollution*, Hill, M.K., 2nd Edition. Cambridge University Press, Cambridge UK, 2005.
2. *Environment Pollution: Types, Sources & Management*. Ghafoor, A., G. Murtaza, M.Z. Rehman, M. Sabir, H.R. Ahmad and Saifullah. Allied Book Centre, Lahore, Pakistan. 2012.

COURSE 22

CLIMATOLOGY

3(3-0)

Objectives:

The objective of this course is to provide know-how regarding Earth's climate and weather systems, processes and the relationships between the atmosphere and climate. Concepts of climate of Pakistan will also be provided.

Course Outlines:

Introduction To Climatology and A Brief History, The Earth Four Spheres, Weather and Climate, Vertical Structure of The Atmosphere, Heat and The Earth's Atmosphere, Radiation and Climate, Solar Radiations, Mechanism of Heat Transfer, The Hydrologic Cycle, Condensation and Cloud Formation, Cloud Classification, Clouds and Vertical Motion in the Atmosphere, Air Pressure, Factors Affecting Air Pressure, Surface Winds, Local Winds, Global Circulation, The Climate of Pakistan, Concept of Seasons in Classification of Climate, Climatic Zones of Pakistan.

Recommended Books:

1. *The Physics of Atmospheres*, John Houghton, Cambridge University Press, 2002.
2. *Climatology*, A. Austin Miller, Ninth Edition SHUBHI Publications, ISBN 81-87226-42-0
3. *The Atmosphere*, Fredrick K. Lutgens, Edward J. Tarbuck, Sixth Edition, ISBN 0-13-350612-6
4. *Atmospheric Chemistry and Physics - From Air Pollution to Climate Change* Seinfeld, John H.; Pandis, Spyros, N. 2nd Editions. John Wiley & Sons, 2006
5. *The meteorology of Pakistan: The climate and weathers of Pakistan*. Shamshad, K.M. Royal book company, sadder, Karachi, ISBN, 9694070821. 1988.

**COURSE 23
PSYCHOLOGY**

3(3-0)

Objectives:

The objective of this course is to introduce the content and methods of psychology as a basic science, with emphasis on the social bases of behaviour, which is directly linked with consumption of natural resources.

Course Outlines:

Introduction to Psychology; nature and application of Psychology with special reference to Pakistan. Historical Background and Schools of Psychology. Methods of Psychology: observation; case history method, experimental method, survey method, interviewing techniques. Biological basis of behaviour: Neuron structure and functions; Central Nervous System and Peripheral Nervous System Endocrine Glands. Sensation, Perception and Attention. Motives, Emotions, Learning, Memory and Individual Differences.

Recommended Books:

1. *Introduction to Psychology* by Fernald, L.D., & Fernald, P.S. (2005), WMC Brown Publishers, USA.
2. *Introduction to psychology* (13th ed.) by Atkinson R. C., & Smith E. E. (2000). Harcourt Brace College Publishers.
3. *Approaches to Psychology* by Glassman, W. E. (2000). Open University Press, UK
4. *Foundation of Psychology* (3rd ed.) by Hayes, N. (2000).

SEMESTER 5

**COURSE 25
APPLIED ECOLOGY**

3(3-0)

Objectives:

This course will make the students aware of the concepts of applied ecology and understand some major environmental issues such as global climate change, sustainable agriculture, conservation of resources in ecological perspectives, their management and ecological restoration.

Course Outline:

Background and scope of applied ecology. Applications of ecological knowledge in solving different environmental issues. Energy and carbon balance: carbon emission and global climate change, effect of increased carbon dioxide concentration on agriculture. Human impact on Nitrogen cycle. Water as an ecological resource: Water and distribution of species, farming practices under limited water supply. Soil as a natural resource: soil salinity and water logging issues in Pakistan, soil erosion and conservation. Agro-

ecology: ecology of food production, Sustainable agricultural practices. Forest ecology: conservation and management of forests and rangelands in Pakistan. Industrial ecology: impact of industrial pollution on ecosystems, pollutant transfer in plant and animals, phyto-remediation. Urban ecology: urban ecological footprint, urban environmental degradation, green cities. Ecological modeling in defining ecosystem problems. Ecological restoration: concepts and techniques.

Recommended Books:

1. *Ecological Restoration: Principles, Values, and Structure of an Emerging Profession*. 2013. Clewell, A.F. 2nd Edition. Island Press.
2. *A Primer of Conservation Biology*. 2012. 5th Ed. Sinauer, P.R.B. Associates Inc. Publ. Sunderland.
3. *Urban Ecology: Patterns, Processes, and Applications*. 2011. Jari Niemela, Jurgen H. Breuste, Glenn Guntenspergen, Nancy E. McIntyre, Thomas Elmqvist, Philip James. Oxford University Press.
4. *Ecology of Industrial Pollution*. 2010. Ed. Lesley C. Batty and Kevin B. Hallberg. Cambridge University Press.
5. *Applied Ecology and Environmental Management*. Newman. E.I. 2nd ed. Blackwell Scientific Publications, Oxford. 2000

COURSE 26

ENVIRONMENTAL TOXICOLOGY

3 (2-1)

Objectives:

The course is focused on providing knowledge related to toxic chemicals in air, water and soil, dose response relationship in living organisms, short term (acute) and long-term (chronic) effects on organ system, their containment and control strategies.

Course Outline:

Introduction to Toxicology. Classification and properties of toxic substances: anthropogenic and natural poisons, acute and chronic effects, genotoxic, mutagens, teratogens, carcinogens and sensitizers. Biological properties of organic and inorganic pollutants: essentiality and toxicity. Routes of absorption. Bioaccumulation and bio-magnification. Quantification of toxicity: dose-response relationships, synergism, antagonism, LD50 and rating systems, Threshold Limit Values. Toxic impacts of atmospheric agents. Fate of absorbed toxins and xenobiotics, including detoxification and bioactivation. Natural detoxification processes. Risk management.

Lab Work:

Analysis of toxins, Dose-response relationship and D/R Curves. *In vitro* & *In vivo* techniques for toxicity testing. Proposed techniques (at least one of these); Ames test, Comet assay, CAM, TTC and Immuno-fluorescent assay or microscopic observation of changes in plant cell morphology after exposure to toxic substances.

Recommended Books:

1. Environmental Toxicology: Biological and health effects of pollutants. Yu M.H., Tsunoda H. and Tsunoda M. 3rd Edition. CRC Press, Taylor & Francis Group. 2011.
2. Casarrett&Doull's *Toxicology- Science of Poisons* , Klassen, W.D., 5th Edition, McGraw-Hill, USA, 2005

COURSE 27

ENVIRONMENTAL PROFILE OF PAKISTAN

3(3-0)

Objectives:

To provide students with a comprehensive knowledge about the environmental resource base of Pakistan in order to learn its efficient utilization for sustainable development.

Course Outline:

Introduction to history of the region; Features: land, geography, people, culture, health, education; Ecological: ecological zones, major ecosystems, topographic zones; Economic: agriculture, industry, water resources, urbanization and pollution.

Recommended Books:

1. *State of the Environment-Pakistan* , Government of Pakistan,2005
2. National Conservation Strategy Government of Pakistan Ministry of Environment and IUCN - 1993

COURSE 28

POPULATION AND ENVIRONMENT

3(3-0)

Objectives:

This course will give the students basic understanding about the human population and its interaction with environment. This will also help them to learn about resource utilization, social and economic services.

Course Outlines:

Environment and Man: The Earth as humanity's home, Changes in global environments, Human origins and dispersals and human settlements.

Nature and field of population studies: Historical outline of world population growth, importance and development of population studies, different concepts and theories, relations of the subject to environment and other disciplines.

Population composition: Urban and rural character, biological characteristics, cultural characteristics.

World distribution of population: Population diversity and distribution, factors influencing population distribution: physical i.e. environmental factors, culture and technological factors, temporal and political factors. Interaction between population distribution and environmental, economic, political and other factors.

Components of population growth: World patterns and trends of fertility, world patterns and trends of mortality, causes and consequences of migration and regional variations. Demographic and epidemiological transition models.

Population policies and their impacts on environment at local, regional and international levels.

Recommended Books:

1. Angus I. and Butler, S. Too Many People? Population, Immigration, and the Environmental Crisis. Haymarket Books, P.O. Box 180165, Chicago, IL 60618. 2011.
2. Shyrock, H.S. and Siegel, J.S. The methods and Materials of Demography. Academic Press, New York. 2004

COURSE 29

ANALYTICAL TECHNIQUES IN ENVIRONMENTAL SCIENCE

3(1-2)

Objectives:

The course will educate the students about different types of solutions, instruments & analytical procedures and enhance their skills about practical aspects of environmental science so that knowledge becomes more productive.

Course Outline:

Quality assurance in an Environmental Science laboratory. Purposes and designs of environmental sampling. Sample collection and preservation methods. Standard solutions and standard curves. Instrumentations: principles and procedure for Potentiometry, Conductivitymetry, pH metery, Titrimetry, Gravimetry, Spectroscopy and Chromatography. Analysis of water, wastewater and soil/solid waste samples.

Lab Work:

S.I. and derived S.I. units. Sample collection, handling, preparation and storage. Analytical techniques for soil, water and plant analysis. Data interpretation for quality control, precision and accuracy. Preparation of Standard solutions and Standard curve. Use of Potentiometry, Conductivitymetry, Titrimetry, Gravimetry, Spectroscopy and Chromatography for the analysis of environmental samples. Determination of chemical characteristics of water and waste water (pH, All Solids, BOD, COD,

Fluoride, NO₃-N & NH₄-N), soil (NPK and organic matter contents, salinity & sodicity).

Recommended Books:

1. *Fundamentals of Analytical Chemistry*, 8th Edition. Skoog, D. A., West, D. M. and F. J. Holler. Thomson and Brooks, 2004.
2. *Standard Methods for the Examination of Water & Wastewater*. 21st Edition. A Greenberg (American Public Health Association), 2005.
3. *Qualitative Chemical Analysis*. 6th Edition. Harris, D. C., Freeman & Co., New York, 2003.

COURSE 30 ELECTIVE-I

SEMESTER 6

COURSE 31 ENVIRONMENTAL ECONOMICS 3(3-0)

Objectives:

The objective of this course is to provide the students the application of natural laws and principles in economics to develop their understanding of internalization of externalities.

Course Outline:

Basic concepts in environmental economics, The Economy and the Environment, Benefits and Costs, the equilibrium principle, marginal cost and supply, economic efficiency and market, markets and Social Efficiency, external costs and external benefits, Pollution Control-a general model, pollution damages and abatement costs, Valuing the environment. Measuring environmental benefits; contingent valuation, the travel cost method and the hedonic approach, the value of life, health, risk and safety, Economic Development and Environment. Natural resource economics.

Recommended Books:

1. Field, B.C. and Field, M.K., 2002. *Environmental Economics: An Introduction*, 3rd 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*, 3rd Ed., John Wiley & Sons. Inc.

COURSE 32
GEOGRAPHIC INFORMATION SYSTEM & REMOTE SENSING
3(2-1)

Objectives:

This course has been designed to impart practical experience in use and interpretation of geographic/spatial data through GIS. The course will provide comprehensive instruction in the underlying concepts and principles of geographic information system (GIS) technology and its application to the analysis of environmental data. The focal point of the course includes fundamental understanding of spatial data acquisition, geo-processing, geo-statistical methods; visualization, and querying of spatial data; network modeling, terrain mapping, and spatial analysis. Students are trained to become proficient in usage of ESRI ArcGIS 9.X software through extensive computer lab sessions.

Course Outline:

Fundamentals of Remote Sensing, Electromagnetic Spectrum. History and data collection. Energy Sources, energy matter interaction in the atmosphere. History and platforms. Active and Passive remote sensing. Remote sensing of vegetation and landscape. Satellite Imageries, Image Processing: Image enhancement, Linear Stretch, Histogram equalization, Interpretation, visual interpretation, Preparation of thematic maps.

Fundamental of Geographic Information System(GIS). Integration with other technologies and its importance. Data acquisition, analysis and output. Types of data used in GIS. Cartography, GIS applications in: Agriculture, Forestry, Fishery and wildlife.

Lab Work:

Getting familiarization with Image processing and GIS software. Conversion of raster to vector data. Demonstration of GPS operations, Interpretation of satellite images for different application, Ground Truthing.

Recommended Books:

1. Remote Sensing and Image Interpretation. Thomas Lillesand (Author), Ralph W. Kiefer (Author), Jonathan Chipman Wiley; 6th edition (2007) ISBN-10: 0470052457
2. Fundamentals of remote sensing and air photo interpretation *Prentice Hall series in geographic information science*, Authors Thomas Eugene Avery, Graydon Lennis Berlin 5th Edition, 2009 ISBN0023050357
3. A Primer of GIS-fundamentals Geographic and Cartographic Concepts. Harvey, F. Guilford Press New York, 2009.
4. *Introduction to GIS*. Campbell. McGraw-Hill Education. 2008.
5. *Remote Sensing of the environment: An Earth perspective*. Jensen, R. Pearsons Education, Inc. 2000.

COURSE 33
ENVIRONMENTAL MANAGEMENT SYSTEMS 3(2-1)

Objectives:

This course is aimed at providing training students on designing Environmental Management Systems for any organization in order to enable them contribute in planning and implementation of EMS in an organization.

Course Outline:

Introduction to the concept of Corporate Social Responsibility (CSR) and environmentally responsible business initiative. Introduction to principles of green economic growth.

Practical Work:

Class room exercises on identification of environmental aspects; assessment of environmental impacts and suggestion of mitigation measures of activities of some hypothetical organization. Development of Environmental Management Plan by a group of students for a hypothetical or real organization. Industrial visits to identify environmental issues of management.

Recommended Books:

1. *Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations*: NSF International Ann Arbor, Michigan, 2001.
2. *Environmental Management Systems: General Guidelines on Principles, Systems and Support Techniques*. American Society for Quality, International Organization for Standardization. 2nd Ed., American Society for Quality, 2005.
3. *Environmental Management Systems: A step-by-step Guide to Implementation and Maintenance*, Sheldon, C. and Yoxon, M., 3rd Edition 2006.

COURSE 34
BIODIVERSITY AND CONSERVATION 3(2-1)

Objectives:

The objective of this course is to familiarize the students with different forms of biodiversity, threats to biodiversity and its conservation.

Course Outline:

Biodiversity: Introduction and levels of biodiversity (Alpha, Beta and Gamma). Biodiversity hotspots (tropical and coral reef ecosystems). Philosophical, ecological, economic, social and ethical values of biodiversity. Plants and animal resources of world and Pakistan. Conservation of biodiversity: Introduction to biological conservation, its history, guiding principles and

characteristics. Need and approach of biodiversity conservation and prevailing threats. IUCN threatened species categories. Conservation at species and population level: applied population biology, establishing new populations, *ex-situ* conservation strategies (botanical gardens and arboreta, zoos, seed banks and aquaria). Conservation at community and ecosystem level: protected areas, their categories and objectives, considerations for reserve design, ecotourism. Conservation outside protected areas: conservation in man-made ecosystems, croplands, cities. Legal protection of species and habitats: national and international laws and agreements for species and habitat protection, National Conservation Strategy of Pakistan.

Field Work:

Reconnaissance survey of different local communities. Study of analytical characteristics of local vegetation types: Population density (D), Relative density (RD), Frequency (F), Relative frequency (RF), Estimating biodiversity, Habitat and ecosystem diversity: Species diversity and Genetic diversity. Indices of biodiversity: Species Richness (Richness Index), Species Diversity (Biodiversity Index), Similarity Index (Simpson's Similarity Index). Visit to National Park/Sanctuary, Zoo and Botanical Garden.

Recommended Books:

1. *A Primer of Conservation Biology*. 5th Ed. Sinauer, P.R.B. Associates Inc. Publ. Sunderland. 2012.
2. *Conservation Biology: A Primer for South Asia*. Bawa, K., Primack, S., Oommen, R.B. and Anna, M., 2011., Orient Black Swan
3. *Essentials of Conservation Biology*, 5thEd., Primack, R. B. Sinauer, P.R.B associates Inc. Publishers, Sunderland MA, USA. 2010.
4. *Conservation Biology: Foundations, Concepts, Applications*. 2nd Ed. Dyke, F.V., Springer, 2010.

COURSE 35

ENVIRONMENTAL MONITORING

3(2-1)

Objectives:

This course aims to provide information of techniques used in environmental monitoring and evaluation of different standards of environmental factors i.e. air, water, soil and living organisms.

Course Outline:

Introduction, objectives of sampling and monitoring programme, design and types of samples, pre-sampling requirements/information, sampling and design purposes, application of national and international methods of sampling, regulatory purposes for NEQS compliance, EIA requirement, NOC for plant operation, Determination of concentration and distribution of a specific pollutant environment 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.

Practical Work:

- Sampling techniques (air, water and soil) for physical and chemical monitoring,
- Study the indicators for biological monitoring of the river and canal water, the indicators for ecological monitoring in the field for fauna and flora,
- Use of various instrumental techniques for analysis of samples,
- Field visit/ study tour to water testing laboratory/local water authority and report writing,
- Visit to EPAs for the study of air and water monitoring procedures,
- Report on monitoring of municipal waste

Recommended Books:

1. Earth Observation of Global Change, Chuviero, E. (ed) Springer, New York, USA, 2008
2. Environmental Monitoring Handbook, Burden, F. R, McKlivie, I. D., Forstner U. and Guethner. (eds.) McGraw-Hill, USA, 2002.
3. Environmental Sampling and Analysis: A Practical Guide. Keith, L. H, 2002.
4. Environmental Chemistry. Manahan, S. E. Lewis Publisher London, UK, 2000.

COURSE 36 ELECTIVE-II

SEMESTER 7

COURSE 37 CLIMATE CHANGE

3 (3-0)

Objectives:

The objective of this course is to provide a wide-ranging understanding on climate change, understanding climate system, being aware of the impacts of climate change on society, understanding of adaptation and mitigation options in relation to climate change.

Course Outline:

Defining Climate, Climate system: Components; controls on climate; Latitude, Earth-sun relationships, Revolution, Rotation, Axial tilt and their combined effect, Distance to large bodies of water, Defining Climate Change, Climate change processes, Green House Gases' emission, Drivers and Indicators of

Climate Change, Cause & Effect of Climate Change, Climate Change Policy, Impacts of Climate Change in Pakistan, Green Economy, Carbon Footprint, Technological Development and Changing climate, Climate Change matters, Present rapid warming, Projection of future climate change, Uncertainty in climate change projections, Climate change impacts-reasons for concern, Impacts on natural systems, societal systems, human health and comforts, Reactions and attitudes to climate change: Adaptation, Mitigation options: increased energy efficiency, fuel substitution, nuclear power, hydropower, solar energy, wind power, biomass energy, tidal, wave and geothermal energy, hydrogen economy, changes in infrastructure and behavior.

Recommended Books:

1. William James Burroughs (2007) Climate change: A Multidisciplinary Approach, Cambridge University Press, Cambridge, UK.
2. Sharon L. Spray, Karen Leah McGlothlin, (2002) Global climate change, Rowman& Littlefield, Maryland, USA
3. Horace M. Karling, (2001) Global climate change, Nova Publishers, New York, USA

COURSE 37

CLIMATE CHANGE

3 (3-0)

Objectives:

The objective of this course is to provide a wide-ranging understanding on climate change, understanding climate system, being aware of the impacts of climate change on society, understanding of adaptation and mitigation options in relation to climate change.

Course Outline:

Introduction to the earth's climate: climate change, and the interactions between climate and the global environment; ; Electromagnetic Radiation and the Global Energy Budget; Energy and Temperature; Climate classifications: Köppen Global Climate; Global Climate Change: Causes & Consequences: Natural & Anthropogenic sources; Human responses to potential climate change; Recent Climate Change Indicators; Predicted changes to the physical world: Predicted changes to the biological world: range shifts, phenological changes, human health, agriculture; Physical, chemical, biological, and social factors contributing to climate and global change; Moisture in the Atmosphere; Precipitation; Patterns in Winds and Pressure; The Measurement of Climate Change; The Causes of Climate Change: Global warming and greenhouse effect; Air Pollution and Acid Rain; Ozone depletion; Regional droughts and cataclysmic climate change; Types & Resources to produce Energy; Role of Energy Production in climate change: Fossil fuels, Hydrocarbons & their byproducts; Future Climates and the Consequences: Ground and Satellite Based Measurements Solutions , Surface and ground water resources,

observing the Cryosphere, Consequences of climate change, measurement of climate change, Prediction of climate change.

Recommended Books:

1. Climate Change Causes, Effects, and Solutions, 1stEdition, Hardy, J. T., John Wiley & Sons, 2003.
2. *Global Warming -The Complete Briefing* by John T. Houghton. (3rdedition) Cambridge University Press, 2004.
3. Climate Change: A Multidisciplinary Approach. William James Burroughs.
4. *Global Change and the earth system*, Keith, A.(ed), Sringer, 2005.
5. *Climate Impact and Adaptation Assessment: A Guide to the IPCC Approach*, Earthscan Publication Ltd, London, 2005.
6. Remote sensing and Global Environmental Change,
7. Sam J. Purkis (Nova South Eastern University), Victor V. Klemas (University of Delaware)
8. Climate Change - Causes, Effects, and Solutions, Hardy, J.T., John Wiley & Sons, 2003.
9. Remote Sensing and Climate Change: Role of Earth Observation (Springer Praxis Books / Geophysical Sciences) Springer; 1stedition

COURSE 38

ENVIRONMENTAL IMPACT ASSESSMENT

3(2-1)

Objectives:

The aim of this course is to enable the participants to build their capacity to integrate environmental concerns in project proposals. The specific objectives of the course are to help students to:

- learn the principles, skills, procedures and practices of integrating environment in development through EIA;
- become aware of the legal and regulatory obligations of integrating environment in development projects;
- familiarize themselves with the techniques of getting public participation and integrate socio-economic aspects in development projects; and enable the participants to conduct an EIA study for a development project.

Course Outline:

Introduction: principles, concepts 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. Methods and techniques for impact prediction and evaluation. Integration during project life cycle. EIA review and post project analysis. EIA process management. Role of quality assurance and quality control in environmental analysis. EIA Regulations and guidelines in Pakistan.

Practical Work:

Screening & Scoping exercises, Using impact prediction and analysis tools; i) Checklist, Matrices, Networks, Overlays. Organizing public Participation; identifying stakeholders, role plays exercises, Field Visit, One case study to be completed by the end of the semester.

Recommended Books:

1. Environmental Impact Assessment Handbook for Pakistan, Fischer, T.S. (ed.), 2014, Liverpool University Press, UK
2. *Introduction to Environmental Impact Assessment*, Glasson, J., Therivel, R., and Chadwick, A., Routledge, London, 2005.
3. *EIA Manual: Training Resource Manual*, Sadler, B., & McCabe, M., (ed.), 2nd Edition, United Nations Environment Programme, 2002.
4. *Environmental Impact Assessment in Practice*, Harrop, D.O. & Nixon, J.A., National Book Foundation, Islamabad, 2000.

NOTE: *Appendix-F is a model curriculum for EIA developed under NIAP through a nationwide consultative process and input from national and international experts. This may be adopted as a whole for undergraduate course of 2+1 credit hours.*

COURSE 39

NATURAL RESOURCE MANAGEMENT

3(3-0)

Objectives:

This course aims at providing student with the basic understanding of principles and concepts of Natural Resource. Course is designed to provide student with the basic understanding of role performed by these natural resources, threats that are associated with them and approaches used for their management. Course will also emphasize on the issues and constraints involved in the management of these resources. Course is designed to provide student with a general overview keeping in view its undergraduate level however special focus will be on Pakistan's perspective.

Other objectives are:

- To provide students with the basic understanding of natural resources we are blessed with and what functions they perform in our lives;
- To investigate the major issues involved in Natural Resource Management in both the global and Pakistani context;
- To develop an integrated approach to the analysis and management of Natural Resources and issues associated with their management;

Course Outline:

Introduction: Natural resources, classification of natural resources, basic definitions and concepts(tragedy of the commons, resource degradation,

carrying capacity, ecological footprints), human demands on natural resources, existing situation in world in general while in Pakistan particularly, brief history of natural resource management, sustainable management of natural resources, different approaches to natural resource management, conservation, preservation, Community based natural resource management, development of natural resource management plan: needs, requirement, process and contents of the management plan. Forest management: forest types and its existing management, watershed management: Importance basic principles, methodologies, national example, wetland management: existing situation, importance, key threats, National wetland policy and brief introduction to Ramsar convention, rangeland management: existing status, importance, threats, causes and methods for its improvement. Rotational grazing, seasonal grazing, National Rangeland policy of Pakistan, livestock management, wildlife management: Management existing situation at national level, wildlife census, reasons for its decline and its possible remedies, existing management approaches, sustainable/trophy hunting projects and its role in local and national development, national and provincial legislation. Agriculture resource management: Existing situation of agriculture sector in Pakistan, agriculture products and their share in GDP, problem in agriculture, agriculture chemicals, their pros and cons, national agriculture policy, management options., Energy (coal, hydrocarbon, hydel) and Mineral Resource (Metallic and non-metallic deposits) Management, Land use Planning and Management: evolution of land use planning, review of land use plans developed by the various organizations, field visit to develop a land use plan for selected area.

Water Resource Management: water conservation at domestic, industrial and agricultural sectors. Flood control, drought management, channelization, desalinization, cloud seeding, rain water harvesting and recharge wells. Technologies for watercourse improvement and Farm layout improvement, Laser land leveling, Improve cropping pattern, groundwater zoning and skimming wells.

Fisheries Management: Types of fishes in Pakistan, existing situation reason for decline and its potential in the national economy, management options.

Recommended Books:

1. *Environmental Science: working with Earth.* 2013. Miller, T.G. 9th Edition. Jack Cary Publisher London.
2. *Basics of forestry and Applied Sciences, Concepts and Theory.* Masood A.A Qureshi, 3rd Ed Vol-1, A-one Publishers 2005.
3. *Environment: Problems and Solutions.* Asthana, D. K & Asthana, M, 5th Ed, S. Chand & company LTD 2006.
4. *Environmental Science: Earth as Living Planet.* Botkin, D., & Keller, E, 8th Ed. John Wiley and Sons 2000.
5. *Environmental Science: working with Earth.* Miller. T. G, 9th Edition, Jack Cary publisher 2003.

COURSE 40

RESEARCH METHODS IN ENVIRONMENTAL SCIENCE

3 (3-0)

Objectives:

At the end of this course, the students should be able to understand some basic concepts of research and its methodologies; identify appropriate research topics; select and define appropriate research problem and parameters. The students will learn how to prepare a project proposal (to undertake a project), organize and conduct research (advanced project) in a more appropriate manner.

Course Outline:

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. *Students project in Environmental Science*, Harrad, S., Batty, h., Diamon, M. and Arhonditsis, G, John and sons Ltd., Chichester, England, 2008.
2. *Designing and Conducting Mixed Methods Research*, Creswell, J. W. & Plano Clark, V.L. Thousand Oaks, Sage CA, USA, 2007.
3. *The Craft of Research* by Wayne C. Booth, 2nd Edition, Univ. of Chicago Press. USA, 2003.
4. *Case Study Research: Design and Methods*, Robert Yin, 3rd Edition, Sage Publishers. USA, 2003.

COURSE 41

ELECTIVE –III

COURSE 42

ELECTIVE –IV

SEMESTER 8

COURSE 43

ENVIRONMENTAL GOVERNANCE

3 (3-0)

Objectives:

This course aims at giving an understanding of the role of state and its instruments in the governance of environment in order to enable the students to learn about responsibilities of state and rights of its citizens to live in environmentally sound conditions to contribute in sustainable development.

Course Outline:

The concept of governance and its relevance to environment; the role of government in a state; derivation of environmental legislation from constitution of Pakistan; Environmental Policies in Pakistan, federal, provincial and local legislation in Pakistan; rules and regulations made there under. Environmental institutions established for enforcement of environmental laws in Pakistan and their functions in federal and provincial level.

Recommended Books:

1. *Environmental Laws and their implementation in Pakistan*, Qadar, S. Law Books House, 2000.
2. Pakistan Environmental Protection Act, 1997, Government of Pakistan
3. Environmental Policies of Govt. of Pakistan
4. SNBP Local Government Ordinance, 2001.
5. Provincial Environmental Laws

COURSE 44

PUBLIC HEALTH AND ENVIRONMENT

3 (3-0)

Objectives:

This course is designed to introduce basic concepts of health and disease with reference to environment, impart knowledge about hazards, risks assessment and management.

Course Outline:

Concepts and basic requirements for a healthy environment. Environmental Exposure: Measuring environmental quality; Human exposure and health Impact: Impact of environmental factors on health. Nature and types of environmental hazards. Health risk assessment and management. Health and disease concepts. Air, Water and sanitation, Food and agriculture. Human settlement and urbanization, Health and energy use. Health and development, Health indicators, Industrial pollution and health issues; Trans-boundary and global health concerns, Action to protect health and the environment; Classification of diseases, basic concepts of Epidemiology, Immunology,

Pathology, Parasitology; Epidemiology of infectious diseases, Communicable diseases, Non-communicable diseases; Personal hygiene and health.

Recommended Books:

1. *Environmental Science (The Way the World Works)* Nebel, B. J. and Wright, R. T., 8th Edition. Prentice Hall International Inc. London, UK, 2004.
2. *Park's Textbook of Preventive and Social Medicine*, Park, K., 2nd Edition. M/s Banarsid. 2002.
3. *Basic Environmental Health*. Yassi, A., Kjellström, T., de Kok, T. and Guidotti, T. L., 1st Edition. Oxford University Press New York, USA, 2001.

COURSE 45

POLLUTION CONTROL TECHNOLOGIES

3(3-0)

Objectives:

The objective of this course is to acquaint the students with the technological approaches used for control of pollution. The students will become familiar with different technologies and modern techniques for their control and abatement.

Course Outline:

Collection, treatment and distribution of drinking water supply; Collection, treatment and disposal of municipal and industrial wastewater; Low cost water treatment and sanitation techniques; Solid and hazardous waste management; Cleaner production techniques; Waste hierarchy (Reduce, re-use and recycling); Waste site investigation and remediation; Air pollution control; Noise pollution control.

Recommended Books:

1. *Solid Waste Technology and Management*, T. Christensen, John Wiley & Sons, 2011.
2. *Water Treatment Technologies*, B. Salopek, Akademija tehničkih znanosti Hrvatske, 2007.
3. *Advanced Air and Noise Pollution Control*, L.K. Wang, N.C. Pereira and Y.T. Hung, Humana Press, 2005.
4. *Preventive Environmental Management*, S.R. Asolekar, R. Gopichandran and Centre for Environment Education, Foundation Books, 2005.
5. *Handbook of Solid Waste Management and Waste Minimization Technologies*, N.P. Cheremisinoff, Butterworth-Heinemann, 2003.
6. *Municipal solid waste management: strategies and technologies for sustainable solutions*, C. Ludwig, S. Hellweg and S. Stucki, Springer, 2003.
7. *Handbook of Water and Wastewater Treatment Technologies*, N.P. Cheremisinoff, Butterworth-Heinemann, 2002.
8. *Handbook of Air Pollution Prevention and Control*, N.P. Cheremisinoff, Butterworth-Heinemann, 2002.

9. Air Pollution Control Technology Handbook, K.B. Schnelle and C.A. Brown, CRC Press, 2002.
10. Basics of solid and hazardous waste management technology, K.L. Shah, Prentice Hall, 2000.

COURSE 46 - 47

FINAL YEAR PROJECT

3-6

ELECTIVE COURSES

E-1

WATER RESOURCES MANAGEMENT

3(2-1)

Objectives:

The aim of this course is to educate students about the Water Resources Management with reference to Pakistan, how to minimize the wastage and how to increase its efficiency especially in irrigation sector.

Course Outline:

Water resource and its management, hydrological cycle, water quality and quantity aspects, water supply and demand management measures, virtual water, groundwater exploitation, its over-mining and pollution and urbanization aspects, improving water productivity/irrigation water efficiency, flood and droughts, water conservation and rain water harvesting in urban and rural environment, wetlands resources management, flood and drought management, recycling and re-use of wastewater, fisheries management, climate change and its impacts on our future water resources, precipitation distribution in Pakistan, Indus Water Treaty 1960 (IWT), Indus Water Accord 1991, water relevant institutions and authorities in Pakistan, water resources management and future challenges in Pakistan. Integrated water resources management (IWRM).

Lab Work:

Study tours to visit water supply & waste water treatment plants, watershed/catchment, with drinking water facilities like springs, tube-wells, pollution aspects, like solid waste and waste water disposal into the natural streams etc.

Recommended Books:

1. *Pakistan's Water Economy Running Dry*, Briscoe, J. and Qamar, U., Oxford University Press Karachi, 2006.
2. *Problems and Politics of Water Sharing and Management in Pakistan*, Cheema, P. I., Khan, R. A. and Malik, A. R., Asia Printer, Islamabad, 2006.

3. *Integrated Water Resources Management in South and Southeast Asia*, Biswas, A.K., Varis, O, and Tortajada, C, (eds.), Oxford University Press New Delhi, 2005.

E-2

SOIL AND ENVIRONMENT

3(3-0)

Objectives:

This course will provide students with the knowledge of the basic properties and significance of soil and its care for sustainable environment.

Course Outline:

Introduction, Soil forming minerals, Types and properties of parent materials, Physical and chemical processes of weathering, Factors and processes of soil formation, Physical and chemical properties of soil, Soil morphology and classification Cation and anion exchange, Soil buffering capacity and its importance, Soil degradation, management and green productivity, Environmental implications of fertilizers and agrochemicals, Environmental impact of agricultural and Industrial wastes, Soil as a natural sink for pollutants.

Recommended Books:

1. *The Nature and Properties of Soils*, Brady, N.C. and Weil, R.R. Prentice-Hall, 14th Edition. Upper Saddle River, NJ, USA, 2007.
2. *Soils in Our Environment*, Miller, R.W., Gardiner, D.T., 11th Edition, Prentice Hall, Upper Saddle River, NJ, USA, 2007.

E-3

DISASTER RISK MANAGEMENT

3(3-0)

Objectives:

This course will provide know how in dealing with natural calamities and their management by encompassing the field of hazard and disaster studies. It discusses a wide range of aspects, i.e., assessment of factors which put societies in vulnerable situations to the disaster management continuum. To underline the importance of disasters in socio-economic development, this course also aims to make an assessment of the consequences of 'natural' catastrophic at both short and long terms. It finally tends to provide the students with basic knowledge on hazard reduction and vulnerability mitigation. The student will learn knowledge of DRM terms and concepts within the global perspective of increasing disaster risk, Explain the processes of hazard, vulnerability, capacity and risk assessment;

Course Outline:

Natural hazards and disasters: The need for hazard and disaster studies, Historical background on Hazard and Disaster research; Disaster its types: Natural vs Man-made; Flooding, Earthquake, Landslide; Natural cycles and

their role, Prediction; Hazards, Risk and Vulnerability: Definitions and characterization, Factors leading to vulnerability, The impact of natural disasters: Direct and short-term impact of disasters, Indirect and long-term consequences of catastrophes, Disaster Management: Components of management, International phenomenon; identifying Risk, Flood Management: Organizational Role; Role of Government and Non-Governmental Organizations (NGOs); Role of Media in Disaster Management; Disaster Management Trainings and Policies, Earthquake and their damages, Landslides and their down slope movements.

Recommended Books:

1. *Natural Hazards and Disasters*. Donald Hyndman, David Hyndman. 2006
2. Update. *Natural Hazards and Disasters*. Donald Hyndman, David Hyndman.
3. *The Environment as Hazard* Burton I., Kates, R.W., and White G.F., 2nd Edition, The Guilford Press, New York, 1993.
4. *Natural Disasters* Alexander, D., Chapman & Hall, New York, 1993.

E-4

POLLUTANT MOVEMENT IN SOIL

3(3-0)

Objectives:

The objective of this course is to learn about pollutants, their nature and movement in the soil environment, their monitoring and estimation.

Course Outline:

Sources, classification and characteristics of pollutants; Water movement in soil: Saturated and unsaturated flow; Convection, dispersion, and hydrodynamic diffusion of pollutants; Solute transport parameters; Movement of volatile pollutants; Movement of adsorbing and inert pollutants; Adsorption isotherms; Pollutant breakthrough curves and their application; Movements of NO₃, pesticides and heavy metals in soil and groundwater. First order decay and pollutant movement; Half-life of various pollutants. Use of various available pollutant transport models for prediction.

Recommended Books:

1. Jury, W.A. and R. Horton. 2004. *Soil Physics*. Academic Press, Boca Raton, FL, USA.
2. Young, R.N., A.M.O. Mohammed and B.F. Warkentin. 1992. *Principles of Contaminant Transport in Soils*. Elsevier Publishers, Tokyo, Japan.

E-5

ENERGY AND ENVIRONMENT

3(3-0)

Objectives:

A course aiming to provide physical principles behind energy, its generation, sources, uses and effects on our environment. To highlight the effect of production and use, on the environment, of the various energy resources being used by man and discuss viable alternatives

Course Outline:

Introduction: Energy Units, forms and types of energy, energy resources, energy use and growth patterns, energy conversion, energy use in developing countries and losses; Energy Mix; Coal Characteristics; Problems associated with Mining & Transportation and use: Petroleum history and Processing; Problems associated with petroleum production, transportation and storage; Energy Conversion, Electric Power Generation; Hydroelectricity: Environmental Issues during Survey, Population Displacement and Construction; Nuclear Energy: Nuclear Fission; Electromagnetic Spectrum, Solar Spectrum, Light Intensity at Earth, Problems with use of energy resources: Wood, Coal and Fossil fuels; local and global issues; Ecological Effects of Large Dams; Spent Nuclear Fuel Disposal Issues; Nuclear Accidents: three-mile Island, Chernobyl, Fukushima etc. Renewable Energy Sources: Microhydel, wind, Solar thermal, Photovoltaic, Biogas etc.; Novel Energy sources: Biofuels, Geothermal, Wave, Tidal; Hydrogen as an Energy Carrier, Fuel Cells, Hybrid Vehicles.

Recommended Books:

1. Energy: Its use and the Environment, 5th Edition, Roger A. Hinrichs and Merlin Kleinbach, Brooks Cole, 2013
2. V. Quaschnig, Renewable Energy and Climate Change, Wiley-IEEE, 2010
3. D. Coley, Energy and Climate change, 2nd Edition, John Wiley, 2008
4. R. Ristinen and J.K. Kraushaar, Energy and Environment, John Wiley, 2006
5. Encyclopedia of Energy Technology and the Environment Four Volume Set, John Wiley & Sons Inc (US), 2005
6. G. Boyle, Renewable Energy, Oxford University Press, 2004

E-6

HYDROLOGY

3(3-0)

Objectives:

Understanding of Hydrology and its systems in Environmental Science, Surface and groundwater and its applications.

Course Outline:

Principles of Hydrology, Surface water origin, Occurrence, Distribution and movement. Hydrologic Cycle, Hydrographs, Precipitation, Evaporation,

Infiltration, Run-off and its types, Basic equations, Stream flow measurements. Groundwater Balance, Ground water exploitation and management, Surface-Groundwater interaction and Ecosystem dependence. Water Balance, Rainfall recharge. Erosion and Silting, Water logging and Salinity problems in Pakistan.

Recommended Books:

1. Todd, D.K., Mays, L.W., 2004. Groundwater Hydrology. John Wiley and Sons, ISBN-10: 0471059374 | ISBN-13: 978-0471059370.

E-7

AGRO-ECOLOGY

3(3-0)

Objectives:

This course trains students to compare agro-ecosystems and attempt to integrate knowledge of natural ecosystems into agricultural practice. Learn to link ecology, socioeconomics and culture to sustain agricultural production, farming communities, and environmental health.

Course Outline:

Application of ecological principles to modern farming systems, goals of long-term food production without depleting Earth's resources. Explore on-farm and off-farm ecological implications of agricultural and livestock practices for crop biodiversity, riparian and wetland systems, agroforestry, soil fertility, and pasture. Application of ecological principles in agro-ecosystems viz; enhance recycling of biomass and optimizing nutrient availability and balancing nutrient flow, securing favorable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity, minimizing losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover, species and genetic diversification of the agro-ecosystems in time and space.

Recommended Books:

1. Gliessman, S. R. 2007. Agroecology: The Ecology of Sustainable Food Systems Taylor & Francis Group, CRC Press, N.W. Corporate Blvd., Boca Raton, FL 33431 ISBN 0-8493-2845-4
2. Gliessman S. R. (Ed). And C. A. Edwards, 2000. Agroecosystem Sustainability Developing Practical Strategies. CRC Press 224 pages
3. Wojtkowski, P. A. Introduction to Agroecology: Principles and Practices, Rutledge,

E-8

OCCUPATIONAL SAFETY, HEALTH & ENVIRONMENT

3(2-1)

Objectives:

The course will provide information on occupational health and safety as well as it will review various types of work place hazards, their exposure and effects

on the body. Focus will be on hazardous chemicals, carcinogens, effects of chemicals acute and chronic health problems related to work and safe use of chemicals at work. Awareness will also be created about the health and safety laws and enforcement, role of health and safety committees at work etc.

Course Outline:

Introduction to occupational health and safety: Accidents, Disease, Normal working, Health and safety problems worldwide, Importance of management and training in occupational health and safety. Common work place associated hazards; biological, chemical, mechanical, physical and psychological hazards and their effects on health and safety, local effects, systemic effects, acute and chronic effects. Chemicals in the work place, Noise at work, Manual handling, Controlling hazards: Methods of control, Elimination, Substitution, Engineering controls, Administrative controls, Personal protective equipment (PPE), Cumulative trauma disorder (CTD), Evaluation of job risk factors, Controlling vibration hazards. Male and female reproductive health hazards in the work place, Health and safety for women and children, Labour code of Pakistan. Occupational health safety management system. Legislation related to health and safety at work, Check list, Role of health and safety representatives and labour union at work; meetings, reports, training education, negotiation, Role of government, Health and safety committee.

Recommended Books:

1. Occupational Health Hazards and Remedies. (2002). Mohapatra, R. Jaypee Brothers Medical Publishers Pvt. Ltd. India.
2. Biosafety Management: Principles and Applications. (2000). Aynor, P. L. Virginia Polytechnic Institute Publications. USA.
3. Hazardous Chemicals Handbook. (2002). 2nded. Carson, P. and Mumford, C. Butterworth Heinemann. Oxford, UK.
4. Basic Environmental Health. (2001). 1sted. Yassi, A., Kjellstrom, T., deKok, T. and Guidotti, T. L. Oxford University Press. NY, USA.
5. Risk assessment of chemicals: An Introduction. 2007. Leeuwen, C.J.V. Springer, USA.

E-9

SOLID WASTE MANAGEMENT

3(3-0)

Objectives:

The students will learn the types, handling and management systems of solid wastes.

Course Outline:

Introduction to solid waste management; Solid waste characterization: Sources, quantities, quality; Waste collection and transport; Treatment technologies: Bioremediation strategies; Composting: Types and methods, environmental requirements, incineration, reuse and recycling; Landfills: Site design and management; Pollution and risk assessment of landfills; Biogas

generation: Use of biogas digest; Recent technologies used for solid waste management.

Recommended Books:

1. *Principles and Applications of Microbiology*. Salvia, D.M., J.J. Fuhrman, G.P. Hartel and A.D. Zuberer. 2nd Ed. Prentice Hall, Upper Saddle River, NJ, USA. 2005.
2. *Compost Science and Technology*. Diaz, L.F., M. de Bertold and W. Bidlingmaier. Elsevier, London, UK. 2007.
3. *Compost*. Kenneth, T. and E. Annelise. Dorling Kindersly, London, UK. 2007.
4. *Organic Waste Recycling: Technology and Management*. Polprasent, C. IWA, London, UK. 2007.

E-10

ECOTOURISM

3(3-0)

Objectives:

The course has been designed for the students to enable them meet the existing global challenges for achieving a sustainable growth in a competitive environment of tourism industry.

Course Outline:

Introduction and general overview, Context and definitions of ecotourism, Types of Ecotourism, Alternative and mass tourism, Principles and philosophies of ecotourism, Ecotourism resources, Protected areas in ecotourism, Identifying and describing ecotourism products, Components of ecotourism, Impacts of ecotourism, Resources required for eco and urban tourism, Ecotourism practices, Environmental and ecological impacts of ecotourism, Ecotourism markets, Clients and motivation, Community based ecotourism, Ecotourism developments, Developing ecotourism products, Ecotourism in the national and global context, Field trip, Report writing.

Recommended Books:

1. Ecotourism. Weaver, D., Milton Qld: John Wiley & Sons. 2008.
2. Ecotourism: An introduction. Fennell, D.A., Taylor and Francis. 1999.

E-11

ENVIRONMENTAL BIOTECHNOLOGY

3(3-0)

Objectives:

This course will provide sound technical foundation for using biotechnology in solving environmental issues and cleanup of the polluted environments. After completion of this course, students will be able to understand the significance, and application of biotechnology in the environment.

Course Outline:

Introduction to biotechnology, Tools in environmental biotechnology, fundamentals of biological interventions, Recombinant DNA Technology, Genetic manipulations, GMOs: Release and Regulations, environmental applications of GMOs, biosafety concerns of GMOs, bio-strategies for pollution control, bioremediation, phytoremediation, biofilm, Biomarkers, Biosensor, Bioreactors. Ethic and legal problems in creations and use of transgenic organisms.

Recommended Books:

1. Environmental Microbiology. 2nd Edition. 2010. Edited by Ralph Mitchell and Ji-Dong Gu. John Wiley & Sons, Inc., Hoboken, New Jersey.
2. *Environmental Biotechnology: Concepts and Applications*, Hans-Joachim, J. and Josef, W. (ed.). Wiley-VCH Verlag, Germany, 2005.
3. *Biotechnology*, Smith, J.E., 5th Ed. Cambridge University Press, New York, USA, 2009.
4. *National Biosafety Guidelines*. National Biotechnology Commission, Government of Pakistan. 2005.
5. Environmental Biotechnology: Theory and Application. Gareth M. Evans and Judith C. Furlong. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England, 2003.

E-12

AIR AND NOISE POLLUTION

3(3-0)

Objectives:

The course aims to introduce types of air, noise and electromagnetic waves. Causes and sources of air pollution, particulate matter, techniques of measurement of air pollutants and particulate matters, greenhouse gases, global warming, causes sources and effects, ozone depletion, acid rain. Air pollution prevention and control, strategies/methodology compliance of NEQS standards for air pollutants, nature of noise and electromagnetic waves. Propagation of electromagnetic waves and electromagnetic wave characterization, potential impacts of health impact of electromagnetic waves and noise pollution, noise measuring techniques and methodology etc. will be covered in this course.

Course Outline:

Air Pollution Essentials; The Risks of Air Pollution; Measurement and Monitoring of Air Pollution; The methodology of Air Pollution; The Regulatory Control of Air Pollution; The Engineering Control of Air Pollution; Introduction to Noise Pollution; Basic concepts of sound and noise; Noise and its effects; approaches to noise problems; Planning to control noise pollution; Noise reduction; Characteristics and impact of surface transportation noise; Traffic noise reduction; Aircraft noise reduction; Preventing airport noise; Control of noise pollution from diesel generator sets; Noise pollution in oil exploring and its control; noise pollution and its control in mining and product industries; Sound control technologies and instrumentation. Electromagnetic waves generated by cellular tower and its potential impact on humans and the environment.

Recommended Books:

1. Electromagnetic Surface Waves: A Modern Perspective (Elsevier Insights) by John Polo 2012.
2. Fundamentals of Air Pollution. Daniel Vallero. 4thEdition. ISBN10: 0-12-373615-3 (2007).
3. Textbook of Noise Pollution and its Control. S.C. Bhatia. Atlantic Publishers and Distributors, (2007).

GRADUATE PROGRAMME

MS in Environmental Science

1. Regarding MS Degree Programme, the NCRC agreed on the following principles, that:
 - a) The nomenclature of the degree will be “Masters Studies (MS) in Environmental Science”.
 - b) The MS Degree Programme will be of two years duration after four years BS Degree in Environmental Science.
 - c) The MS degree will be based on course work of 24 credit hours along with a mandatory research thesis/dissertation of 6 credit hours as per HECs’ policy guidelines.
 - d) To support the students in their specialized areas of research work, it is suggested that they should opt for courses of at least 12 credit hours from the list of elective courses in consultation with their supervisors/mentors.
 - e) The areas of specialization may be offered according to the geographic location of the institutions, availability of the faculty and other facilities.
 - f) The committee also recommended that the pre-requisite for admission to MS Environmental Science must be four years BS Environmental Science.
 - g) The Committee considered the decision of the cabinet of the Government of Pakistan conveyed to HEC vide letter No. F. 1(2)/2012-CC, dated 19 April 2012 through the then Ministry of Climate Change (now Climate Change Division) for introduction of a Master Degree programme on climate change/environmental planning in the universities. The committee resolved that climate change and disaster management are already in the curricula. However, the committee recommended that a new MS degree programme on “Climate Change and Environmental Planning” may be considered in future when there will be demand for such specialized subjects in the job market.
2. The committee proposed the following structure of scheme of studies along with outline of core courses for the degree of Masters Studies in Environmental Science as follows:

| Semester | Recommended Course Titles | Credit Hours |
|---|---|---------------------|
| 1stSemester | <ul style="list-style-type: none"> • Research Methods in Environmental Science • Climate Change Adaptation and Mitigation • Strategic Environmental Assessment • ELECTIVE 1 | 12 |
| 2ndSemester | <ul style="list-style-type: none"> • Environmental Analytical Techniques • ELECTIVE 2 • ELECTIVE 3 • ELECTIVE 4 | 12 |
| 3rd& 4th Semesters | Research Work for Thesis | 6 |
| TOTAL CREDIT HOURS | | 30 |

SCHEME OF STUDIES FOR MS in Environmental Science

The MS program in Environmental Science is a science-oriented qualification and adopts an interdisciplinary approach to fulfill the desired need and provide students with a holistic approach for environmental research and investigation to generate knowledge.

Aim & Objectives:

The overarching aim of this program is to develop human resource in the field of environment to achieve sustainable development through appropriate education and training. After completing this degree, the graduates will be able to:

1. analyze and assess environmental problems, their interrelationships with other systems of the society;
2. acquire skills necessary for management of environmental problems, abatement of pollution and conservation of environment;
3. carry out independent research on various crosscutting aspects of environmental issues.

MS in Environmental Science is an enabling qualification for those who want to complete their eighteen years of education or intend to proceed for PhD in the country or abroad. This will be a 30 credit hours degree program for minimum of two years, one year for taught courses of 24 credit hours and one year for 6 credit hours research thesis as prescribed by HEC.

CORE COURSES:

The Committee agreed that following four courses should be offered as core courses for MS programme in Environmental Science.

| Course Titles | Credit Hours |
|---|---------------------|
| 1. Research Methods in Environmental Sciences | 3(3-0) |
| 2. Climate Change Adaptation and Mitigation | 3(3-0) |
| 3. Strategic Environmental Assessment | 3(3-0) |
| 4. Analytical Techniques | 3(2-1) |

ELECTIVE COURSES:

The Committee proposed that at least two courses should be selected from the following list of elective courses for MS programme. However the other two courses may be offered by the approval of respective University authorities.

1. Environmental Chemistry

2. Applied Environmental Microbiology
3. Freshwater Ecology / Limnology
4. Environmental Sociology
5. Environmental Geology
6. Disaster Risk Management
7. Marine Pollution Management
8. Epidemiology
9. Green Economy
10. Population Dynamics and Environment
11. Environmental Biotechnology
12. Wetland Management
13. Environmental Auditing
14. Wildlife and Forest Conservation
15. Alternative Energy Sources
16. Cleaner Production Technologies
17. Solid and Hazardous Waste Management
18. Remote Sensing & GIS
19. Environmental Risk Assessment and Management
20. Principles and Applications of Bioremediation
21. Sustainable Urban Planning and Management
22. Sustainable Agriculture
23. Industrial Ecology
24. Sustainable Development
25. Project Development and Management
26. Health, Safety and Environmental Management
27. Energy and Environment
28. Carbon sequestration and Environment
29. Advances in Plant Ecology
30. Biological Conservation
31. Urban Ecology
32. Environmental Education
33. Laboratory Management Practices
34. Restoration Ecology
35. Gender and Environment
36. Global Environmental Politics
37. Coastal Environment and Management
38. Agrochemicals in the Environment
39. Remediation Strategies for Contaminated Environment
40. Treatment and Management of Wastewater
41. Environmental Application of Nanomaterials
42. Polymers and the Environment

Outline of Courses for Degree of MS in ENVIRONMENTAL SCIENCE

SEMESTER 1

CORE COURSE 1:

RESEARCH METHODS IN ENVIRONMENTAL SCIENCE 3 (3-0)

Objectives:

The objective of this course is to equip the students with the skills to undertake a project by planning, designing and defining a research problem; and select indicators and parameters of research and its methodologies.

Course Outline:

- Introduction to Research, Nature of Research, Purpose of Research, Ethics in Research
- Types of Research, Tools of Research, Scientific Methods, Techniques & Pre-requisites for Scientific Research
- Types of Questions, Types of Relationships, Variables, Hypothesis, Types of Data,
- Starting a Research Project/Research Proposal, Research Project Conceptualization, Elements of a Research Proposal
- Critical Thinking and Developing the Research Question, Defining the Research Problem; Choosing the Research topics
- Research Proposal: its importance - A pre-requisite for Research, Research Proposal Writing Techniques
- Research Design;
Importance of Research Design, Formulation of Research Design
Reliability, validity, generalization, Experimental design and use of indicators in research, Tradeoffs in design decisions
- Sampling Design;
Introduction to sampling design, Logic of Sampling; Concepts and Terminologies, Types of Sampling Designs (Classifying experimental design, factorial design, randomized block design, covariance design, Quasi experimental design) Relationship among pre-post design.
Advances in Quasi Experimentation
- Survey of Research, Questionnaires construction
- How to put things together? Introduction, Objectives, Material and Methods, Review of Literature, Bibliography, Literature Search: Database, Search Engines; Analytical tools in research: qualitative and quantitative methods;
- Evaluation Research: How to carry out evaluation research, Data Collection: Techniques in data collection: Quantitative & Qualitative Data, Experimental Research, Case Studies, Surveys, Interviews, Questionnaire
- Data Analysis: Conclusion, Validity
- Statistical analyses,
- Descriptive Statistics (Correlations)

Inferential Statistics, Univariate Analysis, Bivariate Analysis, Multivariate Analysis (T-Test, Generalized linear model, Factorial design, randomized block analysis, Analysis of covariance, Regression Analysis)

Data Interpretation, Current data interpretation with comparative studies (Inter-laboratory comparison), Inference based on findings;

- Research Presentation Techniques – Data presentation

Recommended Books:

1. *Students project in Environmental Science*, Harrad, S., Batty, h., Diamon, M. and Arhonditsis, G, John and sons Ltd., Chichester, England, 2008.
2. *Designing and Conducting Mixed Methods Research*, Creswell, J. W. & Plano Clark, V.L. Thousand Oaks, Sage CA, USA, 2007.
3. *The Craft of Research* by Wayne C. Booth, 2nd Edition, Univ. of Chicago Press. USA, 2003.
4. *Case Study Research: Design and Methods*, Robert Yin, 3rd Edition, Sage Publishers. USA, 2003.
5. Gliner, J. A., & Morgan, G. A. (2000). *Research methods in applied settings: an integrated approach to design and analysis*. Mahwah, N.J.: Lawrence Erlbaum.

CORE COURSE 2

CLIMATE CHANGE ADAPTATION AND MITIGATION

3(3-0)

Objectives:

Climate Change Impacts Adaptation and Mitigation is an interdisciplinary course offered at MS level. The focus of the course is climate change impacts and the human response to climate change, including efforts to adapt to climate change, as well as efforts to avoid or reduce the negative impacts of climate change. The aim of the course is to give an understanding of climate change impacts, and provide the knowledge and tools to devise effective strategies for climate change adaptation and mitigation. After completion the students will be able to identify natural and anthropogenic drivers of climate change, have knowledge of the direct observations of climate change, and describe the impacts of climate change on agriculture, forestry, ecosystems, water resources, society and human health. The objective of this course is to provide students with knowledge to learn the dimensions of proliferating effects of climate change on human life and its future generations.

Course Outline:

Introduction, types and their climatic effects, modeling of climate change, types of climate change models. Climate Change and Wetlands: impacts, adaptation and mitigation. Basic understanding of the physical science of climate change, climate change impacts and the human response to climate change. Adaptation to climate change, natural and anthropogenic drivers and direct observations of recent climate change. Potential adaptation strategies in different sectors. Climate change impacts and adaptation practices for

ecosystems, land use, water resources, society and human health, Climate change mitigation strategies, Carbon sequestration, Transition to carbon neutral energy sources, Geo-engineering as well as measures to increase energy efficiency. Climate change policy and social change, international climate change negotiations, regulatory instruments, voluntary agreements and social change.

Climate change and food production, climate change and its effects on Pakistan's agriculture, water resources, forests, etc.

Recommended Books:

1. Adaptation to climate change /Mark Pelling. Abingdon, Oxon, England;New York Routledge,c 2010.
2. Dow, Kirstin, 1963 The atlas of climate change mapping the world's greatest challenge/Kirstin Dow and Thomas E. Downing. London Earthscan, 2011.
3. Climate Change Causes, Effects, and Solutions, 1stEdition, Hardy, J. T., John Wiley & Sons, 2003.
4. *Global Warming -The Complete Briefing* by John T. Houghton.(3rd edition) Cambridge University Press, 2004.
5. *Climate Impact and Adaptation Assessment A Guide to the IPCC Approach*, Earthscan Publication Ltd, London, 2005.
6. *Climate Change - Causes, Effects, and Solutions*, Hardy, J.T., John Wiley & Sons, 2003.
7. IPCC Assessment Reports on Climate Change
8. Botkin D. & Keller E., 2000. *Environmental Science: Earth as Living Planet*. 8th ed. John Wiley and Sons.
9. Cunningham W.P., & Saigo, B.W., 2001. *Environmental Science*, 6th Ed. Mc-Graw Hill

CORE COURSE 3

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)3(3-0)

Objectives:

SEA is a rapidly evolving field around the World. The objective of this course is to explain theory, practice and methodology strategic environmental assessment. After completing this course, the students will be able to:

1. appreciate the relationship between SEA and environmental planning processes.
2. obtain a practical understanding of SEA methods and approaches.
3. develop and awareness of SEA effectiveness and performance requirements.

Course Outlines:

Environmental Assessment Introduction and concepts, methods and tools for EA; Strategic Environmental Assessment: Key concepts. SEA legislation and process, regulatory and planning framework of SEA and Implementation, SEA Tools and Techniques

SEA case studies: examples from a wide spectrum of sectors; SEA case studies for Water and SEA case studies for Waste, Future directions: Cumulative impact assessment, Sustainability assessment.

Recommended Books:

1. A Practical Guide to the Strategic Environmental Assessment Directive (2005)
2. Sheate, W.R. *et al* (2004) Implementing the SEA Directive. Sectoral Challenges and Opportunities for the UK and EU, *European Environment*, Vol 14 (2), 73-93
3. SEA and Integration of the Environment into Strategic Decision-Making: Report to EC (2001)

SEMESTER 2

CORE COURSE 4

ENVIRONMENTAL ANALYTICAL TECHNIQUES 3(2-1)

Objectives:

The objective of this course is to impart skills and techniques necessary for measurement of different environmental pollutants. This course will enable the students to carryout monitoring and evaluation.

Course Outline:

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; Principles for Instrumental Techniques using Spectroscopy, Chromatography, Microscopy and X-Ray Diffraction analyses etc. Assessment and Interpretation of Results using Statistical Tools.

Lab work:

Analyses of Water, wastewater, air and solid wastes for pollutant determination; Instrumental analyses using Spectroscopy, Chromatography, Microscopy and X-Ray Diffraction analyses etc. Data Interpretation using Statistical Tools

Recommended Books:

1. *Environmental Engineering Laboratory*. Ahmed, K.A one Publishers Lahore, Pakistan, 1998.
2. *Standard Methods for Examination of Water and Wastewater*. L. S. Clesceri, A. E. Greenberg, A. D. Eaton. 20th Edition. APHA publisher, USA, 1998.

ELECTIVE COURSE

E-1:

ENVIRONMENTAL CHEMISTRY

3(3-0)

Objectives:

This course is designed to provide knowledge about different chemical process occurring in the environment, various physical and chemical methods to minimize pollution and adverse effects of various pollutants on human health and toxicity.

Course Outline:

Chemistry of atmosphere, Major layers in atmosphere, temperature changes in the atmosphere, units to describe atmospheric chemistry, chemical reactions in the atmosphere sources and effects of following pollutant on human health Carbon dioxide, Nitrogen oxides, Sulfur dioxide, Volatile organic compounds, automobile pollutants, Industrial smog, Photochemical smog, production of hydroxyl radical, their reaction with hydrocarbons, Indoor air pollution various indoor air pollutants, particulates, chemistry of ground level air pollution.

Production of ozone in the stratosphere catalytic destruction of ozone, Hydroxyl Radical cycle, NO cycle, the chlorine cycle, Null cycles, Effects of ozone depletion on human health and environment, Green chemistry, its principles, Water pollution, Types of water pollutants oxidation Reduction reactions in aqueous systems. Suspended solids and sediments, Dissolved solids.

Toxic organic compounds, pesticides, organochlorine insecticides, carbamates. Accumulation in biological systems. Biomagnification and Biodegradation. Toxic heavy metals and their Bioaccumulation.

Recommended Books:

1. *Environmental Chemistry*. Ibanez, J.G., Hemandez-Esparaz, M., Doria-Serrano, C., Fregoso-Infante, A. and Singh, M.M., Springer, Germany.2008.
2. *Principles of Environmental Chemistry*, Girard, IE., 1stEdition. Jones and Barlett, USA, 2005.

3. Environmental Chemistry. Baird Collin and Michael Cann. W.H. Freeman and Company, New York USA. 2008.

E-2

APPLIED MICROBIOLOGY

3(2+1)

Objectives:

The course is designed to disseminate the best available information about the genetics, biochemical and Environmental agriculture related properties of the microorganisms and their possible exploitation in the production of food, vaccines , fermented products, antibiotics, diseases resistant crops, Bioremediation, Solid waste treatment and other similar areas in the most efficient and economic manner.

Course Outline:

Fermentation Technology: Stages of fermentation process, Isolation, screening, preservation and improvement of industrial microorganisms, Media formulation, Sterilization, Inoculum development- The range of fermentation process, Submerged, Solid state fermentation The chronological development of the fermentation industry, The component parts of a fermentation, process Continuous culture, Fed-Batch culture, Chemo stat culture.

Process Engineering: Bioreactor- Design, Operation, Cell Harvesting, and Disruption, Product recovery and Purification, Instrumentation and Process Control, Types of bioreactors.

Fermentation Products: Alcohols, Alcoholic beverages, Organic acids, Polysaccharides, antibiotics, Vitamins, Fermented Foods, Organic acids
Environmental Aspects: Mineral leaching with bacteria, microorganisms involved in the sulfide mineral leaching, chemistry of sulfide mineral oxidation by bacteria, exploitation of bacterial sulfide mineral oxidation, dump and heap leaching, in-situ bacterial leaching of ore, mineral concentrate-leaching utilization of bacterially generated solvents, heavy metal pollutants removal by bioaccumulation, Degradation of toxic wastes, mechanisms of detoxification, biotechnological remedies, waste recovery, single cell protein, biogas technology.

Bioremediation: Microbial control of environmental pollution, Transport and fate, Biodegradation, microbial activities and Environmental effects on biodegradation, transform of metal pollutants, Phytoremediation: Mechanisms involving removal of hazardous compounds and heavy metals from soil and water.

Lab work:

Production of Fermented Food Tempeh, Water analysis, Isolation and screening of metal resistant bacteria, Isolation and screening of metal resistant

fungi, Demonstration of Fermenter, Sterilization Techniques, Identification of microbes.

Recommended Books:

1. Glazer, A. N. 2007. *Microbial Biotechnology: Fundamentals of Applied Microbiology*. 2nd Ed. Hiroshi Nikaido, Cambridge University Press, New York, USA.
2. Patrick, K. J. 2004. *Environmental Microbiology Principles and Applications*. Biological Sciences Department, University of Cincinnati, Cincinnati, Ohio, USA

E- 3

FRESHWATER ECOLOGY

3(3-0)

Objectives:

The objective of this course is to train the students for ecological analysis of freshwater habitats in terms of identification of flora and fauna and the interactions among them. At the end of the course, the students are expected to acquire the techniques for study of freshwater habitats.

Course Outline:

Hydrology and Physiography of various types of freshwater systems. Chemistry of various freshwater systems and associated organisms. Physical relationships, Movement of light, heat and chemicals in water, Hydrology and Physiography of groundwater and wetland habitats, Physiography of lakes and reservoirs. Types of aquatic organisms: Cyanobacteria, Eukaryotic Algae, Aquatic fungi, Protozoa, Non-vascular plants and vascular plants. Animals: Porifera, Cnidaria, Platyhelminthes and Nemertea, Gastrotricha, Rotifera, Nematoda, Mollusca, Annelida, Bryozoa, Tardigrada, Arthropoda, Fishes, Tetrapods; Biodiversity of freshwaters, Measures of diversity, temporal and spatial factors, short term factors influencing local distribution. Invasions of Nonnative species, extinction. Chemicals in freshwater, Redox potential, potential energy and chemical transformations. Distribution of dissolved oxygen in environment, transformations of carbon, fermentation, methanogenesis, Nitrogen, Sulfur, Phosphorus and other Nutrients. Effects of toxic chemicals and other pollutants on aquatic ecosystems, Fish Ecology, Freshwater Ecosystems: Groundwater Ecosystems, Streams, Lakes and Reservoirs, Wetlands.

Recommended Books:

1. Lampert, W. and Sommer, U., 2007. *Limno-ecology: The Ecology of Lakes and Streams*. Oxford University Press, New York.
2. Dodds, W.K., 2002. *Freshwater Ecology: Concepts and Env. Applications*. Academic Press. London.
3. Dodds, W.K. and Whiles, M.R., 2002. *Freshwater Ecology: Concepts and Environmental Applications of Limnology*. 2nd Ed. Academic Press. London.

E-4

ENVIRONMENTAL SOCIOLOGY

3(3-0)

Objectives:

Environmental sociology is the sociological study of societal-environmental interactions, although the focus of the field is on relationship between society and environment in general and the social factors that cause environmental problems in particular. After completing this course the students will be able to explore the various forms of interaction between human society and the environment, focusing on the social dimensions of the surrounding natural and human-made environments.

Course Outlines:

Foundations of Environmental Sociology; Human Dimensions of Environmental Change; Environmental Justice and Social Stratification; Social Dimensions of Environmental Disasters; Consumer Society. Rotating topic seminars in Environmental Sociology should also be included.

Recommended Books:

1. Gottlieb, Robert. 2005. *Forcing the Spring: The Transformation of the American Environmental Movement*. Washington, D.C.: Island Press.
2. Guha, Ramachandra. 2000. *Environmentalism: A Global History*. New York: Longman.

E-5

ENVIRONMENTAL GEOLOGY

3(3-0)

Objectives:

This course aims to provide knowledge about a wide range of topics in geology, discussing fundamental geologic principles to the specific geologic hazards, from an environmental perspective.

Course Outline:

Earth materials and processes. Geology and Ecosystems. Hazardous natural processes: River flooding, Landslides and related phenomena, Earthquakes and related phenomena, Volcanic activity, Coastal hazards, Impact of extraterrestrial objects. Human interaction with environment: Hydrology and human use, Waste disposal, Geologic aspects of environmental health, Climate change. Mineral resources and environment. Energy and environment. Land use and decision making: Landscape evaluation. Related environmental laws.

Recommended Books:

1. Environmental geology: Keller, E.A., 9th edition, Prentice Hall, 2011.
2. Introduction to environmental geology: Keller, E.A., 5th edition, Prentice Hall, 2012.

Objectives:

This course will provide know how in dealing with natural calamities and their management by encompassing the field of hazard and disaster studies. It discusses a wide range of aspects, i.e., assessment of factors which put societies in vulnerable situations to the disaster management continuum. To underline the importance of disasters in socio-economic development, this course also aims to make an assessment of the consequences of 'natural' catastrophic at both short and long terms. It finally tends to provide the students with basic knowledge on hazard reduction and vulnerability mitigation.

Course Outlines:

Natural hazards and disasters: The need for hazard and disaster studies, Historical background on Hazard and Disaster research; Disaster its types: Natural vs Man-made; Flooding, Earthquake, Landslide; Natural cycles and their role, Prediction; Hazards, Risk and Vulnerability: Definitions and characterization, Different approaches and Indicators; Factors of vulnerability: Demographic factors, Socio-economic factors, Cultural factors, Political factors, Physical factors; The impact of natural disasters: Direct and short-term impact of disasters, Indirect and long-term consequences of catastrophes, Disaster as an opportunity for development; Disaster Management: Components of management, identifying communities at risk, International phenomenon; Hazard and vulnerability reduction and Mitigation: hard and soft measures; Earthquake Management, Flood Management: Organizational Role; Role of Government and Non-Governmental Organizations (NGOs); Role of Media in Disaster Management; Techniques and methods to assess hazard, vulnerability and risk: Qualitative and Quantitative approaches; Disaster Management Trainings and Policies, Pre-disaster management (Early warning system, emergency communication), Common environmental disasters in Pakistan, Plate Tectonics and Physical Hazards, Earthquake and their damages, Landslides and their down slope movements, Climate and weather related Hazards: Storms on the horizon, streams and flood processes, flood and human interactions, Coastal erosion.

Recommended Books:

1. Natural Disasters, Alexander, D., Chapman & Hall, New York, 1993.
2. Natural Hazards and Disasters. Donald Hyndman, David Hyndman. 2006 Update. Natural Hazards and Disasters. Donald Hyndman, David Hyndman. ISBN-10: 0538737522. The Environment as Hazard Burton I., Kates, R.W., and White G.F., 2nd Edition, The Guilford Press, New York, 1993.
3. Disaster Management: A Disaster Manager's Handbook. Carter N.W., ADB, Manila, 1991.

4. Rising from the Ashes: Development Strategies in Time of Disaster, Anderson, M.B., and Woodrow, P.J, Westview Press, Boulder, UNESCO, Paris, 1989.

E-7

MARINE POLLUTION MANAGEMENT

3(3-0)

Objectives:

To develop a basic understanding of marine pollution, its sources, impact of pollutants on the biotic and abiotic environment impacting the marine resources. Develop a clear understanding of pollution control and management techniques.

Course Outline:

Introduction to marine pollution, chronic and acute inorganic and organic marine pollutants. Causes, effects and impacts on marine environment and humans. Health of the oceans, various forms of environmental pollution as they affect both the land and maritime environment. Control of pollution in marine and coastal environments Pollution Management, ocean disposal (marine outfalls, shipboard wastes, dumping of sludge, disposal of dredge spoil, radioactive wastes) and its impact. Marine pollution control and mitigation measurements; oil spills contingency plan and combating techniques.

Recommended Books:

1. Managing Ocean Environments in a Changing Climate: Sustainability and Economic Perspectives Kevin J. Noone' Ussif Rashid Sumaila Robert J. Diaz 2013.
2. Marine Pollution and Human Health (Issues in Environmental Science and Technology) R E Hester, R M Harrison RSC Publications 2011
3. Coastal Pollution: Effects on Living Resources and Humans (Marine Science) by Carl J. Sindermann (2005).
4. Marine Pollution and Its Control (McGraw-Hill series in water resources and environmental engineering) by Paul L. Bishop (1982).
5. Protecting the Marine Environment from Land-Based Sources of Pollution: Towards Effective International Cooperation by Daud Hassan (2006).
6. Transboundary Environmental Governance: Inland, Coastal and Marine Perspectives Robin Warner, Simon Marsden 2012

Journals/Periodicals:

- Marine Pollution Bulletin.
- Journal of Environmental Chemistry and Ecotoxicology.
- Marine Chemistry.

Objectives:

The objective of the course is to provide the student with insight in the principles and important issues of environmental epidemiology. This course will focus on assessment of disease burden, measurement of exposure and interpretation of mortality, morbidity concepts. Upon completion of this course, it is assumed that students will be able to comprehend emerging diseases in the context of climate change and global environmental change.

Course Outline:

Environmental risks to human health. Epidemics, endemics, and pandemics. Epidemiology triangle. Disease concepts: Communicable and non-communicable diseases and conditions. Modes of disease transmission and chain of infection. Portals of entry to the human body. Zoonoses.

Type of epidemiology: social, occupational, environmental, nutritional and infectious disease epidemiology. Occupational health and industrial hygiene. Disease surveillance and health impact assessment. Basic concepts: rates, ratios, proportions and relative risks. Measures of association and odds ratio analysis.

Design strategies and experimental epidemiology: case-control studies, cohort studies, double-cohort studies. Role of confounding factors in causation of disease. Web of causation. Sensitivity and Specificity. Designing a randomized controlled trial. Ethics in epidemiologic research.

Statistical Methods in Epidemiology: Sample size determination and statistical inference. Integrating toxicological and epidemiological data. Regression methods. Time-series, spatial analysis and meta-analysis in epidemiology.

Field Epidemiology: Epidemiological field work in population-based studies. Exposure assessment, surveillance and screening methods. Examples of case studies: cardiovascular, cancer, asthma and vector borne diseases.

Recommended Books:

1. Ahrens, W. and Pigeot, I. (2013). *Handbook of Epidemiology*. 2nd Ed. Springer, London. UK.
2. Merrill, R. M. and Timmreck, T. C. (2006). *Introduction to Epidemiology*. (4th ed.). Jones and Barlett Publishers. Boston, USA.
3. Merrill, R. M. (2008). *Environmental Epidemiology: Principles and Methods*. (4thed.). Jones and Barlett Publishers. Boston, USA.
4. Aschengrau, A. and Seage, G. R. 2003. *Essentials of Epidemiology in Public Health*. Jones & Bartlett Learning, 5 Wall Street Burlington, MA

Objectives:

The objective of this course is to develop understanding of basic principles of green economy within the economic, energy and food security context of the country and the region.

Course Outline:

The concept of green economy, framework of policies and approaches that accelerates progress toward sustainable development goals. Carbon footprint assessment, carbon trading and carbon sequestration, REDD and REDD plus mechanisms. Employment and labor market policies for Green Jobs in context of Pakistan. Role of Microfinance in Promoting Renewable Energy. Institutional Framework for Renewable Energy and community adaptation. Entrepreneurship in Energy Solutions. Green economy and its relationship to Livelihood and Poverty Alleviation.

Recommended Books:

1. Lightfoot, H. Douglas, et al, "Nuclear Fission Fuel is Inexhaustible", *Climate Change Technology Conference: Engineering Challenges and Solutions in the 21st Century*, Engineering Institute of Canada, Ottawa, Ontario, Canada, May 10-12, 2006.
2. Boyd, David R, *Sustainability within a generation: a new vision for Canada*, The David Suzuki Foundation, ISBN 0-9689731-6-7, 2004.
3. Day, Danny M. et al, Distributed Hydrogen Production with Profitable Carbon Sequestration: A Novel Integrated Sustainable System for Clean Fossil Fuel Emissions and a Bridge to the New Hydrogen Economy and Global Socio-Economic Stability, *National Hydrogen Association Conference*, Washington, DC., Poster Presentation, March 4-8, 2003.
4. Lehmann, J., D. Kern, B., Glaser, W. Woods, *Amazonian Dark Earths: Origin, Properties, Management*, Kluwer Academic Publishers, the Netherlands, ISBN 1-4020-1839-8, 2003.
5. Love, Murray, et al, *Utility-Scale Renewable Energy Systems: Spatial and Storage Requirements*, Institute for Integrated Energy Systems, University of Victoria (IESVic) and Love, Murray, "Land Area and Storage Requirements for Wind and Solar Generation to Meet the US Hourly Electrical Demand", *M.A.Sc. Thesis*, University of Victoria, August 2003.

Objectives:

This course will provide the conceptual framework to the students for understanding of complex web of multiple dimensions of environmental issues linked with population and development.

Course Outline:

World Population: current scenario and future trends. Framework for understanding population-environment nexus, population size and environment, population distribution and environment. Population composition and environment, population growth and climate change, population growth and land use change, research need for correlation studies. Poverty-population-environment linkages in the context of migration and urbanization. Population-development nexus: integrating environment and development. Response to demographic crisis: Government responses, Individual attitudes and perceptions, sustainable approach to population stabilization, Population dynamics in Pakistan, Pakistan's Biocapacity, resource consumption & crisis.

Recommended Books:

1. Botkin D. & Keller E., 2000. *Environmental Science: Earth as Living Planet*. 8th ed. John Wiley and Sons
2. Cunningham W.P., & Saigo, B.W., 2001. *Environmental Science*, 6th Ed. McGraw-Hill.

E-11**ENVIRONMENTAL BIOTECHNOLOGY 3 (2-1)****Objectives:**

This course will provide sound technical foundation for using biotechnology in solving environmental issues and cleanup of the polluted environments. After completion of this course, students will be able to understand the significance, and application of biotechnology in the environment.

Course Outline:

Introduction to biotechnology, tools of environmental biotechnology, fundamentals of biological interventions, Recombinant DNA Technology, Genetic manipulations, GMOs: Release and Regulations, environmental applications of GMOs, biosafety concerns of GMOs, bio-strategies for pollution control, bioremediation, phytoremediation, biofilm, Biomarkers, Biosensor, Bioreactors. Ethic and legal problems in creations and use of transgenic organisms.

Lab Work:

Introduction to basic molecular techniques; Isolation, purification and preservation of DNA, Recombinant DNA technology, PCR. Gel Electrophoresis, DNA measurement through spectrophotometer.

Recommended Books:

1. *Environmental Biotechnology: Concepts and Applications*, Hans-Joachim, J. and Josef, W. (ed.). Wiley-VCH Verlag, Germany, 2005.
2. *Biotechnology*, Smith, J.E., 5thEd. Cambridge University Press, New York, USA, 2009.

3. *National Biosafety Guidelines*. National Biotechnology Commission, Government of Pakistan. 2005.
4. *Environmental Biotechnology: Theory and Application*. Gareth M. Evans and Judith C. Furlong. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England, 2003.
5. *Environmental Microbiology*. 2nd Edition. 2010. Edited by Ralph Mitchell and Ji-Dong Gu. John Wiley & Sons, Inc., Hoboken, New Jersey
6. *Genetically Engineered Organisms: Assessing Environmental and Human Health Effects*. 2002. Edited by Deborah K. Letourneau and Beth Elpern Burrows. CRC Press, USA

E-12

WETLAND MANAGEMENT

3(3-0)

Objectives:

The course will be helpful to understand the ecological structure and functions of wetlands, significance of wetlands, sustainable use of wetlands, and know how to write a conservation and management plan for wetland.

Course Outline:

Introduction to wetland ecosystem, wetland communities, wetland classification and inventory, wetland values, functions, and evaluation. Identification of important flora and fauna and its role within the wetlands. Ecosystem approach to wetland management. Participatory approach to wetland management. Government regulations and policies on wetland, formulation of wetland management plans for Pakistan.

Recommended Books:

1. William J. M. and James G. G. (2007). *Wetlands*. USA.
2. Falconer R A and Goodwin, P. (1994). *Wetland Management*. United Kingdom
3. Mary, E.K., Roberts, P.B., Staphanie, F.G., Cindy, C.H., Arthur, D.S. and Jean, C.F. (1992). *Wetlands: An approach to improving decision making in wetland restoration and creation*. USA
4. Hammer, D.A. (1992). *Creating freshwater wetlands*. Chelsea, Michigan.

E-13

WILDLIFE AND FOREST CONSERVATION

3(3-0)

Objectives:

This course will make the students familiar with the concepts of wildlife and forest management practices. It further aims to introduce factors that lead towards loss of wildlife and forest resources and its consequences on ecosystems.

Course Outline:

Philosophy and concepts in wildlife management. Biological, scientific, commercial, recreational, philosophical, educational, ethical, social values of wildlife and forests. Variety of wildlife, abundance, evolution, ecological niches, competition and population dynamics. National parks, wildlife sanctuaries and game reserves of Pakistan. Impact of human population on habitat degradation and fragmentation. Effect of pollution and overgrazing on wildlife and forest resources. Role of databases in wildlife management. Wildlife and habitat measurements: indices of ecological density, data collection and analyses for wildlife management. Forests: their ecological and economic importance, factors affecting forest growth and management. Status of forests in Pakistan, their types, distribution, management, deforestation and its control. Participatory forest management. Sustainable forest management. Rangeland management as mitigating measure to resolve human wildlife conflicts.

Recommended Books:

1. Bailey, J. A. 1998. Principals of Wildlife Management. John-Wiley and Sons, New York, USA.
2. Hosetti, B.B. 2005. Concepts in Wildlife management. Daya Publishing House, New Delhi, India.
3. Sinclair, A. R. E., J. M. Fryxell and G. Caughley. 2006. Wildlife Ecology, Conservation and Management. 2nd Ed. Blackwell Publishing, New York, USA.

E-14**ALTERNATIVE ENERGY SOURCES 3(3-0)****Objectives:**

The overarching aim of this graduate course is to enable the students to learn how the energy scenario is building globally in the context of environmental and economic concerns. The specific objectives are to enable the students to:

- gain knowledge of the dynamics of energy in the environment
- learn about skills and techniques of obtaining energy from various sources
- develop attitude for using energy from alternative sources with efficiency

Course Outline:

Matter and energy in nature; flow of energy in nature in ecosystem, Carbon cycle in nature, energy efficiency in nature. Fossil fuels and their environmental effects; Greenhouse effect and acid rain etc. Renewable energy principles; 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-hydroelectric plants; Wind power; Concept and Principles, evaluating potential to use this resource, 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. Role of energy in Green Economy

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. Cassedy, E.D., 2002. *Prospects for Sustainable Energy: A Critical Assessment*. Cambridge University Press.
4. Trivedi, P.R. and Raj, Gurdeep., 1992. *Environmental Energy Resources*. Akashdeep Publishing, New Delhi.

E-15

REMOTE SENSING AND GIS

3 (2-1)

Objectives:

The main objectives of the RS & GIS are to maximize the efficiency of decision making and planning, provide efficient means for data distribution and handling, eradication of the duplicated data, integration of information from many sources. Remote sensing (RS) Geographical Information System (GIS) and had been one of the key subprojects envisaged in the National Information System. The attempts of a digital description of that world create a computerized GIS which is usually a partial description of the world in relation with some feature tasks.

Course Outline:

Review of Basic Remote Sensing, Electromagnetic Spectrum. History and data collection, advantages and limitations of Remote Sensing process. Energy Sources, energy matter interaction in the atmosphere. Aerial photography, history and platforms. Active and Passive remote sensing. Remote sensing of vegetation and landscape. Introduction to Photogrammetry, Satellite Imageries, Image Processing: Image enhancement, Histogram, stretching, colour palettes, Contrast enhancement, Linear Stretch , Histogram equalization, Interpretation, visual interpretation, Preparation of thematic maps.

Review of Geographic Information System(GIS). Integration with other technologies and its importance.Data acquisition, analysis and output. Types of data used in GIS. Cartography, map projection and coordinate systems. 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.

Lab Work:

Review of Image processing and GIS software. Conversion of raster to vector data. Demonstration of GPS operations, Interpretation of satellite images for different application, Ground Truthing. Thematic Maps Generation, Preparation of GIS Maps for different utilities.

Recommended Books:

1. Remote Sensing and Image Interpretation. Thomas Lillesand (Author), Ralph W. Kiefer (Author), Jonathan Chipman Wiley; 6 edition (2007)
2. Fundamentals of remote sensing and airphoto interpretation *Prentice Hall series in geographic information science* Authors Thomas Eugene Avery, Graydon Lennis Berlin Edition 5, 2009 ISBN0023050357
3. *A Primer of GIS-fundamentals Geographic and Cartographic Concepts.* Harvey, F. Guilford Press, New York, 2009.
4. *Dynamic Earth Environmental Remote Sensing Observations from shuttle Mission.* Lulla, K and L. V. Dess inov. John Wiley and Sons. Inc. 2000.
5. *Introduction to GIS.* Campbell. McGraw-Hill Education. 2008.
6. *Remote Sensing of the environment: An Earth perspective.* Jensen, R. Pearsons Education, Inc. 2000.

E-16

ENVIRONMENTAL RISK ASSESSMENTS AND MANAGEMENT 3(2-1)

Objectives:

The course aims to review the forms of hazards and their associated risks, define the elements of risk assessment and describe the types of information needed for each element of risk assessment, describe the ways to risk identification, estimation of magnitude of the potential risks and illustrate different approaches of exposure assessment, explain the principles of risk management and control strategies and outline the approaches to managing the environmental emergencies.

Course Outline:

Environmental risk assessment and management; the what's, whys and how's- a historical perspective: Risk assessment to human health from chemicals in the environment. Risk assessment to ecological systems from chemicals, from biological introductions (excluding genetically modified organisms). 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. Hazard identification, dose and exposure assessment, risk quantification, Epidemiology and environmental risk assessment.

Risk assessment in legislation: Application of risk assessment in policy and legislation in developed and 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.

Lab Work:

The practical exercises will be based on following aspects and will involve site visit.

1. Pollution risk assessment and management by tools and checks.
 - a. Primary protection standards.
 - b. Emission standards.
 - c. Environmental standards in an industrial setup.
2. To study the cause, nature and frequency of chemical accidents in two industries e.g., tanneries and sports industries involving comparison of accident data base.
3. Site visits for ecological risk assessment e.g., habitat survey and study of flora and fauna in certain areas (industrial, agricultural and urban setups).
4. Questionnaires design and epidemiological studies for risk assessment and formation of recommendations for risk management in industrial, agricultural, rural and urban setups.

Recommended Books:

1. *Environmental Risk Analysis*. (2001). Larche, I. and Paleologos, E. K. McGraw-Hill NY, USA.
2. *Occupational Health Hazards and Remedies*. (2002). Mohapatra, R. Jaypee Brothers Medical Publishers Pvt. Ltd., India.
3. *Biosafety Management: Principles and Applications*. (2000). Tarynor, P. L. Virginia Polytechnic Institute Publications. USA.
4. *Environmental Risk Evaluation of Polluted Soils*. (2000). Riviere, J. Oxford and IBH Publishing Company Pvt. Ltd. India.
5. *Environmental Hazards: Plants and People*. (2000). Iqbal, M., Srivastava, P. S. and Siddiqi, T. O. CBS Publishers and Distributors, India.

E-17

PRINCIPLES AND APPLICATIONS OF BIOREMEDIATION 3(3-0)

Objectives:

Bioremediation is the study of role of living entities in treatment of contaminated environments. The course will emphasize how bioremediation works and the students will also learn the role of microbes and different enzymes in bioremediation. This course will also help to design different bioremediation strategies.

Course Outline:

Introduction to biodegradation and bioremediation. Types and nature of recalcitrants, xenobiotics. Types and mechanisms of biodegradation and bioremediation. Bioremediation of organic pollutants (hydrocarbons, PCBs, PAHs, halogenated compounds, plastics, dyes, herbicides and pesticides). Bioremediation of heavy metals. Various methods and technologies used for remediation. Role of enzymes in bioremediation. Factors effecting bioremediation. Aerobic and anaerobic degradation pathways of contaminants. Microbial ecology and metabolism. Microbial community dynamics during bioremediation. Molecular strategies used to explore the role of microbes in bioremediation.

Recommended Books:

1. *Environmental Microbiology, 2nd Edition, Mitchell, T., G. J-Dong. John Wiley & Sons, Inc., Hoboken, New Jersey (2010).*
2. *Bioremediation: Applied Microbial Solutions for Real-World Environment Cleanup by Ronald M. Atlas and Jim Philp (2005).*
3. *Environmental Biotechnology. Concepts and Applications. Jordening H.-J., J. Winter. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2005).*
4. *Biodegradation and Bioremediation- Vol 2. Singh and Ajay Springer-Verlang Berlin and Heidelberg GmbH & Co. Kg, Germany (2004).*
5. *Biodegradation and Biocatalysis. Wackett, L. P., C. D Hershberger. ASM Press, American Society for Microbiology, N. W. Washington, DC (2001).*

E-18

SUSTAINABLE AGRICULTURE 3(3-0)

Objectives:

To extend students' knowledge about management of agricultural resources on sustainable basis.

Course Outline:

Concept of sustainable agriculture. Threatened agricultural resources in Pakistan; soil, water and environment. Sustaining soil resources. Organic farming. Soil erosion control. Soil natural amendments; sewage sludge and

other organic wastes. Sustaining water resources. Control of run-off and evaporation losses, reduction of water losses from deep percolation, use of salt tolerant and drought resistant crops and varieties. Reduction of agricultural pollutants. Optimum use of agricultural chemicals, fertilizers. Cropping systems to sustain productivity. Multiple cropping, rotations, N-fixation, mycorrhizae and alternate land uses. Compromise between higher yields and resource conservation. Principles and strategies for designing sustainable farming systems. Site specific technological options for sustainable crop production.

Recommended Books:

1. Shaw, T. 2010. Dryland Farming. Nabu Press, USA
2. Dixit, R.S. 2007. Croppingsystemsresearch. Kalyani Pub. New Dehli.
3. Lichtfouse, E., M. Nanarrete, B. Debacke, and V. Souchere. 2009. Sustainable Agriculture. Springer, The Netherland.
4. Reddy, T.Y. and G.H.S. Reddy. 2002. Principles of Agronomy. 3rd Edition, Kalayani Publishers, New Delhi.
5. DAS, P.C. 2000. Crops and their production technology under different conditions. 1st Edition. Kalyani Publishers. New Delhi.

E-19

HEALTH, SAFETY & ENVIRONMENTAL MANAGEMENT

3(2-1)

Objectives:

The objective of this course to provide orientation to the students on importance of occupational safety, health and environment.

Course Outline:

Health, safety and environment: Hazards; Physical, mechanical, biological, chemical and psychological hazards and stress. Health and environment, Environmental safety, Hazards identification and risk assessment and management process.

Work place environment: Occupational safety and health issues in industries, construction, agriculture and service sectors, Accidents, injuries and workplace fatalities statistics, Occupational safety and health management systems (international and national).

Safety Management: Regulations of health, safety and environment. Internal control and management philosophy, Duties and rights, strategies and goals, Roles and responsibilities of occupational health and safety professionals. Key principles of management and HSE, Measures and models for HSE, Organizational environment, HSE statutes and regulations, Establishing HSE plans, Challenges of health within working environment, external environment and safety, Different tools and instruments.

Culture, Behaviour, Interactions, participation and communication, health surveillance, injury reporting, Emergency response procedures; fires, spills, leaks etc., Preparedness and monitoring of adverse events and follow-ups, Case studies. Work place safety and health: Assessing current practices and promoting change in the profession, Personnel Protective Equipment, Formulation of Standard operating procedures, Human Factors and Ergonomic, Planning, decision making and problem solving.

Recommended Books:

1. Reese, C. D. 2012. *Occupational Health and Safety Management: A Practical Approach*, 2nd ed., CRC Press, Taylor and Francis group. USA 2012
2. English, P. F. 2012. *Safety Performance in a Lean Environment: A Guide to Building Safety into a Process (Occupational Safety & Health Guide Series)*, CRC press. Taylor and Francis group. USA.
3. Salvendy, G. 2012. *Handbook of Human Factors and Ergonomics*. 4th ed., John Willey Inc. New Jersey, USA.
4. Pain, S. W. 2008. *Safety, Health and Environmental Auditing: A Practical Guide*. CRC press. Taylor and Francis group. USA.

E-20

ENERGY AND ENVIRONMENT3(3-0)

Objectives:

The objective of this course is to provide knowledge about the linkages of energy with environment and the importance of renewable energy.

Course Outline:

Forms of energy, Sources of energy and their environmental/health concerns, Non-renewable and renewable sources: fossil fuels, nuclear, solar, wind, hydel, hydel, tidal, waste-to-energy, bio-fuels, thermal, fuel cells, hydrogen as energy carrier etc.; Overview of energy sources in Pakistani perspective; Losses of energy and its conservation; Building, insulation, cooling, lighting etc. materials, hybrid vehicles; Future trends in energy production and conservation.

Recommended Books:

1. *Energy & Environmental Security: A Cooperative Approach in South Asia*. Suba Chandran, D. and Jeganaathan, J. (Eds.). IPCS, New Delhi, India. 2011
2. *Biomass, Energy, and Environment: A Developing Country Perspective from India*. Ravindranath, N. H. and Hall D. O. Oxford University Press, USA. 1995.
3. *Energy: Its Use and the Environment*. Roger A. Hinrichs, Merlin H. Kleinbach. Cengage Learning; 5th edition. 2013.

E-21

CARBON SEQUESTRATION AND ENVIRONMENT³ (3-0)

Objectives:

The course will provide a comprehensive introduction to carbon sequestration and its role in the environmental sustainability.

Course Outline:

Carbon sequestration: Introduction and concepts; Global carbon cycle; Carbon emissions; Carbon capture and storage; Soil organic matter and terrestrial C cycle; Terrestrial biosequestration; Soil enzymes and plants in C sequestration; Role of C sequestration in the climate change mitigation; Factors influencing C accumulation; National and International adaptation and mitigation plans; Carbon foot prints; Carbon offsets; Carbon trading; Carbon credits and clean development mechanisms.

Recommended Books:

1. Carbon capture: Sequestration and storage. Hester, R.E. and R.M. Harrison. Vol 29. RSC Publishing, Cambridge, UK, 2010.
2. Plant litter: Decomposition, humus formation, carbon sequestration. Berg, B. and C. McClaugherty. 2nd Edition. Springer-Verlag, Berlin, Germany, 2008.
3. Climate change and terrestrial C sequestration in Central Asia. R. Lal, M. Suleimenov, P. Doraiswamy, P. Wall and D. Hansen. (Eds) Taylor and Francis, Amsterdam, Netherlands, 2007.

E-22

ADVANCES IN PLANT ECOLOGY

3 (3-0)

Objectives:

This course is designed to update the students about recent developments in plant ecology and physiological modifications with reference to environment, its conservation and management.

Course Outline:

Global aspects of plant ecology. Life history strategies of plants, survival and extinction. Plant population dynamics: Species richness, vegetation dynamics, fine-scale to large-scale dynamics. Leaf Energy Budgets: Effects of Radiation and Temperature. Life Cycles: annuals and perennials, environmental influences and plant adaptations. Biotic Influences: symbiotic associations, pathogenicity, parasitic associations and carnivory. Ecological Biochemistry: allelopathy and defense against herbivores. Plant invasions and its threats of plant diversity. Conservation, management and restoration of threatened plant communities.

Recommended Books:

1. Vegetation Ecology. Ed. Maarel, ED. Blackwell Publishing, Oxford, UK. 2005.
2. Introduction to Plant Population Biology. Silvertown, J. & Charlesworth, D. Blackwell Publishing.Oxford UK. 2005.
3. Plant Physiological Ecology. Hans Lambers, F. Stuart Chapin, Francis Stuart Chapin (III.), Thijs L. Pons, Springer, 2008.
4. Plant Ecology. Shulze, E.D; Beck, E & Muller-Hohenstein, K. Springer, Berlin. 2005.

E-23

BIOLOGICAL CONSERVATION

3(2-1)

Objectives:

The objectives of this course are to develop a thorough understanding among the students about threats to biodiversity and its conservation using *ex-situ* and *in-situ* approaches and laws and policies related to species and habitat conservation.

Course Outline:

Introduction, biological diversity, Global and national biodiversity, Ecological and economic values of biodiversity, Monetizing Economic tools to promote conservation of Biodiversity. Extinction of Species; The process of extinction, Characteristics of declining populations, Influence of humanity on extinction and loss of biodiversity. Protection and restoration of species, habitats and ecosystems; Translocation and reestablishment, The role of ecological restoration in conservation. *In-situ* and *Ex-situ* conservation; Protected areas, their types and role in conservation, Establishment and management of protected areas, *ex-situ* Conservation strategies (The role of botanic gardens, Gene banks and germplasm conservation, Zoological Gardens and Aquaria).Population Management; Maintaining population characteristics, Viable population planning and risk analysis, Field study techniques, Habitat fragmentation. The Role of Institutions and Policymaking in Conservation; Types of institutions and their roles in conservation, Institution and policy challenges for conservation biology, Conservation Legislation. Conservation of biodiversity in Pakistan, problems and solutions.

Recommended Books:

1. A Primer of Conservation Biology. 5th Ed. Sinauer, P.R.B. Associates Inc. Publ. Sunderland. 2012.
2. Conservation Biology: A Primer for South Asia. Orient Blackswan Bawa, K., Primack, S., Oommen, R.B. and Anna, M., 2011. ISBN # : 9788173717246.
3. Essentials of conservation Biology, 5th Ed., Primack, R. B. Sinauer, P.R.B associates Inc. Publishers, Sunderland MA, USA. 2010.
4. Conservation Biology: Foundations, Concepts, Applications. 2nd Ed. Dyke, F.V., Springer, 2010.

E-24

URBAN ECOLOGY

3(3-0)

Objectives:

This course is designed to develop a thorough understanding of the influence of urbanization and urbanized areas on populations, communities, ecosystems and human societies.

Course Outline:

Introduction to urban ecology. Humans as components of urban ecosystems. Global urbanization patterns (past, present, future) and recent trends in Pakistan. Populations and community diversity in the urban environment. Urbanization effects on environmental health. Functions in urban ecosystem: growth, productivity, disease, exotic species and invasive species in urban areas. Landscape signature and urban heat-island effect. Ecological design and sustainable cities. Concept of urban green spaces for people and biodiversity. Urban inequalities and slum area characteristics. Urban health and emerging diseases. Urban land use planning and management in Pakistan.

Recommended Books:

1. *Urban Ecology*. Cambridge University Press, Cambridge. Gaston, K.J. (ed.) 2010.
2. *Applied Urban Ecology*. Wiley-Blackwell, UK. Richter M and U. Weiland (ed.) 2012.
3. *Land-Use Planning for Sustainable Development*, Silberstein, J. and Maser, C., CRC Press LLC. USA, 2000.

E-25

ENVIRONMENTAL EDUCATION

3 (2-1)

Objectives:

The course is designed to impart knowledge and understanding of the environmental education, introduce various concepts of environmental education at different levels, provide guidelines for the design and development of resource materials for environmental education, train and develop skills for teaching and learning in environmental education with reference to environmental issues and to provide the insight of status of environmental education at national, regional and global levels.

Course Outline:

Education: Knowledge, Information, Education and awareness, Skills, Values, Attitude, Behaviour, Beliefs, Norms. Environmental Education: Aims of environmental education, Types of environmental education.

Teaching and learning: Four stages of learning, Teaching learning theories and EE, How people learn, Types of learners, Role of teacher/educator. Teaching-learning approaches: Inductive and deductive approaches, Teaching learning process, Active and passive learning. Curriculum, syllabus, course development for environmental education at various levels.

History and Philosophy of Education: Guiding principles of Environmental Education (EE), Environmental literacy, Citizen Action and responsibilities. Status of Environmental Education: EE at National, regional and global levels, Events that shaped the development of education in Pakistan, Role of Government, NGOs, Educational institutions.

Environmental policy: EE at primary, secondary and at higher levels of education, EE and research.

Teaching Methodologies: Common teaching methods/activities of formal, non-formal and informal EE. Using community resources for Environmental Education. Teaching Environmental Issues in Classroom and in the real world methodologies, Considerations for teaching environmental issues with particular reference to resources, pollution, population, management and enforcement of policies and regulations in Pakistan.

Communication strategies to work in community: Reading, writing, listening and speaking skills. Designing of seminars, workshops, field trips for Environmental Education.

Computer and EE: Use of computer for Environmental Education, Computer literacy, Internet, Websites and Databases etc.

Practical Work:

- Preparation of teaching material: Development of teaching material
- for Environmental Education and Sample lessons for different levels of EE.
- Preparation of resource material (brochures, pamphlets, posters and booklets etc.) to provide information on various environmental issues.
- Field trips and visits to acquire the knowledge on various environmental issues and to develop management strategies.
- Organization and arrangements of events, festivals and exhibits for EE.
- Campaign designing for National, regional and local environmental issues.
- Organization of seminars and special lectures on general environmental management and specific issues.
- Making of documentaries on various environmental issues.
- Preparation of portfolio for EE.

Recommended Books:

1. Arif, R. Status of Environmental Education in Sustainable development Strategies of Pakistan. (Comparative report). NCS. Islamabad.

2. Engleson, D. C. (1994). *A Guide to curriculum planning in Environmental Education*. Wisconsin Department of Public Instruction. USA.
3. Fordham, P. E. (1993) *Informal, non-formal and formal education program.* In: YMCA George Williams College *ICE301 Lifelong Learning Unit 2*, London: YMCA George Williams College.

E-26

LABORATORY MANAGEMENT AND PRACTICES 3 (1+2)

Objectives:

The objectives of this course are to impart skills for sampling techniques and identification of sampling locations where high molecular-mass organic compounds and metals may accumulate, provide understanding about sampling and sample variability in air, water, land, solid and waste analysis, impart skills for the range of the methods needed for subsequent chemical analysis i.e., from classical to instrumental methods including Mass spectrometer, UV/visible spectrophotometer, Infrared spectrometer, NMR, GC-MS, HPLC etc. and train for methods to interpret the result of analysis and quality assurance.

Course Outline:

The environmental issues Reasons for concern, Pollution. The necessity of chemical analysis.

Transport of pollutants in the environment and approaches to their analysis: Sources, dispersal, re-concentration and degradation., Transport and re-concentration of neutral organic compounds; Bio-concentration, Accumulation in sediments, Bio-magnification and Degradation, Transport and re-concentration of, metal ions: Solubilization, Deposition and uptake by organisms and What is safe level, Sampling and sampling variability: Representative sampling, Samples storage and Critical path and critical group.

Water analysis-Major constituents: Sampling, Techniques for analysis of common ions; UV/visible spectrometry, Emission spectrometry (Flame photometry), Ion-chromatography and Examples of uses of other techniques.

Water analysis-Trace pollutants: Organic trace pollutants; Sampling and storage, Extraction techniques for chromatographic analysis, Gas chromatography, Liquid chromatography, immunoassay and Spectrometric methods. Metal ions; Storage of samples, Pre-treatment, Atomic spectrometry, Visible Spectrometry, Anodic stripping voltametry and Examples.

Ultra-trace analysis: Analytical methods; Mass spectrometry detection, Quantification, Gas chromatography and Examples. Quality control and quality assurance.

Lab Work:

1. Extraction of chlorophyll from plant material.
2. Determination of amount of Fe (II) in a given industrial water sample by visible spectrometry.
3. Quantification of lead in industrial wastewater.
4. Determination of total alkalinity due to Carbonate and Bicarbonate ions present in a given sample.
5. Separation of neutral, acidic/basic organic components by using separating funnel.
6. Complex metric titration for the detection of temporary and permanent hardness of water in terms of ppm.
7. Determination of Total Dissolved Solids (TDS), Total Suspended Solids (TSS), pH and Conductivity of industrial effluents.

Recommended Books:

1. Carson, P. and Mumford, C. 2002. *Hazardous Chemical Handbook*. 2nd Ed. Butterworth-Heinmann. Oxford, UK.
2. Patnaik, P. 1997. *Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes*. CRC Press Inc. USA.
3. *Extraction }; Methods for Environmental Analysis*. 1999. John Wiley and Sons Ltd. UK.

E-27**RESTORATION ECOLOGY****3(3-0)****Objectives:**

The objectives of this course are to develop an understanding among the students of the need and approach of ecological restoration at species, population and landscape level and to enable them to apply their knowledge in real world situation.

Course Outline:

The Background; Introduction and Philosophy, Rationale for Restoration. The Ecological Context; A Landscape Perspective, A Species Population Perspective. The Evolutionary Context; A Species Perspective. Manipulation of the Physical Environment; Terrestrial Ecosystems, Wetlands and still waters. Manipulation of the Chemical Environment; Manipulating the Chemical Environment of the Soil, Chemical Treatment of Water and Sediments. Manipulation of the Biota; In Terrestrial Ecosystems, In Aquatic Ecosystems. Monitoring and Evaluation. Restoration in a changing climate. Biological invasions, resilience and restoration. Restoration Policy and Infrastructure; Social and institutional support, Restoration policy in Pakistan and other countries, Case Studies.

Recommended Books:

1. Clewell, A.F. 2013. Ecological Restoration: Principles, Values, and Structure of an Emerging Profession. 2nd Edition. Island Press.
2. Andel, J.V. and J. Aronson (Eds.). 2012. *Restoration Ecology: The New Frontier*. 2nd Edition. Blackwell.
3. Galatowitsch, S.M. 2012. Ecological Restoration. Sinauer Associates.
4. Howell, E.A., Harrington, J.A. and Glass, S.G. 2011. Introduction to Restoration Ecology. Island Press.
5. Perrow, M.R. and A.J. Davy. (Eds.). 2002. *Handbook of Ecological Restoration. Vol. 1. Principles of Restoration*. Cambridge University Press.
6. Perrow, M.R. and A.J. Davy. (Eds.). 2002. *Handbook of Ecological Restoration. Vol. 2. Restoration in Practice*. Cambridge University Press.

E-28

GENDER AND ENVIRONMENT 3 (3-0)

Objective:

The objective of the course to draw linkages of environmental degradation with gender and the role it can play in addressing the environmental degradation.

Course Outline:

Gender and Environment: Concepts, issues and perspectives, Eco feminism, theories related to Eco feminism, Gender, environment and sustainable environment.

Emerging perspectives on gender and environment: Relationship between Woman and Nature, Question of domination of women and nature rooted in patriarchal ideology. Feminist critiques of science and western concepts of development. Relationship of gender division of labor structure and the natural world.

Women in the two-thirds world: environmental degradation and the struggle for survival. The Green Revolution and its impacts on food production. Cash crop production, appropriation and degradation of land. Affect of environmental degradation on the lives of poor women. Women, water, fuel and forest resources. Gender division of labor and environmental impacts on women's work. Women's traditional ecological knowledge. Poverty, survival and women's roles in maintaining the means of sustenance. Dialogues with and within ecological feminism: Women engagement in environmental action, Ecofeminist perspectives on gender and environment, Major weaknesses of ecofeminist theory and practice.

Political action and cultural transformation: Ecofeminist politics, ethics, and spirituality. Issues in cultural transformation and cultural appropriation. Greenham Common, Chipko Movement, Kenya Green Belt Movement, World Women's Congress for a Healthy Planet, Local stories of women and environmental action.

Recommended Books:

1. Nightingale, A. (2006) 'The nature of gender: Work, gender, and environment', *Environment and Planning D: Society and Space* 24: 165–185
2. McIlwaine, C. and K. Datta (2003) 'From feminizing to engendering development', *Gender, Place and Culture* 10: 369–382
3. Rodda, A. (1991) *Women and the Environment*, London: Zed Books
4. Dankelman, Irene. (2003) *Gender, Environment and Sustainable Development*:
5. Varadarajan, "Women and Environment Eco-feminists' perspectives". In *Empowerment of Women and Ecological Development* 2002:445)
6. Kurian, P. (2000) *Engendering the Environment? Gender in the World Bank's Environmental Policies*, Aldershot: Ashgate

E-29

GLOBAL ENVIRONMENTAL POLITICS 3 (3-0)

Objectives:

This course provides a comprehensive approach of Global Environmental Politics. It gives insight in leading international environmental issues and global politics about environment.

Course Outline:

Global environmental politics as a discipline and its historical perspective. Actors and institutions in global environmental politics. Role of states, international organizations, domestic politics and corporations in global environmental issues. Environmental justice movements. Environmental security uncertainty. North-South relations. Participation and citizenship as key factor in shaping global politics. Political ecology, climate change and globalization. Trade in hazardous waste, endangered species and genetically modified foods. International treaties and regional agreements. Trans-boundary disputes and environmental threats. Environmental advocacy at global, regional and local level.

Recommended Books:

1. Kutting, G. 2010. *Global Environmental Politics: Concepts, Theories and Case Studies*. Routledge.
2. Chasek, P. S., D. L. Downie, J. W. Brown, 2010. *Global Environmental Politics, Dilemmas in World Politics Series*, Westview Press,
3. Macmillan, P. 2000. *Understanding Global Environmental Politics*.
4. Elliott, L. M. 1998. *The global politics of the environment*. New York University, pp 311.

E-30

COASTAL ENVIRONMENTAL MANAGEMENT³ (3-0)

Objectives:

To have a better understanding of Coastal Marine and offshore Areas, Marine Ecosystems. Economic significance of coast line. Coastal phenomena, coastal erosion and accretion, Integrated Coastal Zone Management.

Course Outline:

Develop a Clear understanding of Definitions and boundaries of coastal and offshore areas of Pakistan. Coastal ecosystems, Mangroves, Coral reefs, rocky, sandy, muddy shores and biotic communities, Understanding of coastal Physical phenomena that generate potential energy from Tides, Waves, and Ocean Thermal Energy. Significance, Coastal erosion and accretion. Pelagic and Demersal Living Resources and products of natural marine ecosystems. Non Living Marine Resources. Impact of coastal pollution on coastal resources and amenities. Develop integrated coastal management, conservation and sustainable development of resources. The course will be complimented by Assignment and case studies. Students assess the assigned projects of interests for development, conservation of coastal areas, ecosystems and critical habitats.

Recommended Books:

1. Oceanography, An Invitation to Oceanography 2009 by Paul R. Pinet
2. Oceanography, an introduction to the Marine Environment by Peter K. Weyl. 2008
3. Oceanography: A view of the Earth by Grant Gross. 20

E-31

AGROCHEMICALS IN ENVIRONMENT 3(3-0)

Objectives:

Te objective of this course is to demonstrate the negative and positive impact of use of agrochemicals in the short term and in long term.

Course Outline:

Agrochemicals: Fertilizers, pesticides, soil conditioners, hormones, pharmaceuticals (antibiotics) and fumigants; Fate of agrochemicals in the environment: Sorption/desorption, movement, drift, volatilization, availability, leaching and decay; Impact of agrochemicals on public health and environment: Environmental exposure to pesticides; Fertilizer pollution measurement and prediction models; Pest resistance and phyto-toxicity; Safe handling and awareness about agrochemicals; Factors affecting use for agrochemicals and environmental outcomes; Efficient use of agrochemicals; Management practices and strategies to control agrochemical pollution.

Recommended Books:

1. Cheremisinoff, N.P. and P.E. Rosenfeld. 2011. Handbook of Pollution Prevention and Cleaner Production. Best Practices in Agrochemical Industry. Elsevier, Kidlington, UK.
2. Matthews, G.A. 2006. Pesticides: Health, Safety and the Environment. Blackwell Publishers, Malden, MA, USA.
3. Wheeler, W.B. 2005. Pesticides in Agriculture and the Environment. Marcel and Dekker, Inc. New York, USA.
4. Sparks, D.L. 2003. Environmental Soil Chemistry. 2nd Ed. Academic Press, San Diego, CA, USA.

E-32

REMEDIATION STRATEGIES FOR CONTAMINATED ENVIRONMENT

3 (3-0)

Course Outline:

Environmental remediation; Factors affecting remediation efficiency; Evaluating speciation and contaminant availability in polluted environment; Factors affecting contaminant degradation; Remediation strategies: Natural attenuation, Bioremediation and Phytoremediation, Conventional methods, Physical techniques, Chemical Oxidation and other chemical treatments, Photocatalytic processes, Electrochemical techniques, chemical and biological sorption, Integrated approaches for remediation, Application of nano-materials; Social and economic aspects of remediation.

Recommended Books:

1. Ghafoor, A., G. Murtaza, M.Z. Rehman, M. Sabir, H.R. Ahmad and Saifullah. 2012. Environmental Pollution: Types, Sources and Management. Allied Book Centre, Lahore.
2. Sarkar, B. 2002. Heavy Metals in the Environment. Marcel Dekker Inc., New York, USA.
3. Raskin, I. and B.D. Ensley. 2000. Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. John Wiley & Sons Inc. New York, USA.
4. Lens, P., T. Grotenhuis, G. Malina and H. Tabak. 2005. Soil and Sediment Remediation: Mechanisms, Technologies and Applications. IWA Publishing, London, UK.

E 33

TREATMENT & MANAGEMENT OF WASTEWATER

3(3-0)

Course Outline:

The nature and sources of wastewater; Modern wastewater treatment: primary treatment, secondary treatment, tertiary treatment, removal of pathogens by sewage treatment process, removal of organics and inorganics by sewage treatment processes; Oxidation Ponds; Septic tanks; Use of treated

wastewater; Wetland and Aqua culture system; Sludge processing and land application of biosolids; Biofuel production from wastewater.

Recommended Books:

1. Sharma, S.K. and R. Sanghi (eds.). 2012. Wastewater Reuse and Management. Springer, Heidelberg, Germany.
2. Maier, R.M., I.L. Pepper and C.P. Gerba. 2009. Environmental Microbiology. 2ndEd. Academic Press, London, UK.
3. Tchobanoglous, G. F.L. Burton and D.H. Stensel. 2003. Wastewater Engineering: Treatment and Reuse. 4th Ed. McGraw-Hill Inc.
4. APHA. 1998. Standard Methods for Water and Wastewater. American Public Health Association. Washington, DC.

E-34

ENVIRONMENTAL APPLICATION OF NANOMATERIALS

3(3-0)

Course Outline:

Introduction to nanomaterials; Application of nanomaterials in: remediation of polluted soil and water, pollutant sensing and detection, filtration membranes, green chemistry; Nanomaterials as adsorbents; Nanomaterials for groundwater remediation; Use of nanomaterials as antimicrobial agents; Renewable energy and nanotechnology; Eco-toxicological risks associated with nano-materials; Future challenges in nanotechnology.

Recommended Books:

1. *Environmental Nanotechnology: Applications and Impacts of Nanomaterials*. Mark R. Wiesner and Jean-Yves Bottero. The McGraw-Hill Companies. New York, USA. 2007.
(<http://accessengineeringlibrary.com/browse/environmental-nanotechnology-applications-and-impacts-of-nanomaterials>)
2. *Environmental Applications of Nanomaterials Synthesis, Sorbents and Sensors*. Glen E Fryxell and Guozhong Cao. World Scientific. 2007.

E-35

POLYMERS AND THE ENVIRONMENT

3(3-0)

Objectives:

To develop the basic concepts about polymer science physical and chemical properties of polymers, various synthetic procedures involved in polymerization, characterization techniques used to analyze the type of polymers. Usefulness of thermal analytical techniques involved in polymer characterization techniques for stability and durability and to appreciate the applications of polymers in various fields such as industry, medicine, daily life *etc.* This course aims to provide knowledge and understanding of the environmental benefits and hazards of polymeric materials and responsible use plastics with emphasis to importance of degradable and biodegradable polymers.

Course outline:

Introduction to Polymers: Basic definitions and nomenclature; Various Classifications of polymers; Polymerization Processes; Polymerization Techniques; Thermal Analysis of Polymers; Mechanical properties of polymers; Spectroscopic Analysis of Polymers; Impact of Polymers on Environment: Stability of polymers, Resistance to degradation. Air, water, and solid waste pollution caused by polymeric materials. Effect of additives, fillers and stabilizers on the environment; Monitoring of various types of pollution caused by polymeric materials.

Biodegradable Polymer: Photolytic Polymers, Per-oxidisable Polymers, Photo-Polymers, Hydro-biodegradable Polymers; Biodegradable Copolymers and Composites; Agricultural Applications of Environmentally Degradable Polymers; Technical Advantages of Degradable Mulching Films; Economics of Degradable Mulching Films; Soil Sterilization, Agricultural Packaging; Bio-assimilation of Photo-biodegradable Plastics; Eco toxicological Aspects in the Biodegradation Process of Polymers, Management of Polymer Wastes: The Polymer Waste Problem; Legislation; Disposing of Post-consumer Plastics; Life-cycle Assessment; Air Pollution, Water Pollution, Waste Production, Mechanical Recycling; Reprocessing of Mixed Plastics Wastes, Energy Recovery by Incineration; Liquid Fuel and Feedstock Recovery; Management of Urban Waste; Biodegradable Plastics in Integrated Waste Management; Degradable Plastics: Sewage, Compost, Litter. Management of Polymer Wastes in Pakistan; Polymer Industry in Pakistan.

Recommended Books:

1. *Charles E. Carraher Jr.*, Polymer Chemistry-An Introduction, latest Edition. Marcel Dekket. Inc.
2. Robert J.Young, *Introduction to Polymers*, Chapman Hall Ltd.NY 1981.
3. Fred W. Billmeyer,Jr. *Textbook of Polymer Science*, Wiley-Interscience,John Wiley and Sons.
4. Gerald Scott., *Polymers and the Environment*, Royal Society of Chemistry, UK 1999.
5. Catia Bastioli, Editor, *Handbook of Biodegradable Polymers*, Rapra Technology. Ltd, UK. 2000.

**COMPULSORY COURSES IN ENGLISH FOR BS
(4 YEAR) IN BASIC & SOCIAL SCIENCES**

English I (Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents:

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening

To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books:

1. **Functional English**
 - a) Grammar
 1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492

2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506
- b) Writing
 1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
 - c) Reading/Comprehension
 1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.
 - d) Speaking

English II (Communication Skills)

Objectives:

Enable the students to meet their real life communication needs.

Course Contents:

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

CV and job application

Translation skills

Urdu to English

Study skills

Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills

Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books:

Communication Skills

- a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
- b) Writing
1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
 2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
- c) Reading
1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
 2. Reading and Study Skills by John Langan
 3. Study Skills by Richard York.

English III (Technical Writing and Presentation Skills)

Objectives:

Enhance language skills and develop critical thinking

Course Contents

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books:

Technical Writing and Presentation Skills

- a) Essay Writing and Academic Writing
 1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
 2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
 3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
- b) Presentation Skills
- c) Reading

The Mercury Reader. A Custom Publication. Compiled by northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharon. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Pakistan Studies (Compulsory)

Introduction/Objectives:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline:

1. Historical Perspective

- a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
- b. Factors leading to Muslim separatism
- c. People and Land
 - i. Indus Civilization
 - ii. Muslim advent
 - iii. Location and geo-physical features.

2. Government and Politics in Pakistan

Political and constitutional phases:

- a. 1947-58
- b. 1958-71
- c. 1971-77
- d. 1977-88
- e. 1988-99
- f. 1999 onward

3. Contemporary Pakistan

- a. Economic institutions and issues
- b. Society and social structure
- c. Ethnicity
- d. Foreign policy of Pakistan and challenges
- e. Futuristic outlook of Pakistan

Recommended Books:

1. Burki, Shahid Javed. *State & Society in Pakistan*, The MacMillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy*. Karachi: OxfordUniversity Press, 2000.
3. S.M. Burke and Lawrence Ziring. *Pakistan's Foreign policy: An Historical analysis*. Karachi: OxfordUniversity Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development*. Lahore, 1994.

5. Wilcox, Wayne. *The Emergence of Bangladesh.*, Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno -National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.*Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.*Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, *Pakistan Under Martial Law*, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.*Islamabad: National Commission on Historical and Cultural Research, 1993.

**ISLAMIC STUDIES
(Compulsory)**

Objectives:

Cr: 2

This course is aimed at:

- 1 To provide Basic information about Islamic Studies
- 2 To enhance understanding of the students regarding Islamic Civilization
- 3 To improve Students skill to perform prayers and other worships
- 4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses:

Introduction to Quranic Studies

- 1) Basic Concepts of Quran
- 2) History of Quran
- 3) Uloom-ul -Quran

Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
- 2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- 3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- 4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- 5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
- 2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
- 3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

- 1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
- 2) Life of Holy Prophet (S.A.W) in Makkah
- 3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

- 1) Life of Holy Prophet (S.A.W) in Madina
- 2) Important Events of Life Holy Prophet in Madina
- 3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To Sunnah

- 1) Basic Concepts of Hadith

- 2) History of Hadith
- 3) Kinds of Hadith
- 4) Uloom –ul-Hadith
- 5) Sunnah & Hadith
- 6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

- 1) Basic Concepts of Islamic Law & Jurisprudence
- 2) History & Importance of Islamic Law & Jurisprudence
- 3) Sources of Islamic Law & Jurisprudence
- 4) Nature of Differences in Islamic Law
- 5) Islam and Sectarianism

Islamic Culture & Civilization

- 1) Basic Concepts of Islamic Culture & Civilization
- 2) Historical Development of Islamic Culture & Civilization
- 3) Characteristics of Islamic Culture & Civilization
- 4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

- 1) Basic Concepts of Islam & Science
- 2) Contributions of Muslims in the Development of Science
- 3) Quran & Science

Islamic Economic System

- 1) Basic Concepts of Islamic Economic System
- 2) Means of Distribution of wealth in Islamic Economics
- 3) Islamic Concept of Riba
- 4) Islamic Ways of Trade & Commerce

Political System of Islam

- 1) Basic Concepts of Islamic Political System
- 2) Islamic Concept of Sovereignty
- 3) Basic Institutions of Govt. in Islam

Islamic History

- 1) Period of Khlaft-E-Rashida
- 2) Period of Ummayyads
- 3) Period of Abbasids

Social System of Islam

- 1) Basic Concepts of Social System of Islam
- 2) Elements of Family
- 3) Ethical Values of Islam

Reference Books:

- 1) Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
- 2) Hameed ullah Muhammad, "Muslim Conduct of State"
- 3) Hameed ullah Muhammad, 'Introduction to Islam
- 4) Mulana Muhammad Yousaf Islahi,"
- 5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
- 6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
- 7) Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
- 8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
- 9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" AllamaIqbal Open University, Islamabad (2001)

Statistics-I**Credit 3 (2-1)**

Definition and importance of Statistics in Agriculture, Data Different types of data and variables

Classification and Tabulation of data, Frequency distribution stem-and-Leaf diagram, Graphical representation of data Histogram, frequency polygon, frequency curve.

Measure of Central tendency, Definition and calculation of Arithmetic mean, Geometric mean, Harmonic mean, Median quantiles and Mode in grouped and ungrouped data.

Measure of Dispersion, Definition and Calculation of Range, quartile deviation, Mean deviation, Standard deviation and variance, coefficient of variation.

Practical:

- a. Frequency Distribution
- b. Stem-and-Leaf diagram
- c. Various types of Graphs
- d. Mean, Geometric mean Harmonic Mean,
- e. Median, Quartiles Deviation, mean Deviation.
- f. Standard Deviation, Variance, Coefficient of variation,
- g. Skewness and kenosis

Recommended Books:

1. Introduction to Statistical Theory Part- I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. A. Concise Course in A. Level Statistic with world examples by J. Crawshaw and J. Chambers (1994)
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomes J. Keans

Statistics-II**Credit 3 (2-1)**

Sampling Probability and non-Probability Sampling, Simple random sampling stratified random sampling Systematic sampling error, Sampling distribution of mean and difference between two means. Interference Theory: Estimation and testing of hypothesis, Type-I and type-II error, Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test, Test of association of attributes using X² (chi-square) Testing hypothesis about variance.

Practical:

- a. Sampling random sampling
- b. Stratified random sampling.
- c. Sampling distribution of mean
- d. Testing of hypotheses regarding population mean
- e. Testing of hypotheses about the difference between population means
- f. Chi-square test
- g. Testing of Correlation Coefficient
- h. Fitting of simple linear regression
- i. One-way ANOVA
- j. Two-way ANOVA

Recommended Books:

1. Introduction to Statistical Theory Part-II by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. Principles and Procedures of Statistics A Bio-meterial approach, 2nd Edition, 1980 by R.G.D Steal and James H. Tarric
4. Statistical Procedures for Agricultural Research 2nd Edition (1980) by K.A. Gomez and A.A. Gomez

Note: One course will be selected from the following four courses of Mathematics.

**COMPULSORY MATHEMATICS
COURSES FOR BS (4 YEAR)**

**(FOR STUDENTS NOT MAJORING IN
MATHEMATICS)**

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level

Credit Hours: 3 + 0

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer’s rule.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression. *Binomial Theorem:* Introduction to mathematical induction, binomial theorem with rational and irrational indices. *Trigonometry:* Fundamentals of trigonometry, trigonometric identities.

Recommended Books:

Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin,

Boston (suggested text)

Kaufmann JE, *College Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston

Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)

Credit Hours: 3 + 0

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities. *Limits and Continuity:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.

Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Recommended Books:

Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York

Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)

Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston

Thomas GB, FinneyAR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

3. MATHEMATICS III (GEOMETRY)

Prerequisite(s): Mathematics II (Calculus)

Credit Hours: 3 + 0

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of geometry to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Geometry in Two Dimensions: Cartesian-coördinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line.

Circle: Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.

Conic Sections: Parabola, ellipse, hyperbola, the general-second-degree equation

Recommended Books:

Abraham S, *Analytic Geometry*, Scott, Freshman and Company, 1969

Kaufmann JE, *College Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston

Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

4. COURSE FOR NON-MATHEMATICS MAJORS IN SOCIAL SCIENCES

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|-------------------------------|--------------------------------|
| <i>Title of subject:</i> | MATHEMATICS |
| <i>Discipline</i> : | BS (Social Sciences). |
| <i>Pre-requisites</i> : | SSC (Metric) level Mathematics |
| <i>Credit Hours</i> : | 03 + 00 |
| <i>Minimum Contact Hours:</i> | 40 |
| <i>Assessment</i> : | written examination; |
| <i>Effective</i> : | 2008 and onward |

Aims : To give the basic knowledge of Mathematics and prepare the students not majoring in mathematics.

Objectives : After completion of this course the student should be able to:

- Understand the use of the essential tools of basic mathematics;
- Apply the concepts and the techniques in their respective disciplines;
- Model the effects non-isothermal problems through different domains;

Contents :

1. *Algebra*: *Preliminaries*: Real and complex numbers, Introduction to sets, set operations, functions, types of functions. *Matrices*: Introduction to matrices, types of matrices, inverse of matrices, determinants, system of linear equations, Cramer's rule. *Quadratic equations*: Solution of quadratic equations, nature of roots of quadratic equations, equations reducible to quadratic equations. *Sequence and Series*: Arithmetic, geometric and harmonic progressions. *Permutation and combinations*: Introduction to permutation and combinations, *Binomial Theorem*: Introduction to binomial theorem. *Trigonometry*:

Fundamentals of trigonometry, trigonometric identities.
Graphs: Graph of straight line, circle and trigonometric functions.

2. *Statistics* : *Introduction*: Meaning and definition of statistics, relationship of statistics with social science, characteristics of statistics, limitations of statistics and main division of statistics. *Frequency distribution*: Organisation of data, array, ungrouped and grouped data, types of frequency series, individual, discrete and continuous series, tally sheet method, graphic presentation of the frequency distribution, bar frequency diagram histogram, frequency polygon, cumulative frequency curve. *Measures of central tendency*: Mean, median and modes, quartiles, deciles and percentiles. *Measures of dispersion*: Range, inter quartile deviation, mean deviation, standard deviation, variance, moments, skewness and kurtosis.

Recommended Books:

1. Swokowski. E. W., '*Fundamentals of Algebra and Trigonometry*', Latest Edition.
2. Kaufmann. J. E., '*College Algebra and Trigonometry*', PWS-Kent Company, Boston, Latest Edition.
3. Walpole, R. E., '*Introduction of Statistics*', Prentice Hall, Latest Edition.
4. Wilcox, R. R., '*Statistics for The Social Sciences*',

Theme 3: Main environmental problems the international community and Pakistan are faced with:

Lecture based element

- x The environment: physical, biological and social aspects: see reference **9**, pp60-63. x Drivers for environmental change: see reference **25**, pp 4-30.
- x Existing and emerging environmental threats: see reference **9**, pp66-68. x Principles for environmental integration: see reference **9**, pp63-66.
- x Environmental integration through assessment tools and instruments: impact assessments; territorial ecosystems assessment, organizational assessment, product and technology assessments: see reference **9**, pp27-31.

Practical element

- x The students should reflect on environmental problems in Pakistan and how they're being aggravated (or not) by human activities: see e.g. reference **14** and reference **29b**.

Theme 4: Legal EIA background and guidance on EIA in Pakistan

Lecture based element

- x EIA in Pakistan: an overview: see reference **19**, chapter 5 and reference **29a**. x Introduce legislation:
 - o Pakistan Environmental Protection Agency (Review of IEE & EIA) Regulations 2000/2001.
 - o Pakistan Environmental Protection Act 1997.
 - o Pakistan Environmental Protection Policy 2005.
- x Introduce Guidelines:
 - o Pakistan Environmental Protection Agency Sectoral Guidelines for EIA 2001.
 - o EIA: Guidelines by the Government of Pakistan 1986.

Practical element

- x For hypothetical projects , the students need to decide on whether EIA was likely to be required, based on existing legal requirements

Theme 5: requirements of international development banks

Lecture based element

- x Presenting world bank and other development bank practices
 - o An overview of practices in international organisations: see reference **26e**
 - o Look at www.worldbank.org for general infos (>countries>South Asia gets you to Pakistan); see also reference **30**

- o Look at EIA activities of the Asian Development Bank: reference 1 Practical element:
- x Students to go to World Bank / Asian Development Bank / international development organisations websites and summarise what they find on EIA (how these institutions are attempting to promote good practice)

Theme 6: Screening and scoping

Lecture based element

- x Introduce types of screening: descriptive or discretionary: see reference 26f.
- x Screening in Pakistan: see reference 19, chapter 5, pp100-101; see also reference 4. x Scoping: what is it? Purpose, objectives, guiding principles: see reference 9, pp1 36-139.
- x Scoping: ways of undertaking it and role of the public; criteria of good practice: see reference 9, pp 140-142.
- x Types of impacts to be identified: see reference 7.
- x Methods and techniques used in screening and scoping: see reference 9, pp158-165. x Scoping in Pakistan: see reference 11.

Practical element:

- x Determine the EIA scope for a hypothetical project in Pakistan (e.g. a road or a factory)

Theme 7: Public participation and consultation in EIA

Lecture based element

- x Explain the key role of public participation and consultation in the EIA process: see reference 27a.
- x Elaborate on the public and public interest: see reference 9, pp1 04-105. x Elaborate on the public and stakeholders: see reference 9, p105.
- x Describe the history and rationale pertaining to EA and public decision making: see reference 9, pp1 05-108.
- x Establish participation and consultation techniques and their suitability for different situations: see reference 9, pp1 08-1 12.
- x Elaborate on trans-boundary considerations and public participation: see reference 23.
- x Elaborate on public participation in Pakistan: see reference 19.

Practical element:

- x Visit a public hearing or conduct a public participation mock exercise with the students.

Theme 8: Consideration of alternatives and mitigation in EIA

Lecture based element: based on reference 12a: x Role of alternatives in EIA.

- x Types of alternatives that can be considered.

- x The 'zero' or 'no action alternative'.
- x Identification of suitable alternatives for use in EIA.
- x Establish the importance of avoidance, mitigation, as well as compensation measures
 - o Introduction the importance of mitigation and key elements: see reference **9**, pp166-169.
 - o Avoiding environmental impacts: see reference **9**, pp169-174.
 - o Remedial action: see reference **9**, p1 74-178.
 - o Criteria for successful implementation: see reference **9**, pp1 78-179.

Practical element

- x Students should develop suitable alternatives for EIA in different sectors (e.g. transport, energy, resource extraction and waste)

Theme 9: EIA reporting and EIA report quality reviews

Lecture based element

- x Explain the importance of EIA review: see reference **9**, p52; see also reference **26g**. x Introduce EIA review packages: see reference **6**; a package suitable for reviewing EIAs in Pakistan should be developed.
- x Introduce some 'real' good practice reports' (should be both, international and national; for international examples, see e.g.
 - o Various international statements based on reference **21**.
 - o US: nearly 4,000 environmental impact statements based on reference **3**.
- x Discuss the various parts of an EIA report and ask students to elaborate on what is written well and what isn't; on the adequacy of EIA reports in Pakistan, see reference **20**.

Practical element:

- x Conduct a quality review of an EIA statement (from Pakistan) and discuss review experiences with the teacher and other students.
- x Stress the importance of writing skills; if possible get somebody in from a social science department who is dealing with 'good writing'.

Theme 10: EIA follow-up, monitoring and auditing

Lecture based element

- x What is EIA follow-up and why is it relevant? see reference **9**, pp1 83-185. x Who is involved in EIA follow-up? see reference **9**, pp85-1 86.
- x When and how do you do EIA follow-up? see reference **9**, pp1 86-189.

- x What are barriers and enabling factors for EIA follow-up and challenges: see reference **9**, pp1 89-192.
- x Explain Pakistani specific technical requirements for e.g. air, water and soil monitoring and auditing (if possible, get a water, soil or other expert in from science / engineering department in)

Practical element:

- x Field visit of a project (possibly one which has previously been covered in e.g. within the EIA report quality review theme) and evaluation of situation after construction: is monitoring in place? Have predicted impacts or unpredicted impacts occurred?

Theme 11: Studying a specific EIA (guest lecture by consultant)

Lecture based element

- x Reporting on positives and negatives, problems and success stories of an EIA

Practical element:

- x Students reflecting on how problems and negatives could have been avoided and positives and successes be enhanced in EIA

Theme 12: Studying a specific EIA (guest lecture by a public servant)

Lecture based element

- x Reporting on positives and negatives, problems and success stories of an EIA

Practical element:

- x Students reflecting on how problems and negatives could have been avoided and positives and successes be enhanced in EIA

Theme 13: EIA effectiveness-what do we need to consider in order to enhance positive and avoid negative effects

Lecture based element

- x Exploring effectiveness terminology and conceptual frameworks: see reference **9**, pp1 22-126.
- x EIA effectiveness criteria: see reference **9**, pp1 26-129.
- x Empirical evidence: see reference **9**, pp1 29-131.
- x How to support effective EIA: see reference **9**, pp131-133.
- x Presenting examples showing the impact of EIA: see reference **8**, pp 6-8.

Practical element:

- x Write a short essay on how EIA is effective in greening decision making and find some Pakistani examples.

Theme 14: SEA part 1: SEA applications to plans and programmes

Lecture based element

- x Introduction to SEA; explain how it differs from EIA: reference **12b**, pp4-5.
- x Potential benefits of SEA: reference **12b**, pp5-6.

- x Principles of SEA and different SEA approaches: see reference **12b**, pp7-11.
- x Introduce a tiered approach to SEA: see reference **9**, pp46-47; see also reference **10**, pp38-40.
- x Present some international plan and programme SEA case studies: see reference **17**, 'recommended SEAs'.

Practical element:

- x Students to write a summary on how SEA differs from EIA.

Theme 15: SEA part 2: SEA application to policies and legislative proposals

Lecture based element

- x Introduce policy level SEA: see reference **22**, pp1-7.
- x Evidence for the effectiveness of SEA at the policy level: see reference **28**
- x Present the specific challenges with applying SEA at policy levels of decision making; the need to consider different policy situations: see reference **22**, pp7-8
- x Case study: Renewable energy policy in Scotland: see reference **2**, pp141-149.

Practical element:

- x Students to reflect on the way in which policy, plans and programmes are prepared in Pakistan and how SEA may fit into existing procedures

Theme 16: Developing EIA and SEA further: Integrated and sustainability assessments

Lecture based element

- x Present the rationale for integrating different aspects in assessment: see reference **15**
- x Reflect on pros and cons of integration: see reference **18**
- x Present real life integrated assessment systems (including sustainability assessments) from throughout the world: see e.g. reference **5**; see also reference **13**

Practical element:

- x Student to give a personal account whether integration is desirable or not
Taking HEC requirements into account, the following three main aspects of assessment are taken into account
- x Students to write a seminar paper compiling the various practical elements as outlined in the curriculum above.
- x Students to give a short presentation on one or two aspects they found particularly intriguing
- x Students to attend a written exam (set by lecturer/ teacher)

References for curriculum

x **Key web-accessible sources**

1. Asian Development Bank 1997. *EIA for developing countries in Asia*, <http://www.adb.org/publications/environmental-impact-assessment-developing-countries-asia>
2. Au E, Lam Kin Che, Zhu T and Partidario M (eds) 2008. *International Experience on SEA*, <http://content.undp.org/go/cms-service/download/publication/?version=live&id=1769784>
3. Catalogue of US Government Publications, http://catalog.gpo.gov/F/?func=find-d-0&local_base=GPO01PUB&clear_level=2
4. Environmental Law Alliance Worldwide. *EIA Country Report for Pakistan*, <http://eialaws.elaw.org/content/pakistan>.
5. European Commission 2009. *Impact Assessment Guidelines*, http://ec.europa.eu/governance/impact/commission_guidelines/docs/iaq_2009_en.pdf
6. European Commission 2001. *Guidance on EIA – EIS Review*, <http://ec.europa.eu/environment/eia/eia-guidelines/g-review-full-text.pdf>.
7. European Commission 1999. *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions*, <http://ec.europa.eu/environment/eia/eia-studies-andreports/guidel.pdf>
8. Fischer T B 2009. On the role(s) of (strategic) environmental assessment in 'greening' decision making, University of Utrecht, 2 March, <http://www.twoeam-eu.net/role.pdf>.
9. Fischer, T. B.; Gazzola, P.; Jha-Thakur, U.; Belcakova, I. and Aschemann, R. (eds) 2008. *Environmental Assessment Lecturers' Handbook*, ROAD Bratislava.
10. Furman E and Hilden M 2001. *Does the influence of SEA / Integrated Assessment Reach Decision Making?*, <http://www.ymparisto.fi/download.asp?contentid=19915>
11. Government of Pakistan 1997. *Guidelines for the Preparation and Review of Environmental Reports*, http://www.environment.gov.pk/eia_pdf/D_rev_enReprt.pdf.
12. Department of Environmental Affairs and Tourism 2004. *Criteria for determining alternatives in EIA*, http://www.environment.gov.za/sites/default/files/docs/series11_criteria_for_determining_alternatives.pdf.
Strategic Environmental Assessment, http://www.environment.gov.za/sites/default/files/docs/series10_strategic_environmental_assessment.pdf.
13. Department of Justice Canada 2006. *Regulatory Impact Analysis Statement*, <http://www.justice.gc.ca/eng/dept-min/pub/legis/rm-mr/part4/rias-reir.html>.
14. Green Living Association. <http://www.greenlivingasc.org/?p=1>.
15. HIA Gateway. *Integrated Impact Assessment*, <http://www.apho.org.uk/resource/view.aspx?RID=48174>.

16. International Association for Impact Assessment (IAIA) 1999. *Principles of Environmental Impact Assessment*.
http://www.iaia.org/publicdocuments/special-publications/Principles%20of%20IA_web.pdf.
17. Levett-Therivel Susta inability Consultants, *Recommended SEAs*,
<http://www.levetttherivel.co.uk/SEA.htm>.
18. Morrison-Saunders, A. und Fischer, T.B. 2006. What is wrong with EIA and SEA anyway? - A Sceptic's Perspective on Susta inability Assessment, *Journal of Environmental Assessment Policy and Management* 8(1): 19-39,
<http://wwwstaff.murdoch.edu.au/~angusms/Publications/sustainabilitydocs/ms-fischer-2006.pdf>.
19. Nadeem O 2010. *Public Participation in Environmental Impact Assessment of Development Projects in Punjab, Pakistan*. PhD thesis, University of Engineering & Technology, Lahore, <http://eprints.hec.gov.pk/4031/>.
20. Nadeem O and Hameed R 2008. A Critical Review of the Adequacy of EIA Reports-Evidence from Pakistan, *International Journal of Social and Human Sciences* (2): 813-820,
<https://www.waset.org/journals/ijhss/v1/v1-1-10.pdf>.
21. Routledge. The Natural and Built Environment Series. Examples of Environmental Impact Statements
http://www.routledge.com/cw/nbe_introduction_to_environmental_impact_assessment/p/web_inks2/.
22. Sadler B 2005 (ed). *SEA at the policy level - recent progress, current status and future prospects*, <http://content.undp.org/go/cms-service/download/publication/?version=live&id=1769978>.
23. UNECE 2006. *Guidance on Public Participation in Environmental Impact Assessment in a Trans-boundary Context*,
<http://www.unece.org/fileadmin/DAM/env/documents/2006/eia/ece.mp.eia.7.pdf>.
24. United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). *Integrating Environmental Considerations into Economic Policy Making Processes, Introduction of EIA*,
http://www.unescap.org/drrpad/vc/orientation/M8_first.htm
25. U N EP 2012 .*Global Environment Outlook*,
http://www.unep.org/geo/pdfs/geo5/GEO5_report_full_en.pdf.
26. United Nations University. EIA Open Educational Research. Environmental Impact Assessment Course Module 1-5 – Key elements of the EIA Process,
http://eia.unu.edu/course/?page_id=101.
Course Module 1-3 – Nature and Scope of Environmental Issues and Impacts,
http://eia.unu.edu/course/?page_id=97.
Course Module 1-2 – Purpose and aims of EIA,
http://eia.unu.edu/course/?page_id=93
Course Module 10-2 - EIA as part of the decision process,

- http://eia.unu.edu/course/?page_id=99.
 Course Module 2-4 – EIA Requirements of International Organizations,
http://eia.unu.edu/course/?page_id=111.
 Course module 4 – Screening, http://eia.unu.edu/course/?page_id=30.
 Course Module 9-4 – Main Steps in the EIA Review,
http://eia.unu.edu/course/?page_id=108.
27. United Nations Environment Programme 2002. *EIA Training Resource Manual*, http://www.unep.ch/etu/publications/EIAMan_2edition.htm.
 Topic 3 – Public Involvement.
http://www.unep.ch/etu/publications/EIA_2ed/EIA_E_top3_body.PDF.
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<http://siteresources.worldbank.org/INTRANETENVIRONMENT/Resources/244351-1222272730742/PolicySEAExecSummary.pdf>.
 29. World Bank 2006. *Pakistan Strategic Country Environmental Assessment*,
<http://siteresources.worldbank.org/SOUTHASIAEXT/Resources/Publications/448813-1188777211460/pakceavolume1.pdf>.
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 30. World Bank 1999. *World Bank Operational Manual – Environmental Assessment* <http://www.env.go.jp/earth/coop/coop/document/10-eiae/10-eiae-7.pdf>.

x **Additional key sources**

- Ali Z, Khan D and Hussain R 2012. Adaptation Measures in EIA and Risks Management: An Overview of the Legal Framework in Pakistan, *TOJSAT : Online Journal of Science and Technology*, 2(3): 1-11.
- Fischer T B 2007 *Theory and Practice of Strategic Environmental Assessment – towards a more systematic approach*, Earthscan, London.
- Nadeem O and Fischer T B 2011. An Evaluation Framework for Effective Public Participation in EIA in Pakistan, *EIA Review*, 31(1): 36-47.
- Nadeem O and Rizwan H 2010. Exploring the Potential and Constraints to Implementing the International Best Practice Principles of EIA Follow-up: The Case of Pakistan, *Journal of American Science*, 6(12): 108-121.
- Richardson T and Cashmore M 2011. Power, knowledge and environmental assessment: the World Bank's pursuit of 'good governance'. *Journal of Political Power* 4(1): 105-125.