UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that the Syndicate at its meeting held on 27-07-2023 has approved the recommendations of the Academic Council made at its meeting dated 24-05-2023 regarding approval of the Revised Syllabi and Courses of Reading for Ph.D. in Environmental Sciences under Semester System at the College of Earth and Environmental Sciences w.e.f. the Academic Session, 2021 and onward.

The Revised Syllabi and Courses of Reading for Ph.D. in Environmental Sciences is attached herewith as Annexure 'A'.

Sd/-
REGISTRAR

Admin. Block,
Quaid-i-Azam Campus,
Lahore.

No. D/ 7673 /Acad. **Dated: 11 - 10 /2023.**

Copy of the above is forwarded to the following for information and further necessary action: -

1. Dean, Faculty of Geo Sciences.
2. Principal, College of Earth and Environmental Sciences.
3. Controller of Examinations
4. Director, IT for placement at the website
5. Admin Officer (Statutes)
6. Secretary to the Vice-Chancellor.
7. PS to the Registrar.
8. Assistant Syllabus.

Assistant Registrar (Academic)
for Registrar

COLLEGE OF EARTH AND ENVIRONMENTAL SCIENCES
UNIVERSITY OF THE PUNJAB, LAHORE.

REVISED COURSES & SYLLABUS
PhD Environmental sciences Degree Program

Program Title: **PhD degree in Environmental Sciences**

Department: **College of Earth and Environmental Sciences**

Faculty: **Geoscience**

The curriculum and courses for PhD in Environmental Sciences were revised in the year 2018 and approved from various statutory bodies of the University of the Punjab. Presently College of Earth and Environmental Sciences revised the courses & syllabi keeping in view the advancements in the field of environmental Sciences and new courses recommend by the Higher Education Commission (HEC) revised in 2018. Most of the courses have been designed according to the latest trends of the subject that can provide an interest to the students and later help them for competing in the job market.

Department Mission

The mission of the College is to groom the students into responsible and honest citizens and skilled professionals trained in their respective fields to serve the nation. Character building and moral training is an integral component of student-teacher relationship. student life in the College provides the students with all possible opportunities to acquire the most dynamic personalities with leadership qualities. Academically excellent and experienced faculty members are involved in teaching and research in the College of Earth and Environmental Sciences (CEES). Classes are regularly held, well supplemented with laboratory work and observations in the field.

1. Introduction

College is presently offering multidisciplinary degree program i.e. BS, M.Sc., MS, M.Phil. and Ph.D. degree programs in the disciplines of Environmental Sciences, Applied Hydrology, Tourism & Hospitality Management, Geomatics and Occupational Health and Safety Management. The purpose of these courses is to produce graduates in these emerging disciplines with the insight and knowledge to serve the nation for attaining environmentally sustainable development in the country Environmental changes, like desertification, silting of dam reservoirs, water logging, salinity and contamination of land as well as surface and groundwater, have created problems related to tourism. Over exploitation of resources has adversely impacted the tourism destinations and we are facing the danger of degradation and destruction of ecological infrastructure that is essential for sustainable

tourism. In Pakistan, as elsewhere in developing countries, environmental degradation is occurring due to heavy industrialization concentrated in narrow zones, especially hospitality industry. Keeping in view the importance and the growing demands for training manpower in the emerging discipline, the CEES has been established in the University of the Punjab in 2005. The new building of the College was completed in November 2008, featuring spacious rooms, moderately equipped laboratories, a library and large grounds.

2. Program Introduction

CEES provides a learning educational environment to students with the opportunities to acquire knowledge and skill to build a successful career and become an integral part of the community. Students will study different aspects of climate change, agro-biodiversity, environmental management, pollution and control, population dynamics, ecosystems, and urbanization. Impart quality education based on knowledge, research, and skill to produce graduates of international calibre who contribute to science and technology, of the country with global perspectives. Teach high ethical and moral standards, develop leadership capabilities, and equip with professionalism for the socio-economic and sustainable development of the society particularly in the industrial hub of Pakistan. The program will also help to produce researchers who can contribute for the betterment of society. excel in the field of environmental sciences.

3. Program Objectives

1. To impart advanced knowledge about major areas of Environmental Sciences.
2. To enable the students to learn data collection, organization and statistical analyses.
3. To augment the capabilities of the students to use various practical techniques of planning and management of resources.
4. To train students to plan and execute studies on local environmental issues.
5. To develop abilities and a keen interest in students to seek higher education in areas relevant to environmental sciences.
6. To equip students with professional and research skills to be demonstrated in teaching, research and environmental management.

4. Market Need / Rationale of the Program

The scope of environmental science is increasing day by day with growing environmental concerns. In the public sector, the jobs have been created at federal, provincial and local government levels. In the Pakistan with the 18th constitutional amendments, the subject of environment has been devolved to provinces and provincial institutions have been setup. With the establishment of local bodies system, the opportunities for environmental graduates will further increase as most of the tasks related to environment have been mandated to local bodies. Currently, all provinces, AJK and Gilgat Baltistan have environmental institutions at district level. In the private sector, all multinational companies have jobs related to environment and now local companies are also hiring environmental graduates. There are opportunities in environmental consulting services, where consultancy services are well rewarded. The UN organizations, World Bank, Asian Development Bank have established

environment sections. Non-governmental organizations in the development and conservation sectors are also hiring environmental graduates.

Generally speaking, environmental issues are considered as cleanliness, planting trees, abating pollution etc., but in reality, the scope of environment is much beyond that. It encompasses the ecological, economic, social, cultural, political and commercial dimensions of consumptions and degradation of environmental resources and at the same time includes the technical, technological, legal, moral and ethical approaches to deal with such inter-sectoral issues at local and global level. Technically speaking environment provides the essential life support services to the planet through dynamic interaction of its resources. The human interventions with the environmental resource dynamics for socio-economic development have created complex problems at local and global level. The knowledge to understand such problems and find different approaches to their solution has also developed. Hence, developing human resources capable of understanding the complex science of life support system is also of vital importance to make the development process environmentally sustainable. Therefore, the discipline of Environmental Science has come up as one of the emerging sciences in the new millennium and there is dire need to generate human resource in this emerging field of increasing significance to fulfill the market need. The core philosophy of Environmental sciences education is to provide management and vocational education and training combined with academic learning and hands-on training.

5. Admission Eligibility Criteria

Before entry into a Ph.D. program, it is the rule of the CEES that students have completed his or her BS/MS/MPhil or equivalent degrees. So far, the different Ph.D. programs are ongoing at the College of Earth and Environmental Sciences, university of the Punjab, Pakistan. In the beginning, the students from the different disciplines were adjusted in the Ph.D. program. However, after 2014 owing to several ongoing disciplines, a barrier was maintained and the students with the related fields were allowed to join the Ph.D. program.

Eligibility: MS / M.Phil. in Environmental Science (02 years) and Clause 24(b), Admission regulations 2018-19, Page (8). The eligibility criteria is given in Table 1.

Table 1. The eligibility criteria for the ongoing Ph.D. program at CEES

Program	**Eligibility criteria**
PhD (Regular Scheme) **ENVIRONMENTAL SCIENCES** **Total Merit Reserved** **10 10 00**	**ELIGIBILITY** (i) MS / M.Phil. in Environmental Sciences and Allied Sciences with 18 year of education or equivalent. (ii) BS in Environmental Sciences and Allied Sciences with 16 year of education or equivalent **Admission Criteria:** Basic **Merit Formula** As per Basic Criteria

The GPA requirement of the ongoing Ph.D. program is consistent with the policy guidelines. Overall, for admission in Ph.D. programs, a minimum CGPA of 3.0 (out of 4.0 in the semester system) or First Division (in the annual system) in the most recent degree obtained is required, whether such was degree obtained from Pakistani or foreign universities.

All applicants to Ph.D. programs are required to take a specific admissions test. When the admissions are announced an advertisement is made in the newspaper and the university portal. Test date is decided, and an official test is conducted. The test is organized with the permission of the HEC and an equivalent test is developed by the university, for admissions to graduate programs. The percentage of test is 40 %. The students who qualify for the test and are fulfilling the basic merit criteria (Shown in Table 1) are called to appear for an interview in the panel of the College of Earth and Environmental Sciences. Based on the eligibility criteria a merit list is established and students are enrolled in the Ph.D. program. Applicants to Ph.D. programs shall be required to fulfill the following testing requirements:

Table 2. The basic merit criteria for admission in the PhD program at CEES

Program	**Merit Criteria**
Ph.D. Environmental Sciences	Basic criteria (40 marks for Academic Qualifications, 40 marks for Entry Test, 10 marks for Interview, 05 marks for Professional Experience and 05 marks for research publication in HEC recognized journals

Sr. No.	**Description**	**Marks**
1	Academic qualifications*	**40**
2	Publications in HEC approved journals/ Exhibitions/ Design Projects (One mark for each publication)	**05**
3	Professional experience in relevant field (one mark for each year for job in the relevant field/as per Departmental preference)	**05**
4	Subject written Entry Test*	**40**
5	Interview*	**10**
	TOTAL	**100**

Note: 50% marks required to be obtained in academic merit i.e. a candidate must obtain at least 20 marks in the academic qualification greater and equal to 19.1 (will be rounded to 20), written test & interview separately for M.Phil/equivalent program. However, for the Ph.D program 50% marks are required to be obtained in academic merit, 70% marks in written test & 50 % marks in the interview separately. (The candidate must obtain greater or equal to 19.1 out of 40 marks in academic merit to be eligible for taking the written departmental test).

As part of the application for admission to Ph.D. programs, applicants are informed to submit a statement of purpose at the time of application. Those who qualify for the admission test are also required to bring a statement of purpose and a brief research proposal at the time of the interview. The admissions committee/interview panel uses the information provided to ascertain the preparedness and interest of the candidate in pursuing doctoral studies, and whether the department has the requisite resources to train and supervise the doctoral candidate in the subspecialty he or she is interested in.

6. Duration of the Program

The CEES is following the HEC guidelines and PhD degree is awarded by the university after a minimum of three (3) years period. The general timeline followed by the CEES is three to five years. Number of courses taught in PhD Environmental sciences degree program will be 6 with each course having 3 credit hours. A total of 9 credit hours of course are taught in each semester (3 credit hours of core course and 6 credit hours of elective courses). After successful completion of course work, students' haves to appear in the comprehensive exam before the start of their PhD research work.

The college designated competent authority (DDPC) to determine whether the delay is caused by circumstances beyond the student's control and if so, grant an extension for two in such exceptional circumstances. The date of notification of the award of the Ph.D. degree after the Ph.D. defense is considered to be the date of the completion of Ph.D. studies.

7. Categorization of Courses as per HEC Recommendation and Difference

Semester	Courses	Category(Credit Hours)					
		Core Courses	Basic Courses	Major Electives	Minor Electives	Any Other	Semester Load
1	3	3	--	6	--	--	**9**
2	3	3	--	6	--	--	**9**
PU	**06**	**06**	**--**	**12**	**--**	**--**	**18**
HEC Guidelines	**--**	**--**	**--**	**--**	**--**	**--**	**18**
Difference (HEC &) PU	**NIL**	**NIL**	**NIL**	**NIL**	**NIL**	**NIL**	**NIL**

**Core: Compulsory, Basic: Foundation, Major Electives: Professional Minor Electives: Specialization*

Note: The course/column heads are customizable according to nature and level of the program.

8. Scheme of Studies / Semester-wise workload

Presently College of Earth and Environmental Sciences revised the courses & syllabi keeping in view the advancements in the field of environmental Sciences and new courses recommended by the Higher Education Commission (HEC). Most of the courses have been designed according to the latest trends of the subject that can provide an interest to the students and later help them for competing in the job market. The students can select the courses according to their interests and research directions to fulfill the requirement. The detailed core and elective courses are given in the table below.

Sr. #	Code	Course Title	Course Type	Prerequisite	Credit hrs
SEMESTER I					
1.	ENSC-701	Advances in Environmental Research	Core Course	MS / M.Phil. Environmental sciences/ Equivalent	03
2.	ENSC-702	Bioremediation	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
3.	ENSC-703	Green Chemistry	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
4.	ENSC-704	Sustainable Energy Conservation	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
5	ENSC-705	Disaster Risk Management	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
6	ENSC-706	Mining and Management of Radioactive Material	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
7	ENSC-707	Water Resources, Sustainability and Modeling	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
8	ENSC-708	Toxic Organics in Environment	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
9	ENSC-709	Composting Science and Technology	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
10	ENSC-710	Advanced Approaches in Water Conservation	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
11	ENSC-711	Sustainable Urban Planning & Management	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
12	ENSC-712	Environmental Biogeography	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
SEMESTER 2					
1.	ENSC-713	Global Warming and Climate Change	Core Course	MS / M.Phil. Environmental sciences/ Equivalent	03
2.	ENSC-714	Global Environmental Politics	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
3.	ENSC-715	Environmental Applications of Nano Materials	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
4.	ENSC-716	Agrochemicals in Environment	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03

Sr. #	Code	Course Title	Course Type	Prerequisite	Credit hrs
5	ENSC-717	Environmental Education	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
6	ENSC-718	Remote Sensing and GIS	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	02+01
7	ENSC-719	Environmental Issues Related to Petroleum Industry	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
8	ENSC-720	New Developments in Wastewater Treatment	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
9	ENSC-721	Hazardous Solid Waste Management	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
10	ENSC-722	Urban Green Space System	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
11	ENSC-723	Strategic Environmental Assessment	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03
12	ENSC-724	Freshwater Ecology	Elective Course	MS / M.Phil. Environmental sciences/ Equivalent	03

1. *Type of course may be core (compulsory), basic (foundation), major elective (professional), minor elective (specialization) etc.*

Research Thesis / Project /Internship

The College of Earth and Environmental Sciences is following the HEC guidelines. Besides course work, each Ph.D. researcher is required to write a doctoral dissertation that meets the HEC defined criteria. The Ph.D. dissertation is supervised by a faculty member who holds a Ph.D. (or equivalent) degree and is an HEC approved supervisor. Furthermore, at the time of appointment as supervisor, the faculty member is a full-time faculty member of the University of Punjab in which the student is enrolled. The Ph.D. thesis is evaluated by the committee member and by at least two external experts. The external reviewers are Ph.D. experts from academically advanced countries. A plagiarism test following the HEC's Plagiarism Policy is conducted on the dissertation before its submission to the external experts. Further an open defence is organized by the review committee to evaluate and approve the dissertation.

9. Award of Degree

Degree awarding criteria stating:

- As a requirement, the 18 credit hours are offered in the first year of the doctoral degree. Each student is required to achieve 3 CGPA in the course work.
- According to university policy and HEC guidelines following the completion of coursework, every Ph.D. student is required to pass a comprehensive examination to be granted candidacy as Ph.D. researcher; provided that if the student fails to pass the comprehensive test, he or she shall be allowed one more attempt to take the test.
- After qualifying for the comprehensive examination, the student is officially allowed to start the research and DPCC evaluates the projects and refers to the advanced research board.

- Each Ph.D. researcher is required to write a doctoral dissertation that meets the HEC defined criteria. The Ph.D. dissertation is supervised by a full-time faculty member who holds a Ph.D. (or equivalent) degree and is an HEC approved supervisor. The Ph.D. thesis is evaluated by the committee member and by at least two external experts. Further, a plagiarism test following the HEC's Plagiarism Policy is conducted on the dissertation before its submission to the external experts. An open defence of the dissertation is required after a positive evaluation of the dissertation by the committee members.
- According to university and HEC guidelines, each Ph.D. researcher is required to publish at least one research paper as the first author during his or her doctoral studies in an HEC approved Y category (or above) journal for the award of Ph.D. degree.

10. NOC from Professional Councils

The ongoing Ph.D. program in Environmental Sciences at the College of Earth and Environmental Sciences is consistent with the university regulations and HEC guidelines. Since the program is launched in 2005, and NOC is not the requirement of the ongoing Ph.D. program.

11. Faculty Strength

Degree	Teachers	Area/Specialization	Total
PhD	1. Prof. Dr. Sajid Rashid Ahmad	Earth and Environmental Sciences, Climate Change, Remote Sensing & GIS	**15**
	2. Prof. Dr. Irfan Ahmed Shaikh	Water and Wastewater Treatment	
	3. Dr. Nadia Jamil	Analytical / Environmental Chemistry	
	4. Dr. Abdul Qadir	Environmental Biology, Plastic Pollution and Climate Change	
	5. Dr. Yumna Sadef	Environmental Sciences	
	6. Dr. Muhammad Kamran	Eco Tourism	
	7. Dr. Muzaffar Majid Ch.	Environmental Geology	
	8. Dr. Azhar Ali	Water and Wastewater Treatment, Health & Safety	
	9. Dr. Sana Ashraf	Biotechnology Bioremediation and Env. Microbiology	
	10. Dr. Muhammad Bilal Shakoor	Environmental Toxicology	
	11. Dr. Naeem Akhtar Abbasi	Water and Wastewater Treatment and Quality Assessment	
	12. Dr. Mehvish Mumtaz	Environmental Engineering / Toxicology	
	13. Dr. Rizwan Aziz	Hydrology and Water Resources Management	
	14. Dr. Muhammad Awais	Hydrology and Water Resources Management	
	15. Dr. Muhammad Asif Javed	GIS & Remote Sensing	
		TOTAL	**15**

12. Present Student Teacher Ratio in the Department

49:10 **1:5**

COURSE OUTLINES SEPARATELY FOR EACH COURSE

FIRST SEMESTER

Sr. #	Code	Course Title	Course Type	Prerequisite	Credit hours
SEMESTER I					
1.	ENSC-701	Advances in Environmental Research	Core Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
2.	ENSC-702	Bioremediation	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
3.	ENSC-703	Green Chemistry	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
4.	ENSC-704	Sustainable Energy Conservation	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
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10	ENSC-710	Advanced Approaches in Water Conservation	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
11	ENSC-711	Sustainable Urban Planning & Management	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
12	ENSC-712	Environmental Biogeography	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03

ENSC-701: ADVANCES IN ENVIRONMENTAL RESEARCH (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

The students will be able to

- Have basic knowledge about research methods and its importance.
- Formulate the research problem and draft the research plan.
- Learn about data collection techniques.
- Analyze data, interpret data by using data analysis and modeling techniques.
- Have the skill to communicate results in the form of paper, presentation, or scientific report.

CONTENTS

Unit 1 Research – Objectives and Process

1.1 Introduction
1.2 Research Objectives
1.3 Types of Research
1.4 Research Process and Research Output
1.5 Phases in Research
1.6 Need for Research Methodology and innovation
1.7 Research Ethics and Integrity
1.8 Critical appraisal

Unit 2 Formulation of Research Problems/Question

2.1 Nature of Research Problems
2.2 Choice of Problem Area
2.3 Critical Thinking, developing the research question,
2.4 formulation of research problems
2.5 Illustrations of Problems
2.6 Concretizing Problem Formulation and choosing research topic

Unit 3 Research Design/Research proposal development

3.1 Introduction
3.2 Choice of Variables and Need for Data
3.3 Mechanisms and design for Data Collection
3.4 Formulating and testing hypothesis
3.5 Quality of Measurements, and ethical considerations
3.6 Research Project Conceptualization
3.7 Research Proposal its elements and Writing Techniques

Unit 4 Formulation of Experimental design

4.1 Valid experimental design and its basic requirements
4.2 Types and Objectives of Experiments
4.3 Classification of experimental design (Factorial design, randomized block design, covariance design, Quasi experimental design)
4.4 Experimental design and use of indicators in research
4.5 Formulation of experimental design its reliability, validity, and generalization

Unit 5 Collection of data

5.1 Techniques in data collection: (Quantitative & Qualitative Data)
5.2 Collection of Primary and Secondary Data
5.3 Data integration
5.4 Sample Surveys/ Planning of Sample Surveys/ Types of surveys/ Survey Data Quality
5.5 Questionnaires/scaling of Responses
5.6 Interviews

Unit 6 Data analysis and interpretation

6.1 Introduction to data Analysis/ Data Interpretation
6.2 Descriptive statistics
6.3 Analysis of variance/ Univariate Analysis, Bivariate Analysis,
6.4 Correlation/ regression
6.5 Principal-Component Analysis
6.6 Factor Analysis and Cluster Analysis
6.7 Discrimination and Classification

Unit 7 Multivariate analysis for Data analysis

7.1 Models and modeling
7.2 The need for models
7.3 Types of models
7.4 Analysis of dynamic data

Unit 8 Validation and Communication of Research Findings

8.1 Communication of research findings
8.2 Preparing a research paper/report
8.3 Points to remember in paper preparation
8.4 Research presentation techniques

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment during the semester covering: classroom participation, attendance, assignments and presentation, homework, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	At the end of the semester, it is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED BOOKS / SUGGESTED READINGS

1. Mukherjee, S. P. (2019). *A guide to research methodology: An overview of research problems, tasks and methods.* CRC Press.
2. Tjora, A., (2018). *Qualitative Research as Stepwise-Deductive Induction*. Routledge Publisher.
3. Bartels, K.P.R. & Wittmayer, J.M. (2018). *Action Research in Policy Analysis: Critical and Relational Approaches to Sustainability Transitions*. Routledge Publisher.
4. Alley, M. (2018). *The Craft of Scientific Writing*. Springer-Verlag. New York.
5. Smith, R.L., Nychka, D., Waller, L.A. & Schmidt, A. (2018). *Applied Environmental Statistics*. CRC Press, Taylor & Francis Group
6. Creswell, J. W. (2018). *Research design: Qualitative, quantitative and mixed methods approaches*. 5th Ed. Thousand Oaks, CA: Sage,
7. Walliman, N. (2010). *Research methods: The basics*. Routledge
8. Fowler Jr, F. J. (2013). *Survey research methods*. Sage publications.

Further Reading: As suggested by the Instructor

ENSC-702: BIOREMEDIATION (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

The students will be able to

- understand about bioremediation techniques
- learn about advantages of bioremediation process
- learn about applications of bioremediation to reclaim polluted environment
- learn how to optimize the environmental conditions to execute the bioremediation process

CONTENTS

Unit 1 Introduction to Bioremediation

1.1 Introduction to bioremediation and biodegradation,
1.2 Sources of contamination and their degradation process
1.3 Identification of source and type of pollution
1.4 Bioremediation of organic, Inorganic, and metal contaminants
1.5 Application of Bioremediation Technologies

Unit 2 Bioremediation Process

2.1 Bioremediation processes in natural and artificial environment
2.2 Factors Affecting the Bioremediation Processes.
2.3 Solid - Liquid-phase bioremediation
2.4 Bioleaching and Bio-methanation
2.5 Molecular approaches to bioremediation

Unit 3 Phytoremediation

3.1 Phytoremediation and bioavailability of contaminants
3.2 Processes involved in phytoremediation,
3.3 Types of phytoremediation
    3.3.1. Phytoextraction, Phyto stabilization, Phyto stimulation,
    3.3.2. Phyto transformation and Rhizofiltration
3.4. Myco and Phyco-remediation

Unit 4 Microbial remediation

4.1 Microbial classification,
4.2 Microbiology of bioremediation
4.3 Bioaugmentation and Biostimulation
4.4 Biofilms Microbial remediation
4.5 Land farming and Natural attenuation

Unit 5 Biological Reactor

5.1 Bioreactor Designs and Development
5.2 Factors affecting bioreactor design
5.3 Types of biological Reactors
5.4 Application of Bioreactor Technologies
5.5 Biofuel Cells as an alternative source of energy

Unit 6 Management of bioremediation project

6.1 Defining the project and goals
6.2 Experimental design, methodologies, and Costs
6.3 Site characterization,
6.4 Screening and selecting remediation alternatives
6.5 Process design and remediation
6.6 Field activities

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED BOOKS / SUGGESTED READINGS

1. Hakeem, K. R., Bhat, R. A., & Qadri, H. (Eds.). (2020). *Bioremediation and Biotechnology: Sustainable Approaches to Pollution Degradation*. Springer Nature.
2. Varjani, S. J., Agarwal, A. K., Gnansounou, E., & Gurunathan, B. (Eds.). (2018). *Bioremediation: applications for environmental protection and management*. Springer Singapore.
3. Prasad, R., & Aranda, E. (2018). *Approaches in bioremediation*. Springer International Publishing https://www. springer. com/de/book/9783030023683.
4. Shiomi, N. (Ed.). (2018). *Advances in Bioremediation and Phytoremediation*. BoD–Books on Demand.
5. Das, S., 2017. Microbial Biodegradation and Bioremediation, Elesvier.

Further Reading: As suggested by the Instructor.

ENSC-703: GREEN CHEMISTRY (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

Upon successful completion of the course student will be able to

- Understand the basic concept of Green chemistry and its role in reducing environmental pollution caused by synthetic chemicals and chemical processes.
- Have a working knowledge of the basic Twelve Principles of Green Chemistry and their practical applications in industry and research.
- Possess the ability to assess chemical products and processes and design greener alternatives when appropriate.

CONTENTS

Unit-1 Introduction

1.1 Introduction to green chemistry
1.2 Accidents and Their Unintentional Consequences
1.3 Green Chemistry: Reimagining Chemistry
1.4 Green chemistry and environment

Unit-2 Principles of Green Chemistry

2.1 12 Principles of Green Chemistry
2.2 Practical applications in industry and laboratories
2.3 Limiting Reagent, Yield, and Atom Economy
2.4 Sustainability

Unit-3 Green Chemistry Metrics

3.1 The Molecule
3.2 Stoichiometry and Reactions
3.3 Alternative solvents
3.4 Alternative reagents

Unit-4 Green Analytical Chemistry

4.1 Chemical Exposure and Dosage
4.2 Molecular Toxicology
4.3 Designing Future Products with Reduced Toxicity
4.4 Safe Chemical Design Game

Unit-5 Reaction Types, Design and Efficiency

5.1 Fundamentals of Green Chemistry: Efficiency in Reaction Design
5.2 Stoichiometry and Reactions
5.3 Designing for Recycling and Degradation
5.4 Catalysis
5.5 Solvents: Understanding Their Role and working without Solvents

Unit-6 Green Technologies and Industry

6.1 Green Chemistry and Energy
6.2 Microwave and ultrasonic
6.3 Microbial transformation
6.4 Enzymatic applications in industry
6.5 Phytoremediation

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
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3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Kaliaguine, S., & Dubois, J. L. (Eds.). (2020). *Industrial Green Chemistry*. Walter de Gruyter GmbH & Co KG.
2. Sanjay K. Shrama. 2020. *Green Chemistry and Water Remediation: Research and Application*. Elsevier
3. Torok, B., & Dransfield, T., 2017. *Green Chemistry: An inclusive Approach*, Ist Edition, Elsevier.
4. Lancaster, M. (2016). *Green Chemistry an Introductory Text.* Royal Society of Chemistry, Cambridge, UK.
5. Anastas, P.T., & Warner, J. C. (2000). *Green Chemistry: Theory and Practice*. Oxford University Press: Oxford, UK.

Further Reading: As suggested by the Instructor.

ENSC-704: SUSTAINABLE ENERGY CONSERVATION (THEORY) (03 Credit Hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

Students will learn about:

- The basic concept of energy, its units, sources and various types
- The renewable energy resources and the transformation of energy (solar, water, nuclear, biomass and wind) into electricity.
- Use of various types of biomass from agricultural, industrial and municipal sources for energy production
- Global and Pakistan's energy reserves and potential to produce renewable energy from readily available sources of energy production

CONTENTS

Unit-1 Introduction

1.1 Energy units, types, resources and growth pattern
1.2 Difference between Energy and Power
1.3 Growth patterns
1.4 Energy use in developing countries

Unit-2 Energy Demand and Consumption Trends

2.1 Global energy demand and consumption
2.2 Pakistan Energy demand and consumption
2.3 Energy conservation strategies

Unit-3 Renewable Energy Resources

3.1 Promising renewable energy sources
3.2 Microhydel and wind,
3.3 Solar, thermal and Photovoltaic
3.4 Biomass and biofuels

Unit-4 Alternative Energy sources

4.1 Biofuels, Geothermal, Wave,
4.2 Tidal, Hydrogen as an Energy Carrier,
4.3 Hydrogen as energy carrier, fuel Cells, Hybrid Vehicles
4.4 Biogas, biomass resources and their application

Unit-5 Analyses of Energy Resources

5.1 Global and Pakistan Energy Reserves
5.2 Power Potential
5.3 Case Studies of Energy and Power Issues (Global and National)
5.4 Energy Guide

Unit-6 Developing Energy Management and Auditing Programs

6.1 Energy corporate structure
6.2 Parts of energy management programs
6.3 Energy Data Analysis
6.4 Energy Auditing and Reporting

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
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3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED BOOKS / SUGGESTED READINGS

1. Gupta, A. K., De, A., Aggarwal, S. K., Kushari, A., & Runchal, A. (Eds.). (2020). *Innovations in Sustainable Energy and Cleaner Environment*. Springer.
2. Kundu, S. N., & Nawaz, M. (Eds.). (2019). *Sustainable Energy and Environment: An Earth System Approach*. CRC Press.
3. Michaelides, E. E. (2018). *Energy, the environment, and sustainability*. CRC Press.
4. Bizon, N., Mahadavi, T. N., Blaabjerg, F., & Kurt, E. (2017). *Energy harvesting & Energy Efficiency: Technology, Methods, Applications*, Springer.
5. Vaclav, S. (2017). *Energy and Civilization: A history*, MIT Press.
6. Kaushika, N. D., Reddy, K. S., & Kaushik, K. (2016). *Sustainable energy and the environment: a clean technology approach*. Springer.

Further Reading: As suggested by the Instructor.

ENSC-705: DISASTER RISK MANAGEMENT (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

After successful completion of this course, students will be able to:

- Understand the advance concepts of flooding, earthquakes, landslides and Plate Tectonics.
- Understand the Organizational Role, Role of Government and Non-Governmental Organizations (NGOs); Role of Media in Disaster Management

CONTENTS

Unit-1 Natural hazards and disasters

1.1 The need for hazard and disaster studies,
1.2 Historical background on Hazard and Disaster research;
1.3 Pre-disaster management: Early warning system and emergency communication

Unit-2 Disaster its types

2.1 Natural vs Man-made;
2.2 Flooding, Earthquake, Landslide;
2.3 Natural cycles and their role,
2.4 Prediction; Hazards, Risk and Vulnerability,

Unit-3 Different approaches and Indicators

3.1 Factors of vulnerability:
3.2 Climatic and weather factors
3.3 Demographic factors,
3.4 Socio-economic factors,
3.5 Cultural, Political and Physical factors

Unit-4 The impact of natural disasters

4.1 Direct and short-term impact of disasters,
4.2 Indirect and long-term consequences of catastrophes,
4.3 Behavioural impacts on Human individuals
4.4 Disaster as an opportunity for development

Unit-5 Disaster Management

5.1 Components of management and identifying communities at risk,
5.2 Hazard and vulnerability reduction and Mitigation
5.3 Earthquake and Flood Management:
5.4 Role of Government and NGOs and Media in Disaster Management.
5.5 Techniques and methods to assess hazard, vulnerability, and risk:
5.6 Disaster Management Trainings and Policies

Unit-6 Common environmental disasters in Pakistan

6.1 Plate Tectonics and Physical Hazards,
6.2 Earthquake and their damages,
6.3 Landslides and their down slope movements,
6.4 Climate and weather related Hazards:
6.5 Flood and drought human interactions and Coastal erosion.

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- resentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Sakurai, M., (2021). Emerging Technologies for Disaster Resilience: Practical Cases and Theories. Springer Nature.
2. Tomaszewski, B., (2020). Geographic information systems (GIS) for disaster management. Routledge.
3. Montz, B.E., Tobin, G.A., & Hagelman, R., R. (2017). Natural Hazards: Explanation and Integration. Guilford Publications.
4. Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (2014). At Risk: Natural Hazards, people's Vulnerability and disasters, Routledge.
5. Donald, H., & David, H. (2006). Natural Hazards and Disasters. Update. ISBN-10: 0538737522.
6. Burton, I., Kates, R.W., & White, G.F. (1993). The Environment as Hazard 2nd Edition, The Guilford Press, New York.

Further Reading: **As suggested by the Instructor.**

ENSC-706: MINING AND MANAGEMENT OF RADIOACTIVE MATERIAL (THEORY)

(03 Credit hrs)

PRE-REQUISITE: MS / M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

By the end of the Units, students should be able to demonstrate knowledge & understanding of:

- storage and management of nuclear waste and environmental impacts of nuclear waste management.
- apply to specific projects, knowledge, and understanding of hazard identification, reduction, and relevant legislation & policy.
- treatment and encapsulation technologies and waste management strategies to specific projects/ case studies.
- understand the geological disposal of nuclear waste and the multi-barrier approach to the construction of a post-closure safety case.

CONTENTS

Unit-1 Introduction to mining and management

1.1 Types of mining
1.2 OHS and Mining
1.3 Classification of resources and reserves
1.4 mining methods
1.5 metals reserve and recycling
1.6 Life Cycle of a Mine and Related Matters
1.7 Environmental impacts of milling and upgradation.

Unit-2 Geological deposits and uses of Uranium

2.1 Geological deposits of minerals and their impact of mining
2.2 Uranium ores,
2.3 Impacts on environmental milling of ores
2.4 Uranium concentrates
2.5 Fusion and fission
2.6 Isotopes and Geo-chemistry of uranium
2.7 Uranium enrichment and their environmental impacts
2.8 Fuel fabrication and fuel assemblies and their impacts

Unit-3 Radioactive material mining, use and principles

3.1 Nature of Radioactive material,
3.2 Radioactivity and radiogenic process
3.3 radioactive decay
3.4 Radioactive material, and mining
3.5 Hazard and Radiation protection
3.6 Detailed studies of deep geological disposal of radioactive waste including case studies
3.7 Transuranic waste and its disposal
3.8 case studies of nuclear accidents
3.9 stable isotopes decay, and radiometric dating

Unit-4 Nuclear power plants

4.1 Nuclear power plants and their classification
4.2 Impacts of nuclear power plants on environment
4.3 Weapon production
4.4 Facilities, and the nuclear waste
4.5 Low and intermediate-level nuclear waste
4.6 High-level nuclear waste
4.7 Natural nuclear reactors, and their implications

Unit-5 Sources and management of radioactive waste

5.1 Radioactive Waste Management
5.2 Types of radioactive waste
5.3 Generation of radioactive wastes
5.4 Geological sources of nuclear wastes and food security
5.5 Mining through to fuel fabrication
5.6 Electricity generation
5.7 Decommissioning nuclear plants

5.8 Non-nuclear power waste
5.9 Geological investigation for In-situ leaching
5.10 Impacts of ISL on the environment

Unit 6 Mine Management

6.1 Mines management and control
6.2 Fundamentals of mine ventilation
6.3 Control of gases, dust, and temperature
6.4 Methane drainage
6.5 Computer network simulation, and economics of airflow
6.6 Theory and practice of mine management
6.7 Government relations

Unit-7 Coal Mining Methods

7.1 An in-depth study of all aspects of coal mining
7.2 Coal reserves and geology
7.3 Planning and development of coal mines
7.4 Surface and underground mechanized methods of face preparation
7.5 Coal extraction, handling and preparation
7.6 Longwall advancing,
7.7 Horizon mining

Unit 8 Environmental and Occupational Health and Safety in Mining Industry

8.1 A detailed study of health and safety principles
8.2 Practices and analyses
8.3 Regulations, risks and hazards recognition
8.4 Mitigation and control
8.5 Disaster prevention in the mining industry
8.6 Ethics and risks management

TEACHING-LEARNING STRATEGIES

- Lecture-based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- attendance, assignments, and presentation,
- homework
- hands-on-activities,
- short tests, quizzes, etc.

ASSESSMENT AND EXAMINATIONS:

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RECOMMENDED TEXTBOOKS / SUGGESTED READINGS

1. Roy, W. R. (2021). Radioactive Waste Management In The 21st Century. World Scientific.
2. Spitz, K., & Trudinger, J. (2019). Mining and the environment: from ore to metal. CRC Press.
3. Saling, J. H., & Fentiman, A. W. (2018). Radioactive waste management. Routledge.
4. Claire, C., & Neil, H. (2018). Nuclear Waste Management, IOP Publishing Limit.
5. Dimitrakopoulos, R. (Ed.). (2018). Advances in applied strategic mine planning. Springer.
6. Pusch, R., Yong, R. N., & Nakano, M. (2017). Geologic disposal of low-and intermediate-level radioactive waste. CRC Press.
7. Ronald, P., Raymond, N. Y, & Masashi, N. (2017). Geologic Disposal Radioactive Waste, CRC Press.
8. Abzalov, M. (2016). Applied mining geology (Vol. 12). Switzerland: Springer International Publishing.

Further Reading: As suggested by the instructor.

ENSC-707: WATER RESOURCES, SUSTAINABILITY AND MODELING (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

The students will be able to learn

- the basic concepts of sustainable water resources, background and importance
- the ecological and economic perspectives of sustainable water resources management
- the modelling and optimization methods in water resources sustainability
- about the uncertainties, challenges, threats, and climate change impacts on water resources sustainability

CONTENTS

Unit-1 Water Sustainability

1.1 Introduction to the water occurrences and sustainability
1.2 Challenges and Threats to the sustainable water supply
1.3 Importance and applicability
1.4 Water quantity and water budget
1.5 Background with past civilizations and the present
1.6 Current global water challenges
1.7 Linking water supplies and growth
1.8 Global and local view of climatic conditions and trends

Unit-2 An Ecological-Economics Perspective of Water Resources Sustainability

2.1 An ecological-economics view of sustainability
2.2 Measuring the ecological-economic value of water
2.3 A human right to water
2.4 Integrated water resources management

Unit-3 Optimization and Modeling for Water Resources Sustainability

3.1 Introduction to modelling and optimization
3.2 Sustainable Groundwater and Conjunctive use policy development
3.3 Simulation/Optimization Models,
3.4 Methods of Simulating and optimization within S/O Models,
3.5 Optimization Problem Formulations

Unit-4 Multi-objective Analysis/ Conjunctive Use Planning of Groundwater and Surface Water:

4.1 Introduction to surface Water and Groundwater interactions
4.2 Governing Equations
4.3 Management Objectives in Conjunctive use Projects
4.4 Supply Objectives, Quality Objectives, Economic Objectives, Environmental Objectives
4.5 Multi-objective Optimization, Multicriteria Decision Making

Unit-5 Uncertainties and Risks in Water resources projects,

5.1 Risk Considerations in Hydrosystems,
5.2 Data Requirements in Risk-Based Approach
5.3 Uncertainty Analysis, future scenarios, population and other trends

Unit-6 Climate change Effects and Water Management Options,

6.1 The Climate System
6.2 Definition of Climate Change, Climate Change Prediction
6.3 Droughts
6.4 Climate Change Effects
6.5 Water Management Options and climate change

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- homework
- hands-on-activities,
- short tests, quizzes etc.

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RECOMMENDED TEXTBOOKS / SUGGESTED READINGS

1. Nazish, K. S., & Lawrence, K. W. (2016*). Water Engineering, Hydraulics, Distribution and Treatment*, 1st Eds.
2. Shrestha, S., (2016). *Groundwater Environment in Asian Cities: concepts, methods & ease study.* Amsterdam, Elsevior.
3. Gebriye, D., & Maria, C. (2015). *Sustainability of Integrated Water Resources Management*, Water Governance, Climate and Ecohydrology, Springer.
4. Jones, A. A. (2014). *Water Sustainability: A Global Perspective*. Routledge, New York. Setegn, Shimelis.
5. Rooney, A. (2009). *Sustainable Water Resources (How can we save our world?).* Arcturus Publishing, New Delhi.
6. Larry, M. (2006). Water Resources Sustainability, McGraw Hill.

Further Reading: As suggested by the instructor.

ENSC-708: TOXIC ORGANICS IN ENVIRONMENT (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

Upon successful completion of the course student will be able to

- Understand environmental pollution caused by organic compounds and their chemistry.
- Recognize different types of synthetic pesticides, herbicides and other industrial/agricultural organic compounds and their toxicological information.
- Develop a concept of need-based and modern research areas of toxic organic compounds and of their environment friendly alternatives.

CONTENTS

Unit-1 Introduction to Toxic organics

1.1 Persistent, Bio-accumulative, and Toxic (PBT) Chemicals
1.2 General classification of Toxic Organic Chemicals
1.3 Sources of Toxic Organics Chemicals
1.4 Fat in Toxic Organics environment

Unit-2 Persistent Toxic Organic Pollutants

2.1 Classification of Persistent Organic Chemicals
2.2 Organochlorine toxicity and fate in environment
2.3 Polychlorinated Biphenyls toxicity, Sources and fate in environment
2.4 Persistence behaviour of Dioxins and Furan in environment

Unit-3 Non-Persistent Toxic Organic Pollutants

3.1 Non-persistent toxic organics and their classification
3.2 Organophosphate toxicity and fate in environment
3.3 Neonicotinoid and their toxic impacts on the environment
3.4 Application of new Chemistry pesticide in crop protection

Unit-4 Polynuclear Aromatic Hydrocarbons (PAHs)

4.1 Chemistry of Polycyclic Aromatic Hydrocarbons
4.2 Sources and exposure of PAH
4.3 Atmospheric PAH and Particulate Matter
4.4 PAHs as an environmental carcinogen

Unit-5 Volatile Organic Compounds

5.1 Prevalence of Exposures to Volatile Organic Compounds,
5.2 Health and Volatile Organic Compounds,
5.3 Prevalence of the Sick Building Syndrome,
5.4 Guidelines for Volatile Organic Compounds Management

Unit-6 Emerging class of contaminants

6.1 Industrial Origin Compounds
6.2 Polybrominated Flame Retardants
6.3 Classes and toxic effects of per- polyfluoroalkyl compounds
6.4 Antibiotics and Pharmaceutical Residues
6.5 Monitoring methods emerging of contaminants

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Neilson, H. A. (2018). *Organic Chemicals in the Aquatic Environment: Distribution, Persistence, and Toxicity.* CRC Press, USA.
2. Hayakawa, K. (Ed.). (2018). *Polycyclic aromatic hydrocarbons: environmental behavior and toxicity in East Asia*. Springer.
3. Abelkop, A. D., Graham, J. D., & Royer, T. V. (2018). *Persistent, bioaccumulative, and toxic (PBT) chemicals: technical aspects, policies, and practices*. CRC Press.
4. Speight, J. G. (2016). *Environmental organic chemistry for engineers*. ELSEVIER.
5. Ibanez, J.G., Hernandez-Esparza, M., Doria-Serrano, C., Fregoso-Infante, A. & Singh, M.M. (2008). *Environmental Chemistry.* Germany.
6. Girard, E., J. (2005). *Principles of Environmental Chemistry.1st Ed.,* Jones & Barlett, USA.
7. Baird, C. & Cann, M. (2012). *Environmental Chemistry.* 5th Ed., W.H. Freeman and Company, New York.
8. Miller, G.T. (2004). *Environmental Science.* Thomson-Brooks, Canada.

Further Reading: As suggested by the Instructor.

ENSC-709: COMPOSTING SCIENCE AND TECHNOLOGY (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/ MPhil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

The students will be able to learn

- The students will be able to learn the science of composting and related process parameters.
- Students will get aware of the different composting technologies and degradation of pollutants during composting.
- Knowledge of compost quality standards and health and safety guidelines working with compost
- Need-based research areas of compost, its soil nutrient recycling uses, and environmental sustainability aspects.

CONTENTS

Unit-1 The Science of Composting

1.1 Basic Concepts of Composting
1.2 Composting biology, Chemistry and Physics
1.3 Composting Process parameters

Unit-2 Composting technology

2.1 Types of composting
2.2 Turned windrow
2.3 Static Pile
2.4 Mattress composting
2.5 In-vessel, home composting

Unit-3 Degradation of Pathogens

3.1 Turnover of nutrients during composting
3.2 Bioremediation of heavy metals and organic toxicants by composting
3.3 Reduction of pathogens and degradation of organic pollutants during composting,

Unit-4 Composting Quality

4.1 Compost stability and maturity
4.2 Compost quality parameters
4.3 Compost quality standards

Unit-5 Environmental Impacts of Composting

5.1 Value added benefits of compost
5.2 Health and Safety practices in composting
5.3 Environmental impacts of composting

Unit-6 Composting Scenario

6.1 Composting facility and site selection criterion
6.2 Composting at International Level
6.3 Composting Scenario in Pakistan
6.4 Successful stories of Composting

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Hettiarachchi, H., Caucci, S., & Schwärzel, K. (2020). *Organic waste composting through nexus thinking: practices, policies, and trends*. Springer Nature.
2. Meghvansi, M. K., & Varma, A. (Eds.). (2020). *Biology of Composts* (Vol. 58). Springer Nature.
3. Maheshwari, D. K. (Ed.). (2014). *Composting for sustainable agriculture* (Vol. 3). Springer.
4. Insam, H., Riddech, N., & Klammer, S. (Eds.). (2013). *Microbiology of composting*. Springer Science & Business Media.
5. Epstein, E. (2011). Industrial composting. *Environmental engineering and facilities management.* New York: Taylor and Francis Group.
6. Diaz, L. F., De Bertoldi, M., & Bidlingmaier, W. (Eds.). (2011). *Compost science and technology*. Elsevier.
7. Pleasant, B., & Martin, D. L. (2008). *The Complete Compost Gardening Guide: Banner Batches, Grow Heaps, Comforter Compost, and Other Amazing Techniques for Saving Time and Money, and Producing the Most Flavorful, Nutritious Vegetables Ever*. Storey Publishing.

Further Reading: As suggested by the instructor

ENSC-709: ADVANCED APPROACHES IN WATER CONSERVATION (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

Upon successful completion of the course student will be able to

- This course will provide the basic concepts of Water conservation approaches, both in term of quantity as well as quality.
- The students will learn about the water conservation techniques at watershed level.
- The students will learn about the water conservation approaches in agriculture and the water efficient irrigation practices
- The students will be able the learn the advanced approaches for water conservation in Industries.

CONTENTS

Unit-1 Introduction to Water Conservation

1.1 Introduction and importance of water conservation
1.2 The water cycle rainfall, evaporation, infiltration, effective rainfall
1.3 Local, regional and global significance of water conservation
1.4 Water quality conservation, sources of water pollution,
1.5 water quality parameters and standards

Unit-2 Watershed Management for Water storage

2.1 Introduction to watershed management
2.2 Storage ponds, reservoirs
2.3 Water harvesting systems,
2.4 Cultivated reservoirs,
2.5 farm ponds shallow wells, karez.

Unit-3 Water Harvesting and Conservation

3.1 Floodwater harvesting within the stream bed (Check dams);
3.2 floodwater diversion (Sailaba, Rod Kohi etc.)
3.3 Roof-top water harvesting.
3.4 Groundwater resources development
3.5 Aquifer recharging
3.6 Desalination of sea water

Unit-4 Water Conservation in Agriculture

4.1 Importance of water conservation in Agriculture
4.2 Estimation of irrigation water requirement,
4.3 Irrigation rates, irrigation efficiency, and plant water use efficiency
4.4 Efficient irrigation practices for water conservation
4.5 Agronomic practices and water conservation

Unit-5 Water Conservation in Industries

5.1 Concept of Reuse of Water in industries.
5.2 Water conservation practices in industries.
5.3 Water and wastewater treatment approaches
5.4 Water Reuse and Recycling Wastewater

Unit-6 Virtual water Conservation

6.1 The Concepts of Water Footprint and Virtual Water
6.2 The Economics of Water Use
6.3 Calculation of a Nation's 'Water Footprint'
6.4 Strategic Water related Issues and Population - Food - Trade Nexus
6.5 Global Trade in Virtual Water

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Sheryl, M., 2018. Integrated Approaches to Water Pollution and Control. Callisto Reference, USA.
2. Brooks, K. N., Ffolliott, P. F., & Magner, J. A. (2012). *Hydrology and the Management of Watersheds*. John Wiley & Sons..
3. Jana, B., L. (2008). Water Harvesting and Watershed Management. Agrotech Publishing Academy, Udaipur, India
4. Parker, R., Morris, N., Fair, F.N., & Batia, S., E. (2008). *Waste-water Engineering*. CBS Publishers, New Delhi, India.
5. Laycock, A. (2007). *Irrigation Systems Design, Planning and Construction*. CABI International, Wallingford, UK
6. Woodard, F. (2001). *Industrial waste treatment handbook*. Elsevier., USA.
7. Metcalf & Eddy, 2003. Wastewater Engineering: Treatment and Reuse. McGraw-Hill, New York, USA.
8. Henze, M., Harremoes, P., la Cour Jansen, J., & Arvin, E. (1995). *Wastewater treatment: biological and chemical processes:(2002)*. Springer.

Further Reading: As suggested by the instructor

ENSC-711: SUSTAINABLE URBAN PLANNING & MANAGEMENT (THEORY) (03 Credit Hrs)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

This course will help the students to:

- Understand the concept of urban environment and sustainability
- Connect real world urban challenges with the idea of sustainability and supporting technology
- Gain the ability to communicate effectively on the issue of urban sustainability
- Develop the concept of sustainable transportation in urban settings
- Recognize the significance of green spaces and mitigating the causes and effects of climate change
- Utilize geospatial tools for the designing and management of sustainable urban planning

CONTENTS

Unit 1 Introduction to Urbanization

1.1 Introduction to urbanization and sustainability
1.2 Sustainable cities, peri-urban and cosmopolitan areas.
1.3 Difference between and natural and built environment.
1.4 Urban infrastructure and environment.

Unit 2 Urban planning and Management

2.1 City limits and urban sprawls,
2.2 urban migration and settlements
2.3 urban hazards and vulnerabilities
2.4 Mitigation with some recent case studies

Unit 3 Urban Economic System

3.1 Urbanization and economic development,
3.2 Economic gains sustainable
3.3 Direct and indirect impacts of urbanization on environment
3.4 Urban poverty and Economic inequality,

Unit 4 Urban Human Population and Health

4.1 Population dynamics and urban environment quality.
4.2 Urban air and water quality
4.3 Health disparity,
4.4 epidemiological transition,
4.5 Nutritional transition

Unit 5 Urban Infrastructures and Environmental Challenges

5.1 City transport and mass transit infrastructures
5.2 Urban development and climate change,
5.3 Urban carbon sequestration.
5.4 Urban transportation design and sustainability

Unit 6 Urban Mapping and

6.1 Urban interactive mapping and use of Geographical Information System (GIS)
6.2 Urban green spaces
6.3 Urban forestry
6.4 Sustainable cities; elements of sustainability
6.5 Green buildings in urban development,

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	Will take place at the mid-point of the semester
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Berney, R. ed. (2018). *Bicycle Urbanism: Reimagining Bicycle Friendly Cities*. Routledge.
2. Donald, M., & Gert, de R. (2017). *Urban environmental planning policies, instruments, and methods in an international perspective*. Taylor and Francis.
3. Etingoff, K. ed. (2017). *Sustainable cities: urban planning challenges and policy*. CRC Press.
4. Levy, J.M. (2016). *Contemporary Urban Planning.* 11th Edition. Taylor & Francis. pp 1-476,
5. Wheeler, S.M., & Beatley, T. (2014). *Sustainable Urban Development Reader*.3rd Ed. Routledge.
6. Geertman, S., Toppen, F., & Stillwell, J. (2013). *Planning Support Systems for Sustainable Urban Development.* Springer.
7. Novotny, V., Ahern, J., & Brown, P. (2010). *Water centric sustainable communities: planning, retrofitting, and building the next urban environment*. John Wiley & Sons..
8. Riddell, R. (2008). *Sustainable Urban Planning: Tipping the Balance.* Blackwell Publishing.
9. Cohen, N. (2001). *Urban Planning, Conservation, and Preservation*. McGraw Hill Professional. Volume 1.pp. 359.
10. Burayidi, M.A. (2000). *Urban Planning in a Multicultural Society*. Praeger, London.

Further Reading: As suggested by the instructor

ENSC-712: ENVIRONMENTAL BIOGEOGRAPHY (THEORY) (03 CREDIT HOURS)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

Upon completion of this unit, students will be able to:

- apply and use principles of biogeography in the fields of environmental and conservation planning
- understand the basic principles of biogeography and develop understanding of the spatial and temporal patterns governing the global distribution of biological diversity
- understand the various subdisciplines of biogeography like historical biogeography, ecological biogeography and paleoecology the world

CONTENTS

Unit 1 Introduction to Environmental Biogeography

1.1 Origins of Modern Biogeography
1.2 The Development of Environmental Biogeography
1.3 Ecological versus Historical Biogeography
1.4 Biogeography and Evolution
1.5 Biogeographical Regions of Plants and Animals

Unit 2 Patterns of Global Biodiversity

2.1 Diversity in Space and time
2.2 How Many Species are There?
2.3 Latitudinal Gradients of Diversity
2.4 Latitude and Species Ranges
2.5 Diversity and Altitude
2.6 Biodiversity Hotspots

Unit 3 Dynamics of biogeography

3.1 Geographical and environmental factors shaping the life
3.2 Dispersal and immigration
3.3 Island Biogeography
3.4 Fragmentation and conservation
3.5 Extinction and speciation as a natural process

Unit 4 Climate and biogeography

4.1 Ice age and climate Change
4.2 Climatic Wiggles
4.3 Biological Changes in the Pleistocene
4.4 The Last Glacial and Causes of Glaciation
4.5 Climatic Cooling and Warmth

Unit 5 Human Intrusion and global impacts on biodiversity

5.1 The Emergence of Humans
5.2 Modern Humans and the Megafaunal Extinctions
5.3 Plant and Animal Domestication and Agriculture
5.4 Diversification of Homo sapiens
5.5 Environmental Impact of Early Human Cultures

Unit 6 Conservation Biogeography

6.1 The Scope of Conservation Biogeography
6.2 Anthropocene – The age of man
6.3 Biodiversity Crisis and its Management
6.4 Conservation Biogeography in Action

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	Will take place at the mid-point of the semester
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Lomolino, M. V. (2020). *Biogeography: A Very Short Introduction*. Oxford University Press.
2. Cox, C. B., Moore, P. D., & Ladle, R. J. (2016). *Biogeography: an ecological and evolutionary approach*. John Wiley & Sons.
3. Harcourt, A. (2012). *Human biogeography*. University of California Press.
4. Stevens, L. (Ed.). (2012). *Global Advances in Biogeography*. BoD–Books on Demand.
5. Renema, W. (Ed.). (2007). *Biogeography, time and place: distributions, barriers and islands* (Vol. 29). Springer Science & Business Media.
6. Morrone, J. J. (2008). *Evolutionary biogeography: an integrative approach with case studies*. Columbia University Press.
7. Ladle, R. J., & Whittaker, R. J. (Eds.). (2011). *Conservation biogeography*. John Wiley & Sons.

Further Reading: As suggested by the instructor

SECOND SEMESTER

Sr. #	Code	Course Title	Course Type	Prerequisite	Credit Hours
SEMESTER-2					
1.	ENSC-713	Global Warming and Climate Change	Core Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
2.	ENSC-714	Global Environmental Politics	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
3.	ENSC-715	Environmental Applications of Nano Materials	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
4.	ENSC-716	Agrochemicals in Environment	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
5	ENSC-717	Environmental Education	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
6	ENSC-718	Remote Sensing and GIS	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	02+01
7	ENSC-719	Environmental Issues Related to Petroleum Industry	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
8	ENSC-720	New Developments in Wastewater Treatment	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
9	ENSC-721	Hazardous Solid Waste Management	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
10	ENSC-722	Urban Green Space System	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
11	ENSC-723	Strategic Environmental Assessment	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03
12	ENSC-724	Freshwater Ecology	Elective Course	MS / M.Phil. Environmental Sciences/ Equivalent	03

ENSC-713: GLOBAL WARMING AND CLIMATE CHANGE (THEORY) (03 Credit Hrs)

PRE-REQUISITE: MS / M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

Upon successful completion of the course student will be able to

- carry out research, teaching, and consultancy in the field of global warming and climate change.
- familiarized with the present and past climate change and its consequences.
- Analyze that how the higher temperatures are worsening and may cause many types of disasters, including storms, heatwaves, floods, and droughts.

CONTENTS

Unit 1 Introduction to Climatology

1.1 Introduction to meteorology
1.2 Variables of climate
1.3 Large scale heat redistribution
1.4 Global Air pressure and circulation
1.5 The El Niño-Southern Oscillation (ENSO) cycle
1.6 Radiative forcing.

Unit 2 Global Warming

2.1 Global warming and its related controversies
2.2 Global vs regional changes
2.3 Natural and Anthropogenic factors in climate change
2.4 Sulfate aerosol and their Relation to Global Climate
2.5 Carbon emission and sequestration

Unit 3 Past and Present Climate Change

3.1 Geo-historical of climate change
3.2 Climate changes during geological periods
3.3 Climate change during six historical periods
3.4 Methods of determining past climate changes
3.5 Reasons for rapid climate change
3.6 Recent future climate change

Unit 4 Consequences of Climate Change at Global Level

4.1 Evidences of climate change
4.2 Milankovitch cycles,
4.3 Ice age to greenhouse gases effect
4.4 Disturbance in global CO_2 level
4.5 Shrinkage of the cryosphere,
4.6 Proxies of climate change.
4.7 Consequences of climate change
4.8 Mitigation strategies
4.9 Geoengineering technologies

Unit 5 Climate change and Global Natural Systems

5.1 Ecological effects of climate change,
5.2 Climate change and agriculture
5.3 Climate change and marine environment,
5.4 Marine chemistry and climate Change
5.5 Natural buffers and global climate stability
5.6 human health and climate change

Unit 6 Human Effort to Mitigate the Climate Change

6.1 Adaption to climate change
6.2 Policy for climate change
6.3 Kyoto protocol
6.4 Paris agreement
6.5 United nations framework convention on climate change
6.6 Economic and politics of climate change

TEACHING-LEARNING STRATEGIES

- Lecture-based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is a continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments, and presentation,
- homework
- hands-on-activities,
- short tests, quizzes, etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
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RECOMMENDED TEXTBOOKS / SUGGESTED READINGS

1. Beer, T., Li, J., & Alverson, K. (Eds.). (2018). *Global Change and Future Earth: The Geoscience Perspective* (Vol. 3). Cambridge University Press.
2. Juha, I., Uitto, J., &Robd, V. B. (2017). *Evaluating Climate Change Action for Sustainable Development*, Springer.
3. Avery, E. H. (2017). A Global Threat: The Emergence of Climate Change Science, Cavendish Square Publishing L.L.C., Amazon.com.
4. Wolfson, R., and Norton, W. W. (2012). *Energy, Environment and Climate*, USA, 2nd edition.
5. Tomecek, S.M. (2012). *Global Warming and climate change (science foundation*), Chelsea House Publ. (library), pp. 1-121.
6. Kindersley, D., & Harvey, L. D. D. (2010). *Global Warming the Hard Science, India*, Second Edition.
7. Marquina, A. (2010). *Global Warming and Climate Change: Prospects and Policies in Asia & Europe*, Palgrave Macmillan, U.K. pp. 1-519.
8. Philander, S.G. (2008). *Encyclopedia of Global Warming & Climate Change*, SAGE, pp 1-1283.
9. Drake, F. (2000). *Global Warming: The Science of Climate Change*, A Hodder Arnold Publication, pp 1-286
10. William James Burroughs, W. J. (2007). *Climate Change, A Multidisciplinary Approach, 2nd Edition, Cambridge University Press*, pp. 1-392.

FURTHER READING: As suggested by the instructor.

ENSC-714: GLOBAL ENVIRONMENTAL POLITICS (THEORY) (03 Credit hr.)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

By the end of the course, the student is expected:

- To critically understand global environmental politics and its historical background
- To have an understanding about international key role players in global environmental politics
- To construct arguments about outcomes of North-South relations, global food crisis, climate change, global justice etc.
- To be able to apply theoretical knowledge to various real world environmental problems such as pollution, environmental refugees, nuclear energy, climate change, unsustainable resource use, etc. to promote better management practices
- To be able to identify political perspectives of environmental issues with their socioeconomic backgrounds which give rise to them

CONTENTS

Unit 1: Global Politics and the Environment

1.1 Introduction to global environmental politics as a discipline.
1.2 Different theories, perspectives and practices in environmental politics.
1.3 State of the Planet
1.4 The Politics of Environmental Change

Unit 2: Tragedy of the Commons:

2.1 Human Nature and the Commons
2.2 Historical Inaccuracies
2.3 Population and Poverty
2.4 Over-consumption and depletion of natural resources,
2.5 Global food crisis, loss of biodiversity

Unit 3: Actors and Global Governance System

3.1 Main actors and institutions in global environmental politics,
3.2 role of states, international organizations.
3.3 The Contradictions of Capitalism
3.4 The Ecological Contradiction
3.5 Ecological Imperialism
3.6 Eco-socialism

Unit 4 International Laws and Policies

4.1 Policies within global environmental politics
4.2 International law,
4.3 Foreign policy institutions,
4.4 Domestic politics,
4.5 Corporations and transnational actors.

Unit 5: International Relations and Environmental Multilateralism

5.1 North-South relations,
5.2 Consumption and Its Environmental Impact
5.3 Social Movements and Resistance
5.4 Global trade and environment,
5.5 Ecological Footprint
5.6 The Concept of Sustainable Development and Environmental Future

Unit 6: Major Issues in Environmental Politics

6.1 Climate change and the risk industry: the multiplication of fear and value
6.2 Agriculture and the Environment
6.3 Global Governance of Chemicals and Hazardous Waste
6.4 Global garbage: waste, trash trading, and local garbage politics

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Documentaries
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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RECOMMENDED TEXTBOOKS / SUGGESTED READINGS

1) Chasek, P. S., & Downie, D. L. (2020). *Global environmental politics*. Routledge.
2) Roussopoulos, D. (2019). *Political Ecology: System Change Not Climate Change*. Black Rose Books.
3) Stevenson, H. (2017). Global environmental politics: Problems, policy and practice. Cambridge University Press.
4) Howe, J. P., & Cronon, W. (2016). *Behind the Curve: Science and the Politics of Global Warming.* University of Washington Press.
5) Spilker, G. (2013). *Globalization, political institutions and the environment in developing countries*. Routledge.
6) Steinberg, P. F., & VanDeveer, S. D., (Eds.). (2012). *Comparative Environmental Politics: theory, practice, and prospects*. MIT Press.
7) Peet, R., Robbins, P., & Watts, M. (Eds.). (2010). *Global political ecology*. Routledge.
8) Conca K.& Dabelko, G. D. (2019). *Green Planet Blues Critical Perspectives on Global Environmental Politics* 6th Ed. Routledge.
9) Chasek, P. S., Downie, D. L., & Brown, J. W. (2010). *Global Environmental Politics, Dilemmas in World Politics Series.* Westview Press.
10) Kütting, G., & Herman, K. (Eds.). (2018). *Global environmental politics: concepts, theories and case studies*. Routledge.
11) Karin, B. (Ed.). (2010). *Environmental politics and deliberative democracy: Examining the promise of new modes of governance*. Edward Elgar Publishing.

Further Reading: As suggested by the Instructor

ENSC-715: ENVIRONMENTAL NANOTECHNOLOGY (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

The student will learn about:

- The basic concepts of nanomaterials and nanostructures and their properties
- Nanomaterials fabrication methods and their application for polluted air and soils
- Nanomaterials as efficient material for the remediation of water and wastewater
- Potential risks associated with the application of nanomaterials and future challenges

CONTENTS

Unit-1 Introduction

1.1 Introduction to Nanotechnology
1.2 Properties of nanomaterials
1.3 Types of nanomaterials
1.4 Structure and Properties of nanomaterials
1.5 Use of Nanoparticles in environmental sciences

Unit-2 Application of Nanomaterials

2.1 Remediation of polluted soil, air and water
2.2 Pollutant sensing and detection
2.3 Nanomaterials as adsorbents
2.4 Antimicrobial agents
2.5 Renewable energy
2.6 Photocatalysis

Unit-3 Synthesis of Nanomaterials

3.1 Designing methods of nanomaterials
3.2 Production of chemical and biological nanomaterials
3.3 Development of Nanocomposites
3.4 Application in environment and health sciences

Unit-4 Biomaterials and Nanotechnology

4.1 Raw materials
4.2 Properties
4.3 Biochar based nanocomposites
4.4 Binary and ternary composites of nanomaterials for environmental remediation

Unit-5 Nano-remediation Technologies

5.1 Environmental Nano Remediation Technologies-Thermal, Physico-Chemical and Biological Methods

5.2 Nano Filtration for treatment of waste – removal of organics & inorganics and pathogens

5.3 Nanotechnology for water remediation and purification.

5.4 Treatment of hi-tech industrial waste waters using nanoparticles

Unit-6 Fate of Nanomaterials

6.1 Environmental fate and transport of nanomaterials,
6.2 Environmental implications of nanomaterials
6.3 Future challenges in nanotechnology

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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RECOMMENDED TEXTBOOKS / SUGGESTED READINGS

1. Dasgupta, N., Rajan, S., & Lichtfouse, E. (2018). *Environmental Nanotechnology*, Springer.
2. Fulekar, M.H., & Pathak, B. (2017). *Environmental Nanotechnology*, CRC Press.
3. Sels, B., & Van de Voorde, M. (Eds.). (2017). *Nanotechnology in Catalysis, 3 Volumes: Applications in the Chemical Industry, Energy Development, and Environment Protection*. John Wiley & Sons.
4. Kumar, C. S. (Ed.). (2019). *Nanotechnology Characterization Tools for Environment, Health, and Safety*. Springer.
5. Bhat, A. H., Khan, I., Jawaid, M., Suliman, F. O., & Al-Lawati, H. (2019). *Nanomaterials for Healthcare, Energy and Environment* (Vol. 118). S. M. Al-Kindy (Ed.). Springer.
6. Saglam, N., Korkusuz, F., & Prasad, R. (Eds.). (2021). *Nanotechnology Applications in Health and Environmental Sciences*. Springer Nature.

Further Reading: As suggested by the Instructor

ENSC-716: AGROCHEMICALS IN ENVIRONMENT (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

After learning this course, the students are expected to

- understand obsolete, current and emerging kinds of agrochemicals, its toxicological impacts during and after use.
- Explain the nature of damage caused by agrochemical, their fate in the environment and human population and suggest appropriate controlling measures
- The students will also learn about the strategies for the management of agrochemicals in the environment.

CONTENTS

Unit-1 Introduction

1.1 Introduction to Agrochemicals
1.2 Major types of agrochemicals
1.3 pesticides and soil conditioners
1.4 Need of agrochemicals
1.5 Fate of agrochemicals in environment

Unit-2 Emerging agrochemicals: status, technologies and technological solution

2.1 Emerging environmental contaminants
2.2 Emerging agrochemicals in different environmental matrices
2.3 Health effects of Emerging environmental contaminants
2.4 Removal technologies: Status and challenges
2.5 Nano materials in tackling emerging agrochemicals

Unit-3 Impact of agrochemicals on soil health

3.1 Current use of agrochemicals in agriculture
3.2 Fate and toxicity of agrochemicals in soil
3.3 Effects on soil biota and soil microflora
3.4 Effect on nutrient cycling microbial communities
3.5 A consequence of agrochemicals on soil health

Unit-4 Toxicological effects of agrochemicals

4.1 Types of Toxicological effects of agrochemicals
4.2 Factors influencing agrochemical toxicity
4.3 Effects on Soil, surface, and ground water
4.4 Effects on human health and Effects on ecosystem
4.5 Impact of agrochemicals on food quality
4.6 Effect of agrochemicals on climate change

Unit-5 Toxicological effects of Herbicides

5.1 Use of herbicides: popular tool for weed management
5.2 Toxic consequences of the Green Revolution
5.3 Impacts of herbicides Seed germination, Plant growth and Crop quality
5.4 Herbicide use and environmental pollution
5.5 Herbicide toxicity and human health

Unit-6 Risk assessment and Management of agrochemicals

6.1 Framework of ecological risk assessment
6.2 Toxicity assessment and Exposure assessment
6.3 Risk assessment and management
6.4 Bioremediation for removal of agrochemicals
6.5 Technologies available for degradation of agrochemicals
6.6 Nanotechnology for removal of agrochemicals
6.7 Carbon-based nanomaterials

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion

- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Larramendy, M., & Soloneski, S. (2015). *Toxicity and Hazard of Agrochemicals*: IntechOpen.
2. Nollet, L. M. L., & Rathore, H. S. (2016). *Handbook of Pesticides: Methods of Pesticide Residues Analysis:* CRC Press.
3. Pohanish, R. P. (2014). *Sittig's Handbook of Pesticides and Agricultural Chemicals:* Elsevier Science.
4. Prasad, M. N. V. (2020). *Agrochemicals Detection, Treatment and Remediation.* Elsevier Science & Technology.
5. Tadros, T. F. (2018). *Agrochemicals, Paints and Coatings and Food Colloids.* De Gruyter.
6. Wani, K. A. (2018). *Handbook of Research on the Adverse Effects of Pesticide Pollution in Aquatic Ecosystems.* IGI Global.

Further Reading: As suggested by the Instructor

ENSC-717: ENVIRONMENTAL EDUCATION (THEORY) (03 Credit hrs.)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

The student will learn about:

- history and philosophy of environmental education
- basic understanding about different stages of learning
- The students will learn about teaching, awareness raising methodologies
- Non formal communication strategies to work in community for environmental conservation

CONTENTS

Unit-1 Multi-disciplinary Nature of Environmental Education

1.1 Environmental Education (EE): Definition, Scope and Importance
1.2 Purpose of Environmental Education and social change
1.3 Environmental Education for sustainable development
1.4 Need for Public Awareness

Unit-2 History and Philosophy of Environmental Education

2.1 Guiding principles of Environmental Education
2.2 Environmental literacy, Citizen Action and responsibilities
2.3 Status of Environmental Education at National, regional and global levels

Unit-3 Teaching and learning

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

Unit-4 Teaching Methodologies

4.1 Common teaching methods/activities of formal, non-formal and informal EE.
4.2 Using community resources for Environmental Education
4.3 Teaching Environmental Issues in Classroom and in the real-world methodologies
4.4 Advocacy and teaching of environmental issues

Unit-5 Communication strategies in Community Education

5.1 Reading, writing, listening and speaking skills
5.2 Management of seminars, workshops, field trips for Environmental Education.
5.3 Use of Computer for Environmental Education,
5.4 Role of social media, Internet in websites Environmental Education.

Unit-6 Environmental Education in Pakistan

6.1 Rise and development of education in Pakistan
6.2 Role of Government, NGOs, Educational institutions
6.3 Management and enforcement of environmental educational policies and regulations in Pakistan.
6.4 Environmental policy: EE at primary, secondary and at higher levels of environmental education
6.5 and research

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Krasny, M. E. (2020). *Advancing environmental education practice*. Cornell University Press.
2. Jickling, B., & Sterling, S. (Eds.). (2017). *Post-sustainability and environmental education: Remaking education for the future*. Springer.
3. Lieberman, G. A. (2017). Fitting the Environment in Education/Gerald A. Lieberman.
4. Stevenson, W. (2020). *The Origins of Roman Christian Diplomacy: Constantius II and John Chrysostom as Innovators*. Routledge.
5. Tomar, A. (2007). *Environmental education*. Kalpaz Publications.
6. Pachhauri, S. (2012). *Environmental education*. Pearson Education India.
7. Palmer, J. (2002). *Environmental education in the 21st century: Theory, practice, progress and promise*. Routledge.

Further Reading: As suggested by the Instructor.

ENSC-718: ADVANCED REMOTE SENSING AND GIS (THEORY) (02 Credit Hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

COURSE LEARNING OUTCOMES

The students will get

- knowledge about applications of Remote sensing and GIS in Environmental sciences.
- the different freely and paid available online spatial data platforms
- the knowledge about different spatial models being used for environmental studies
- training to use the different advanced digital cartography techniques

CONTENTS

Unit-1 Spatial and non-Spatial Datasets

1.1 Raster and Vector datasets
1.2 Digitization and Topological errors
1.3 Geodatabases

Unit-2 Advanced Digital Cartography

2.1 Advancement in Cartography
2.2 Cartography techniques
2.3 Large and Small scale maps

Unit-3 Spatial Data Acquisition

3.1 Online freely available platforms
3.2 Spatial data creation
3.3 Data joining and import

Unit-4 Geo-statistical Analysis

4.1 Interpolation methods
4.2 Analytical Hierarchy process
4.3 Multicriteria indexing and scoring

Unit-5 Spatial Analysis

5.1 Site suitability techniques
5.2 Digital Elevation models
5.3 Image classification techniques

Unit-6 Spatial Modelling

6.1 Model Builder in Arc GIS
6.2 Hydrological Modeling 1D and 2D
6.3 Environmental and Hydrological Models

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- attendance, assignments and presentation,
- homework
- hands-on-activities,
- Short tests, quizzes etc.

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Kang-tsung, C. (2018). Introduction to Geographic Information Systems, 9th Edition, McGraw-Hill Education.
2. Maribeth, P. (2018). Mastering ArcGIS, 8th Edition, McGraw-Hill Education.
3. Lavender, S., & Lavender, A. (2015). Practical handbook of remote sensing. CRC Press.
4. William, E. & Adriano, C. (2017). Introduction to Satellite Remote Sensing: Atmosphere, Ocean, Land and Cryosphere Applications, 1st Edition, Elsevier, ISBN: 9780128092545
5. Liu, J. G., & Mason, P. J. (2016). Image processing and GIS for remote sensing: techniques and applications. John Wiley & Sons.
6. Fox, L. (2015). Essential Earth imaging for GIS. Esri Press.
7. Thomas, L., Ralph, W., Kiefer, J. C. (2015). Remote Sensing and Image Interpretation, 7th Edition, Wiley.
8. Mather, P. M., & Koch, M. (2011). Computer processing of remotely-sensed images: an introduction. John Wiley & Sons.

ENSC-719: SAFETY AND ENVIRONMENTAL ISSUES IN PETROLEUM INDUSTRY

(03 CREDIT HRS)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

After successful completion of this course, students will be able to:

1. Understanding of petroleum reserves at Pakistan chapter
2. To familiarize the students with advanced concepts of petroleum exploration
3. Understanding of Health safety and Environmental issues and application of controls at drilling operation, Rig installation and related activities

CONTENTS

Unit-1 Introduction environmental issues in Petroleum industry

1.1 Understanding of petroleum reserves,

1.2 Society and Energy demonds
1.3 Occurrence of petroleum exploration and production,
1.4 Exploration issues of the geophysical and geological parties.

1.5 Global distribution network of petroleum resources

1.6 Climate change and the energy industry

1.7 Carbon reduction methods

1.8 Economics of carbon reduction

Unit-2 Exploration, Drilling, Testing and Production

2.1 Economics of Exploration

2.2 Exploration tools, methods and mechanics
2.3 Rig safety issues.

2.4 Evaluation of drilling results

2.5 Oil and gas processing and fractionation of products

2.6 Properties of hydrocarbon fluids

2.7 Reserve estimation techniques

2.8 Production management techniques

2.9 Refining basics and Hydrocarbon chemistry

Unit-3 Safety Assurance and Assessment in petroleum exploration

3.1 Introduction to Safety, Health, and Environment Management in petroleum exploration

3.2 Importance of Safety in Offshore and Petroleum Industries

3.3 Objectives and Guidelines of HSE

3.4 Hazard Identification and Risk Characterization

3.5 Hazard Classification and Assessment

Unit-4 Safety and Health Measures in Design and Operation

4.1 Introduction to Purging and factors Affecting Purging

4.2 Flammability Characteristics of Liquids

4.3 Fundamentals of Fire and Explosion

4.4 Fire and Explosion Characteristics of Materials

4.5 Explosion Characteristics and Modeling

4.6 Fire and Explosion Preventive Measures

4.7 Safe Work Practices Explosion Prevention Systems

4.8 Process Safety Management (PSM) at Oil and Gas Operations

4.9 Hazard Analysis in Confined Space, Excavations, and Hazardous Environments

Unit-5 Environmental Issues in drilling of petroleum

5.1 Primary Environmental Issues in Oil and Gas Resources

5.2 Impact of Oil and Gas Industries on Marine Environment

5.3 Drilling Operations and Consequences on the environment

5.4 Pollution Produced Due to Waters During Drilling

5.5 Environmental challenges of underwater Storage Reservoirs Crude Oil

5.6 Detection of Oil Content in Marine Pollution

Unit-6 Environmental Monitoring and Management of oils spills and gaseous Release

6.1 Environmental Protection: Principles applied to Oil and Gas Activities

6.2 Environmental Impact of Oil Spill

6.3 Environmental Management: Standards and Requirements

6.4 Ecological Monitoring and assessment of oil spills

6.5 Atmospheric release of toxic gases from operational site

6.6 Evaluation of Toxic effects of Dispersed Liquid and Gas

6.7 Environmental Damage Estimate Modeling

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

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- homework
- hands-on-activities,
- short tests, quizzes etc.

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Gluyas, J.G. and Swarbrick, R.E., (2021). *Petroleum geoscience*. John Wiley & Sons.

2. Kuppusamy, S., Maddela, N.R., Megharaj, M. and Venkateswarlu, K., (2020). *Total petroleum hydrocarbons: environmental fate, toxicity, and remediation*. Springer.
3. Richard, C. S., and Stephen, A. S., (2017). *Elements of Petroleum Geology, 3rd Eds*., Academic Press.
4. Chandrasekaran, S. (2016). *Health, safety, and environmental management in offshore and petroleum engineering*. John Wiley & Sons.
5. Glendon, A.I., Clarke, S., & Mckenna, E. (2016). *Human Safety and Risk Management*, CRC Press.
6. Haimes, Y.Y., (2015). *Risk Modeling Assessment and modeling, assessment, and management*. John Wiley & Sons.

Further Reading: As suggested by the Instructor.

ENSC-720: NEW DEVELOPMENTS IN WASTEWATER TREATMENT(THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

- The aim of this course is to teach most significant advances and usage of innovative methods for wastewater treatment
- Student will develop a sound understanding of latest developments and technologies being employed presently in wastewater treatment sector
- At the end of the course, students should be able to design a most modern wastewater treatment system for municipal and industrial sectors, like petroleum, refinery, fertilizers, chemicals, pharmaceuticals, textiles, leather, paper, etc.

CONTENTS

Unit-1 Advanced Oxidation Processes (AOPs)

1.1 Ozonation , Peroxone, its combination, advantages and disadvantages
1.2 Fenton & Photo-Fenton
1.3 Ultraviolet and its combinations, such as UV, UV/O_3, UV/H_2O_2, $O_3/UV/H_2O_2$
1.4 Photocatalysis and its modern applications

Unit-2 Biological Treatments

2.1 Bio-cleaner treatment method for industrial effluents
2.2 Developments in suspended growth treatment systems: Sequencing Batch Reactors (SBR) and Rotating Biological Contactors (RBC)
2.3 Advancements in Trickling filters and Biologically active Filters
2.4 New Extended Aeration Vs. Conventional activated sludge process

Unit-3 Applications of Membrane Technology (MT)

3.1 Ultra-filtration (UF) and its application
3.2 Technological innovations in modern Reverse Osmosis (RO) treatment plant
3.3 Currents trends of using Micro-filtration (MF) for water treatment
3.4 Low-pressure membrane system Vs. high-pressure membrane systems

Unit-4 Nanotechnology in WWT

4.1 Nanofiltration (NF) and its application
4.2 Silver, Copper and Zero-Valent iron (ZVI) nanoparticles
4.3 Nano-membranes, and Nano-adsorbents
4.4 Nanocatalysts, Magnetic Nanoparticles, and Nanosensors

Unit-5 Zero Liquid Discharge

5.1 Thermal Evaporation and Crystallization Systems
5.2 Microbial fuel cells for electricity production from wastewater
5.3 Heat Recovery systems for wastewater
5.4 Electro-dialysis (ED) and electro-dialysis reversal (EDR)

Unit-6 Case Studies

6.1 Removal of micropollutants, nanoparticles and microplastics from wastewater
6.2 New disinfection technologies including UV & Ozone
6.3 Cost-effective & energy efficient treatment methods
6.4 Ultra-low energy biological treatment
6.5 Technological innovations in modern constructed wetlands
6.6 Water treatment system in Singapore: An exemplary case study

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. ProQuest Ebook Subscriptions, Rene, E. R., Shu, L., & Jegatheesan, V. (2020). *Sustainable eco-technologies for water and wastewater treatment.* IWA Publishing.
2. SpringerLink (Online service), Inamuddin, Ahamed, M. I., Lichtfouse, E., & Asiri, A. M. (2020). *Methods for bioremediation of water and wastewater pollution*. Springer.
3. Chen, J., Luo, J., Luo, Q., Pang, Z., & Group, C. E. P. (2018). *Wastewater treatment: Application of new functional materials. China Environment Publishing Group.* Walter de Gruyter.
4. PALCI EBSCO books & Barrett, L. M. (2014). *Wastewater treatment: Processes, management strategies and environmental/health impacts.* Nova Science Publishers, Inc..
5. ProQuest Ebook Subscriptions & Gernaey, K. V. (2014). *Benchmarking of control strategies for wastewater treatment plants*. IWA Publishing.
6. Metcalf & Eddy, Inc. (2003). *Wastewater engineering : treatment and reuse.* Boston :McGraw-Hill

Further Reading: As suggested by the Instructor.

ENSC-721: HAZARDOUS SOLID WASTE MANAGEMENT (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/ MPhil. Environmental Sciences or related disciplines

LEARNING OUTCOMES

- The students will learn the fundamental of hazardous solid waste generation and how hazardous it differs across countries.
- The students will understand the physical, chemical and biological characteristics of hazardous waste, and associated environmental risks.
- The students will have knowledge of global and state laws which govern the generation, handling, and storage of hazardous solid waste.
- The students will have knowledge of global hazardous waste management practices and health impacts.

CONTENTS

Unit-1 Introduction to Hazardous Waste

1.1 Introduction of hazardous Waste
1.2 Sources of hazardous Waste
1.3 Characteristics of hazardous Waste
1.4 US-EPA hazardous waste lists

Unit-2 Types of Hazardous Waste

2.1 Hazardous waste priorities
2.2 Types of hazardous wastes
2.3 Characteristics of Hazardous Waste

Unit-3 Global Laws on Transboundary movements of hazardous wastes

3.1 Basel Convention
3.2 Environmental sound management
3.3 Hazardous waste laws
3.4 Guidelines for generator, Transportation, storage, and disposal facility requirement

Unit-4 Hazardous Waste Treatment

4.1 Physical treatment
4.2 Chemical treatment (precipitation, oxidation and reduction, Sorption, and stabilization)
4.3 Incineration of hazardous waste
4.4 Combustion standards under RCRA

Unit-5 Hazardous Waste Treatment Centers, Management and Disposal

5.1 Hazardous waste treatment centers and design approach
5.2 Waste treatment prior to land disposal
5.3 Land disposal restrictions
5.4 Management issues in Nuclear Waste Disposal

Unit-6 Hazardous Waste Practices

6.1 Best practices of hazardous waste management in world (developed/developing)
6.2 Hazardous waste management regulations in Pakistan
6.3 Transition to Low waste society

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- classroom participation,
- attendance, assignments and presentation,

- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Cabaniss, A. D. (Ed.). (2018). *Handbook on household hazardous waste*. Rowman & Littlefield.
2. Goel, S. (Ed.). (2017). *Advances in solid and hazardous waste management*. Springer.
3. Blackman Jr, W. C. (2016). *Basic hazardous waste management*. CRC press.
4. Buckley, J.F. (2017). *RCRA Regulations & Keyword Index 2017*. Walters Kluwer Law and Business, Netherlands.
5. Rao, M. N., Sultana, R., Kota, S. H., Shah, A., & Davergave, N. (2016). *Solid and hazardous waste management: science and engineering*. Elsevier Publishing.
6. LaGrega, M. D., Buckingham, P. L., & Evans, J. C. (2010). *Hazardous waste management*. Waveland Press.

Further Reading: As suggested by the Instructor.

ENSC-722: URBAN GREEN SPACE SYSTEM (THEORY) Credit hours (03 Hrs)

PRE-REQUISITE: MS/MPhil. in Environmental Sciences or Equivalent

LEARNING OUTCOMES

- Understand the need of urban ecosystem research and green infrastructure in cities
- Analyze and discuss best practices for management of urban green and blue areas
- Critically evaluate the key principles relating to urban ecosystems thinking and ecosystem services
- Display a knowledge and understanding of advanced methodologies relating to ecosystems services and landscape planning

CONTENTS

Unit 1: Human Development and its Impact on Environment

1.1 History of human development

1.2 Human development and alteration in natural habitats
1.3 Human development and decreasing green spaces

Unit 2: Introduction and Need of Urban Green Space

2.1 Differences between open space and green space

2.2 Components of urban green space
2.3 Modern urban infrastructure and green space
2.4 Challenges in maintaining green in modern urban structure
2.5 Urban green spaces and human lifestyle

Unit 3: Urban green Spaces and Human Well-Being

3.1 Recreational, Aesthetic and psychological benefits

3.2 Urban green spaces and human health benefits
3.3 Economic, social and cultural well being
3.4 Air pollution and urban green spaces
3.5 Carbon sequestration and urban green spaces

Unit 4: Biodiversity and Urban Green Spaces

4.1 Urbanization and species decline
4.2 Linkage between urban biodiversity and urban green space
4.3 Urban biodiversity services
4.4 Opportunities of habitat in modern urban infrastructure

Unit 5: Urban green Spaces and Climate Change Effects

5.1 Intensity of changing climate effects in cities
5.2 Concept of urban heat island
5.3 Urban floods, windstorms, cyclones etc. and urban green spaces
5.4 Weather pattern regulation and urban green spaces

Unit 6: Urban Structures and Sustainable Activities

6.1 Linking municipal waste with green value added products
6.2 Gardening, protecting trees, development of Parks
6.3 Behavioral developments towards green cities

Unit 7: Development of Green Spaces

7.1 Urban forestation
7.2 Increasing green belts
7.3 plantation of fruit trees
7.4 Concepts of green roofs, green walls
7.5 Case studies of increasing urban green spaces

Unit 8: Management of Urban Green Space System

8.1 Community involvement

8.2 Social awareness
8.3 Volunteers services

8.4 Public private partnerships
8.5 Laws and regulations

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

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- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

- Pearlmutter, D., Calfapietra, C., Samson, R., O'Brien, L., Ostoić, S. K., Sanesi, G., & del Amo, R. A. (Eds.). (2017). *The urban forest: cultivating green infrastructure for people and the environment* (Vol. 7). Springer.
- Ning, Z. H., Nowak, D. J., & Watson, G. W. (2017). *Urban forest sustainability*. Champaign: International Society of Arboriculture.
- Salbitano, F., Borelli, S., Lonigliaro, M., Chen, Y., (2016). *Guidelines on unban and peri-urban forestry by FAO* (Publishers).
- Sandberg, L. A., Bardekjian, A., & Butt, S. (Eds.). (2014). *Urban forests, trees, and greenspace: A political ecology perspective*. Routledge.
- Harnik, P., (2012). Urban Green – *InnovativeParks for Resurgent Cities*. Island Press.
- Mambretti, .I.M., (2011). *Urban Parks Between Safety and Aesthetics: Exploring Urban Green Space Using Visualisation and Conjoint Analysis Methods.* IRL-Bericht.
- Gaston, K.J. (2010). *Urban Ecology*. Cambridge University Press.
- Chen, W. Y., & Jim, C. Y. (2008). *Assessment and valuation of the ecosystem services provided by urban forests.* Ecology, planning, and management of urban forests, 53-83.

Further Reading: As suggested by the Instructor.

ENSC 723 STRATEGIC ENVIRONMENTAL ASSESSMENT (THEORY) (03 Credit hrs)

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

LEARNING OUTCOMES

After the completion of this course, the students will be able to

- Understand the basic concepts and components of Strategic Environmental Assessment (SEA)
- Rationally analyze the objectives underlying SEA
- Understand the methods used for baseline data collection and impact prediction
- To prepare a comprehensive SEA Report

CONTENTS

Unit-1 Introduction to Strategic Environmental Assessment

1.1 The Origins of Environmental Assessment.
1.2 Principles of SEA
1.3 Objectives and Stages of SEA
1.4 Environmental Impact Assessment and SEA
1.5 Advantages and disadvantages of SEA

Unit-2 Strategic Environmental Assessment Protocols

2.1 Strategic Environmental Assessment Directives of European union
2.2 Strategic Environmental Assessment protocols of UNECE,
2.3 The world bank piloting SEA in polices and reform sectors
2.4 A critical analysis of SEA directives and protocols

Unit-3 Strategic Environmental Assessment process

3.1 SEA and quality assurance,
3.2 screening process of SEA,
3.3 SEA as a decision making tool,
3.4 SEA baseline,
3.5 How to collect and document SEA baseline data,
3.6 Scoping and decision of goals in SEA,

Unit-4 Environmental Baseline and SEA

4.1 Identification of Environmental Problems
4.2 Indicators, objectives, and targets in SEA
4.3 Collecting and documenting environmental baseline data
4.4 Setting targets and linking to strategic actions

Unit-5 SEA Implementation, Reporting, Review and Monitoring

5.1 Detailed study of all elements of SEA
5.2 A critical study of alternatives, reiteration process and scoping stages,
5.3 A study of evaluation and prediction techniques in SEA,
5.4 How to organize document data and Monitoring process in Capacity building in SEA

Unit-6 SEA Implementation in different Developmental plans

6.1 Assessing Biodiversity in SEA
6.2 SEA in Urban and Transport Planning
6.3 SEA for Agricultural Program
6.4 SEA of Waste Management Plans
6.5 Use of SEA in Industry, Energy and Sustainable Development
6.6 SEA and Future Challenges and Possibilities

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Fischer, T.B. and González, A. eds., (2021). *Handbook on Strategic Environmental Assessment.* Edward Elgar Publishing.
2. Campeol, G. ed., (2020). *Strategic Environmental Assessment and Urban Planning: Methodological Reflections and Case Studies*. Springer Nature.
3. Anji, R. M., (2017). *Environment Impact Assessment: Theory and Practice, Butterworth Heinemann,* Elsevier.
4. Cutaia, F. (2016). *Strategic Environmental Assessment: Integrating landscape and Urban Planning,* Spring International publishing, pp 1-111.
5. Therivel, R. (2012). *Strategic environmental assessment in action*. Routledge.
6. Sadler, B., Aschemann, R., Dusik, J., Fischer, T. B., Partidario, M. R., & Verheem, R. (2011). *Handbook of Strategic Environmental Assessment, Earthscan,* U.S.A.
7. Ahmed, K., & Amohez-triana, E. (2008). *Strategic environmental assessment for policies: an instrument for good governance,* Washington, D.C" World Bank, pp1-238.
8. Fischar, T., B. (2007). *Theory & Practice of strategic environmental assessment: Toward a more systematic approach,* UK and USA, pp 1-208.

Assorted research papers

Further Reading: As suggested by the Instructor.

ENSC 724 **FRESHWATER ECOLOGY (THEORY)** **Credit hours (03 Hrs)**

PRE-REQUISITE: MS/M.Phil Environmental Sciences or related disciplines

Learning outcomes

- To understand knowledge of Basic limnology and water quality of freshwater bodies
- Overview of major functional groups of organisms in freshwater
- Effects of land use, climate change and other anthropogenic sources of influence on freshwater ecosystems
- Effects of abiotic factors on eco-physiology and life history of freshwater organisms
- Effects of abiotic factors on trophic interactions, with emphasis on competition, predation and parasitism Phenotypic responses to trophic interactions
- The role of bottom-up vs. top-down regulation in freshwater food webs
- To understand environmental problems in freshwater and the regulatory mechanisms for management of freshwater
- To underpin the knowledge about RAMSAR convention on wetlands and its significance in managing wetlands

Contents

Unit 1: Fundamental of Freshwater ecosystem and water quality
- 1.1 Introduction to freshwater resources
- 1.2 Water quality and its significance in freshwater resources
- 1.3 The concern of declining freshwater resources
- 1.4 Sustainability and freshwater resources

Unit 2: Types, formation and composition of freshwater ecosystems
- 2.1 Types of freshwater bodies
- 2.2 Formation of lakes, streams, rivers, wetlands
- 2.3 Groundwater systems and its significance
- 2.4 Nutrients recycling and trophodynamics in freshwater
- 2.5 Economic and ecological importance of freshwater resources

Unit 3: Chemistry and biodiversity of lentic and lotic water
- 3.1 Different zones and its properties in a typical freshwater body
- 3.2 Light penetration and oxygen availability in different zones
- 3.3 Organic contents in freshwater bodies
- 3.4 Microbial diversity in freshwater bodies
- 3.5 Invertebrates and phytoplankton in freshwater
- 3.6 Animals and plants diversity in freshwater ecosystem

Unit 4: Fish ecology and fisheries
- 4.1 Freshwater: habitat of fish
- 4.2 Types of fish in freshwater bodies
- 4.3 Feeding, breeding and behavioural ecology of fish in freshwater
- 4.4 Fisheries and economic benefits
- 4.5 Concern of invasive fish species and extinctions

Units 5: Pollution challenge in freshwater
- 5.1 Micropollutants in freshwater bodies
- 5.2 Level and risk assessment of micropollutants in freshwater bodies
- 5.3 Eutrophication and its control
- 5.4 Pollution management strategies for freshwater

Unit 6: Anthropogenic activities and freshwater resources
- 6.1 Agriculture and freshwater resources
- 6.2 Urbanization and freshwater resources
- 6.3 Climate change and freshwater resources
- 6.4 Human needs and freshwater resource

Unit 7: Future prospects of freshwater resources

7.1 Past current and future scenario of world freshwater resource
7.2 Water scarcity for drinking, agriculture and industry and other human needs
7.3 Droughts and famine challenges
7.4 Threats of desertification, habitat loss, food and water scarcity for wildlife

Unit 8: Sustainable management of freshwater resource

8.1 Protecting wetlands
8.2 Minimize explorations and enhance recharge
8.3 Human Behavioral changes to minimize water loss
8.4 Ramsar Conventions and its role in wetlands conservation
8.5 Ramsar sites of Pakistan

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Moss, B. R., (2018). **Ecology of Freshwaters:** *Earth's Bloodstream Publisher:* Wiley.
2. Mamta, R., Sumit, D., & Chandrakasan, S., (eds.) (2015). *Aquatic Ecosystem: Biodiversity, Ecology and Conservation,* Springer, India.
3. Brian, M., (2010). *Ecology of freshwaters : a view for the twenty-first century fourth edition,* John Wiley & Sons Ltd, UK
4. Closs, G., Downes, B., & Boulton, A., (2009*). Freshwater ecology: a scientific introduction.* John Wiley & Sons.
5. Dobson, M., & Frid, C., (2008). *Ecology of aquatic systems*. Oxford University Press.
6. Lampert, W., & Sommer, U. (2007). *Limno ecology: The Ecology of Lakes and Streams*. Oxford University Press, New York.
7. Bobbink, R., Beltman, B., Verhoeven, J. T., & Whigham, D. F. (Eds.). (2007). *Wetlands: functioning, biodiversity conservation, and restoration (Vol. 191).* Springer Science & Business Media.
8. Dodds, W.K. (2002). *Freshwater Ecology: Concepts and Env. Applications*. Academic Press. London.
9. Dodds, W.K., & Whiles, M.R. (2002). *Freshwater Ecology: Concepts and Environmental Applications of Limnology.* 2nd Ed. Academic Press. London.

Further Reading: As suggested by the Instructor.