केरल केंद्रीय विश्वविद्यालय
CENTRAL UNIVERSITY OF KERALA

(संसद के अधिनियम, वर्ष 2009 द्वारा स्थापित / *Established under the Act of Parliament in 2009)*

Ref: No.CUK/ACA/IIIrd AC/5th Meeting/736/2019-20/ Dated, 15th July 2019

MINUTES OF THE 5TH MEETING OF THE 3RD ACADEMIC COUNCIL HELD AT 10.30 AM ON 28TH JUNE 2019 AT CUK.

AC 03:05:01 ***Approval of the minutes of the last Academic Council-Reg:-***

The Minutes of the Academic Council meeting held on 12.12.2018 was placed before the Academic Council for approval.

Decision: Minutes approved

AC 03:05:02 ***Approval of the Action Taken Report - Reg:-***

The Action Taken Reports (ATR) of the Academic Council Meeting held on 12.12.2018 was placed before the Academic Council for approval.

Decision: ATR approved

AC 03:05:03 ***CUCET be made mandatory for NET Qualified candidates - Reg:-***

As per clause 1 of Regulations No.1/2018 for the award of the degree of Doctor of Philosophy (PhD) of the Central University of Kerala 2018 dated 06.08.2018, application for admission to the PhD programme will be invited twice in a year i.e. June-July and December –January. The June – July admission is done through the CUCET. Only JRF and similar fellowship holders are exempted from the CUCET score. However they are required to register through the CUCET if they are seeking admission during this round. The December- January admission is exclusively reserved for to JRF and similar fellowship holders.

It is often creating confusion with the UGC-JRF and UGC-NET (Only) qualifications as an exemption for appearing for CUCET for Ph.D. Admission.

Therefore, it is proposed that the UGC-NET qualified candidates have to appear invariably for CUCET for admission for Ph.D. This is subject to approval by EC also.

Decision: The Academic Council approved the proposal and recommended to EC for its consideration.

AC 03:05:04 ***Academic Performance Review- MHRD- Reg:-***

a) The Vice Chancellors meeting held on 15.12.2018 at Shastri Bhawan, New Delhi with Secretary, MHRD and Chairman of UGC to review the implementation status of all parameters indicated by the Central Universities in the Tripartite MoU (CUK, MHRD & UGC). In accordance with the decisions of the meeting the following Circular were issued wide Circular No. CUK/ACA/728/2018-19/1877 &1878 , dated 13.03.2019

   i) To discourage research in irrelevant areas. When Fellows are being admitted for PhDs, the topics for the thesis should be in accordance with the national priorities. Allotting privilege topics to the PhD students should be dispensed with;

   ii) Therefore, all the Heads of the Department is hereby directed to convene the meeting of the Faculties and to prepare a shelf of project to be taken for research study pertaining to their subject considering national priorities. The student can opt from the shelf of project.

b) i. Take advantage of the unique initiative of online professional development of in-service teachers' using MOOCs platform SWAYAM- Annual Refresher Programme in Teaching (ARPIT) launched by MHRD. It has been decided by the UGC that successful completion of the courses offered under the ARPIT programme with 40 hour of instruction material with a proctored examination will be treated as equivalent to one Refresher Course for the purposes of Career Advancement. Compulsory enrollment of all the teachers in this program may be ensured.

b) ii. Actively participate in the recently launched scheme "impactful Policy Research in Social Sciences (IMPRESS)" and encourage their faculty members to send proposal to ICSSR. Each CU at least has one project under this scheme. Professors may also be advised to participate in other schemes of DST and MHRD such as IMPRINT, SPARK and STARS.

b) iii. Nominate good researchers to IPR Cell for patents.

b) iv. Discourage Non-NET in order to ensure good quality research scholars/papers.

b) v. Encourage research publications and each teacher should have at least two publications in a year.

The Circulars issued by the University and Minutes of the Tripartite MoU meeting of Vice-Chancellor's are placed before the Academic Council for appropriate decision.

Decision: The Academic Council discussed the matter in detail. During the discussion on a(i) and (ii) the VC has pointed out that MHRD had already issued a clarification regarding the subject that it was a matter discussed in VCs conference and the discussions were recorded and minutes prepared. It was not the decision of MHRD. VC further pointed out that the circular was of advisory nature and it is for the HODs to consider it or not. The clarification given by VC has been accepted. Other agenda items were also approved.

AC 03:05:05 ***Introduction of Vocational Courses- Reg:-***

The Vice Chancellors meeting held at Shastri Bhawan, New Delhi to review the implementation status of all parameters indicated by Central Universities in the Tripartite MoU (CUK, MHRD & UGC). In accordance with the decisions of the meeting it is also decided to introduce vocational courses not only in service sectors but also on other important areas like agriculture sector etc.

Decision:-

The AC welcomed the proposal. To have greater thrust in this area Dr. Ifthikar Ahmed has been nominated as the Coordinator for drafting the proposal and follow up work by the AC.

AC 03:05:06 Commencement of P.G. Diploma Courses in Dept. of Hindi - Reg.

The Dept. of Hindi in its BoS 08.03.2019 has proposed to start following Hindi Diploma courses from this Academic Year i.e. 2019-2020. The Competent authority has approved the proposal on 16.04.2019 subject to Academic Council ratification. **(Annexure - IV)**

i. Post –Graduate Diploma in Mass Communication in Hindi

ii. Post –Graduate Diploma in Translation and Office Procedure

Decision: AC Ratified the Proposal. Credits shall be as per the CBCS/Diploma Regulations of CUK. VC pointed out that other Departments can also try for similar proposals. The HoD EVS should take action to introduce a PG diploma in EVS with the support of External agencies

A sub-committee has been constituted to frame guidelines for the operationalization of Certificate/Diploma/PG Diploma of CUK with following members: HOD Hindi (Coordinator), HoD Education, HoD English and Dr TJ Joseph Asst Professor, Economics .

AC 03:05:07 Approval of the BoS Minutes and Syllabus – Reg.

The following Departments have conducted their BoS for revision of syllabus. The revised syllabus is attached;

i. **Dept. of Hindi:-**

The BoS met on 08.03.2019, and approved the syllabus of MA Hindi and Ph.D. Course Work **(Annexure V-A)**

The revised syllabus of Ph.D. Course Work and MA Hindi and Comparative Literature to be implemented from 2019- academic year onwards.

Decision: The Academic Council approved the syllabus containing 72 credits incorporated with many contemporary items.

ii. **Dept. of Mathematics:-**

The BoS Meeting of Dept. of Mathematics held on 07.02.2019 has approved the revised syllabus of M.Sc. Mathematics to be implemented from 2019 onwards.

Decision: The Academic Council approved the proposal (72 credits)

iii. **Dept. of Plant Science:-**

The BoS Meeting of Dept. of Plant Science held on 15.04.2019 has proposed a revised syllabus of M.Sc. Plant Science. This is to be made effective from 2019- onwards.

Decision: The Academic Council approved the proposal in principle. The AC suggested 8 credits for both dissertation and viva voce together. The AC further pointed out to have Continuous Assessment of 40 marks and it is to be moderated by guide. Dissertation requires to be treated as a Core Course with double valuation.

iv. **Dept. of Environmental Science:-**

The BoS Meeting of Dept. of EVS held on 03.06.2019 has proposed a modified syllabus (Skeleton) and scheme of Evaluation for M.Sc. Environmental Science effective from 2019 onwards. **(Annexure V-D)**

Decision: Resolved to approve the syllabus with retrospective effect 2018-19. AC directed the department to change the Credits for core courses from the existing 3 to 4 credits.

AC resolved to have only one external evaluation and one internal evaluation for each core course.

v. **Dept. of Computer Science:-**

The BoS Meeting of Dept. of Computer Science held on 05.01.2019 (Minutes Enclosed) has proposed the following. **(Annexure V-E)**

i. Revised programme Structure for M.Sc. Computer Science(2019 Onwards).

ii. Establishment of Computational Intelligence

iii. Amendment on the Eligibility conditions for M.Sc. Computer Sciences(from next year onwards)

Decision: AC approved the proposal.

The Academic Council also constituted a committee to revisit the issue of credits to be assigned to Elective courses with Controller of Examinations, Dr. Govinda Rao, Dr. Rajendra Pilankatta and AR (Academic) to finalise the credit matter.

AC 03:05:08 New Departments – Commencement -Reg.

The UGC vide letter No. F.No.1-1/2013(CU) Vol-XVII dated 06.03.2019 has conveyed the approval of the University Grants Commission for commencing 4 New Department and also confirmed the establishment of Dept. of International Relations (UG). Accordingly(**ANNEXURE X**).

1. **Dept. of Management Studies:-** A meeting of the duly constituted Consultative Committee for **MBA** Programme was held on 8.05.2019 and 29-30 May 2019 for deliberation on implementation of MBA Scheme, Regulation, Syllabus and qualification for faculty recruitment. Proceeding of the Committee is placed at **(Annexure VI)** for perusal please. The total credit will be 100 with 4 semesters.

   The Committee recommended commencing of the MBA Programme at the Central University of Kerala during the Academic year 2019-20 in accordance with UGC guidelines /AICTE regulations.

   The regulations framed by the Consultative Committee may be adopted in the University for Commencement of MBA Programme.

2. **Dept. of Tourism Studies:- MBA in T&TM**. The Consultative Committee of Tourism and Travel Management met on 16.05.2019 and 06.06.2019 at CUK Periya and finalized the MBA as MBA (Tourism and Travel Management). The total credit will be 100 with 4 semesters. **(Annexure VII)**

3. **Dept. of Commerce and International Business:- M.Com**. The Consultative Committee met on 18.05.2019 and 07.06.2019 and finalized the syllabus of Commerce and International Business **(Annexure VIII)**.

   The Consultative Committee finalized two programmes i.e. M.Com and M.Com (International Business) however, recommend the University to offer M.Com from this academic year.

   Recommended for establishing separate Computer Lab with minimum 30 Computers.

   Investment of Rs.5 Lakhs for books, Journal including e resources in this regard.

   80 credits minimum and 12 credits for electives.

4. **Dept. of Kannada:-** the Consultative Committee met on 16.05.2019 and 07.06.2019 at periya finalized the syllabus of **MA Kannada** four Semester programme. The Syllabus contains 15 core papers and 12 elective papers. **(Annexure IX)**

Decision: Academic Council noted and approved the syllabus prepared by consultative committee of the new 4 Departments with suggestion to change the word 'open' as Elective. The Syllabus will be revisited once BoS of the Department become functional.

AC 03:05:09 **CUK Ordinance 38 –Ordinance on the Recognition of Associations for Teachers and Non-Teaching Employees of the University –Reg.**

The Executive Council in its meeting vide items No. EC: 03:11:16, held on 24.01.2019 has approved the Ordinance on the Recognition of Associations for Teachers and Non-Teaching Employees of the University. The E.C. authorized the VC to notify the Ordinance.

As Per Statute 14 (d) of CU act the Academic Council is the authority to prepare the Ordinances of the University and recommend the same to the Executive Council for approval. Considering the Emergency situation, as per Clause 11(3) of the University Act 2009, the Vice-Chancellor has approved the

draft Ordinance -38 (Mentioned as 40 in the EC Minutes) and after legal vetting submitted the same for the approval of the Executive Council.

Decision: The Academic Council approved the Ordinance with dissent of Dr. Joseph Koyippally, Dr. Vilfred, Prof. (Dr.) Ajith Kumar and Dr. T J Joseph on the 33% of working strength mandated for Association to have its approval and existence as per Ordinance 38. However the Vice-Chancellor pointed that the matter is under the consideration of the Hon. High Court and hence further implementation of the Odinance-38 will be as per the decision of the Hon. Court.

AC 03:05:10 ***Awarding Degrees during Convocation 2019 - Ratification – Reg.***

The Controller of Examination has informed that 692 Candidates (UG 45, PG. 635 and Ph.D. -12) have applied for receiving the Degree in the Third convocation held on 02.03.2019. Since the time was insufficient to convene the meeting of the Academic Council, the Vice-chancellor by exercising his powers under section 11 (3) of University Act 2009 has approved awarding of the degrees.

Decision: The Academic Council ratified the action.

AC 03:05:11 **Extension of Ph.D. Registration**

As per the Order No. CUK/ACA/Ph.D. Physics/11/14 dated 04.04.2019 based on the recommendation of The Department Research Committee, Dept. of Physics dated 16.01.2019, the Ph.D. Registration of following scholars have been extended as follows(ANNEXURE XIV).

l.No.	Name of Scholar & Reg. No.	Dt. of Registration.	Registration period completed	Extension required
1	Mr. Shareef. M. MPH071301	05.02.2013	04.02.2019	1 year 05.02.2019 04.02.2020
2.	Ms. Subha A, MPH071302	04.02.2013	03.02.2019	1 year 04.02.2019 03.02.2020

During this period they are not entitled for any fellowship.

As per UGC regulation 2016 the maximum duration of Ph.D. is Six years which are extendable by one year for Male and 2 years for female. Extension beyond the above limits will be governed by the relevant clauses as stipulated in the statute/Ordinance of the University.

As per CUK Ordinance 12, clause 2, Extension beyond the above limits will be decided by the Academic Council/Executive Council of the University on the basis of the recommendations of the Research Advisory Committee. As per Clause 30 (iii), the DRC shall be competent to recommend to the Director Research to extend the period of Registration for one more year on the recommendations of the RAC based on satisfactory progress made by the research students.

Accordingly, the Registration of Research of above scholars has been extended by one year as indicated against their name.

Decision: The Academic Council ratified the action.

AC 03:05:12 PBAS of Teachers

The committee constituted vide Order CUK/PBAS/TEACH/2017 dated 07.12.2018, to study and finalize the procedure for performance Based Appraisal System for Teachers has recommended the University to call for performance Based Appraisal System annually from all faculty members to be submitted within three months at the end of every academic year as a mandatory part for CAS Promotions.

The Minutes of the committee and proforma developed by the Committee for CUK incorporating the latest UGC Regulation 2018 is placed before the Academic Council for approval.

Decision: The Academic Council approved revised PBAS proforma.

AC 03:05:13 Consideration of PhD Thesis submission as a vacancy for Research Guide- Reg.

The Central University of Kerala Ordinance and Regulations was silent on the stage of arising of PhD vacancy under a Research Guide. i.e, whether at thesis submission time or after Open Defence. It is observed that the time gap between thesis submission and conduct of open defence vary from Institution to Institution. Hence, a suitable policy decision on the stage at which vacancy can be treated as arisen is to be made by the AC.

Decision: The Academic Council did not approve the agenda. However, the Academic Council resolved to consider requests on case to case basis depending on the merit. On this particular aspect, AC resolved to collect a representation from Dr. Sudha, Associate Professor, Animal science and authorized VC to take a decision.

AC 03:05:14 AA **To consider amendment in the Revised CBCS Regulations for PG Programmes -*Reg:-***

As per clause 54 of Revised CBCS Regulations, "In determining the grades for courses, Continuous Assessment shall carry 40% weightage, while End Semester Assessment shall carry 60% weightage. For Dissertation, weightage for Continuous Assessment is 40% and for viva it is 60%". It is submitted by the Head, Dept. of International Relations and Dept.of Public Administration, that no Continuous Assessment is possible for Dissertation/Viva Course.

Hence clause 54 may be amended as follows.

> "In determining the grades for courses, Continuous Assessment shall carry 40% weightage, while End Semester Assessment shall carry 60% weightage. For dissertation, there shall be no Continuous Assessment"

Further, clause 54 (a) may be inserted as follows.

54 (a) For PG Degree programmes, out of 100 marks for Dissertation/Viva, 40 marks is to be awarded by internal examiner, 40 marks by external examiner for Dissertation and 20 marks by external for Viva voce.

Decision: The Academic Council resolved to adopt the decision on agenda item 03:05:07.

AC 03:15: AA **To consider amendment in the Regulations for BA programme in International Relations - *Reg:-***

As per clause 9.3 of BA Regulations, "In determining the grades for courses, Continuous Assessment shall carry 40% weightage, while End Semester Assessment shall carry 60% weightage. For Dissertation, weightage for Continuous Assessment is 40% and for viva it is 60%".

But as per clause 10.3, there shall be no continuous assessment for Dissertation/Project work.

Thus there exists contradiction between these two clauses.

Hence following modifications are proposed.

1. 9.3 may be amended as follows. "In determining the grades for courses, Continuous Assessment shall carry 40% weightage, while End Semester Assessment shall carry 60% weightage. For dissertation, there shall be no Continuous Assessment"

2. Further, 9.3 (a) may be inserted as, "Out of 100 marks for Dissertation/Viva, 40 marks is to be awarded by internal examiner, 40 marks by external examiner for Dissertation and 20 marks by external for Viva voce."

3. 10.3 may be amended as, "Two copies of the report of the Project/Dissertation Work shall be submitted by the student in the prescribed format to the Department before the completion of the sixth semester."

A new CBCS Form III (a) has been designed for Dissertation and appended. Form II need not be submitted. The same may be approved.

Decision: The Academic Council resolved that BOS be convened and a new syllabus be prepared by the Department at the earliest and submit to university for further consideration.

AC 03:05:16 AA ***To consider levying of late fee for delayed application for additional examination -Reg:-***

As per clause 76 & 78 of Revised CBCS Regulations, a student getting F grade shall remit the fees for additional examination within 5 teaching days and apply within 3 weeks from the date of publication of the results. Since late

submission of applications is increasing day by day, a late fee may be imposed to discourage such instances as follows.

i) Till 10 working days from the date of publication of the result : NIL

ii) For delay from 11th day till 21st day: Rs.100/- per paper

iii) Beyond 22nd day till one month: Rs.200/- per paper, with special permission from V C.

Decision: The Academic Council approved the proposal.

AC 03:05:17 AA **Equivalency of M.Sc. Animal Science to M.Sc. Zoology with a retrospective effect - *Reg:-***

3rd meeting of IIIrd Academic Council has approved the proposal of Dept. of Animal Science for changing of name of M.Sc. Animal Science to M.Sc. Zoology w.e.f. 2019-20.

The University has later received requests from pass out students of M.Sc. Animal Science that they are facing difficulties while applying for research or teaching positions outside the Kerala State and also during interview and verification process. The name Animal Science is often confused with the veterinary Science course. The equivalency Certificate issued by University of Kerala could be used only in the state of Kerala.

Hence, in order to cater the employment related needs, a Notification on equivalency of M.Sc. Animal Science as M.Sc. Zoology may be approved with retrospective effect.

Decision: Academic Council rejected the proposal. The AC suggested that whenever requests are received HOD may issue Equivalency Certificate to the students without delay.

AC 03:05:18 AA **Exemption from CBCS Regulations clause 54 - *Reg:-***

The Heads Dept. of International Relations and Politics and Public Administration & Policy Studies have informed that as per the provisions of CBCS regulations clause 54, for dissertation, weightage for continuous assessment is 40% and for viva it is 60%. As per the approved syllabus of MA IR&PS and PA&PS dissertation carries a weightage of 4 credits and

viva 4 credits, i.e. Dissertation and Viva Carries 200 marks. Viva is comprehensive in nature, as it covers all the courses included in the programme. Continuous Assessment is not there for the dissertation, considering the practical difficulty in calculating the same. The mismatch between the provisions of CBCS Regulations and the approved Syllabus will affect the declaration of Results of MA (IR&P and PA&PS).

Therefore, both departments have requested to exempt the provisions of CBCS Regulation Clause 54 for MA (International Relations and Politics and Public Administration & Policy Studies.

Decision: The implementation of resolution AC03:05:07 will resolve the problem

AC 03:05:19 AA Regulations for Post – Graduate Diploma in Yoga Programmes under Choice Based Credit and Semester System -Reg.

The Academic Coordinator, Dept. of Yoga has proposed the Regulations for Post – Graduate Diploma in Yoga Programmes under Choice Based Credit and Semester System. The Examination Branch after verification has suggested some correction and to revise the Regulations. Accordingly, the revised regulation is placed before the Academic Council.

Decision: Academic Council approved the Regulations containing 36 credits for 2 semesters.

AC 03:05:20 AA Approval of the BoS Minutes and Syllabus – Reg.

The Department of Biochemistry and Molecular Biology have conducted BoS meeting on 18.12.2018 and the syllabus of M.Sc. Biochemistry is revised. The revised syllabus to be implemented from 2019- academic year onwards.

Decision: Academic Council approved the proposal.

AC 03:05:21 AA Commencement of Certificate Course for CUK employees - Reg.

As per the minutes of the meeting of Faculty Members and Hindi Officer with Vice-Chancellor on 18.03.2019 it has been decided for starting the Certificate Course for CUK employees for implementation of Official Language Policy of Govt. of India. The meeting has resolved to commence short term course for CUK employees in 2019. The Head of the Department of Hindi has proposed the details of syllabus for the course.

Decision: Academic Council approved the proposal.

AC 03:05:22 AA **Change of name of M.Sc. Plant Science to M.Sc. Botany - Reg.**

The Academic Council meeting held on 01st June 2018, while approving the name change of Animal Science suggested that the Dept. Plant Science also may submit their proposal for title rationalization. Accordingly, the Faculty Council of Dept. of Plant Science has now proposed (26.06.2019) to retain the department name as Plant Science and to rename the M.Sc. programme as M.Sc. Botany.

Decision: Academic Council approved the proposal and recommended EC for its consideration.

Minutes of Tabled Agendas

1. **Clarification on CA & ESA of LL.M Students and request for approval of Clause 39 (x)**

The LL.M course was introduced in the University in the year 2014 and since then LL.M in Administrative Law and Commercial Law was offered as specializations courses. However in the year 2018 Intellectual Property Rights (IPR) and Constitutional Law were introduced as additional specializations which were approved by the Board of Studies in Law as well as the Academic Council of the University. Thereafter the LL.M course was running with three specializations namely Constitutional Law, Criminal Law and IPR- out of which Constitutional Law (LML 5106) was opted by all students of 2018-20 batch whereas IPR(LML 5107) was opted by 14 students and Criminal Law (LML 5105) was opted by 10 students of the said batch. In this regard, it was informed by the examination branch that the newly introduced courses were not properly recorded in the exam branch and the same is to be added in the Parent regulation (CBCS) as clause 39(C) for approving the same by exercising power under clause 101 and for the forthcoming batches of LL.M it may be added to the parent regulation as clause 39(C) in the following terms.

The specializations in the department are the following ones:

(1) Administrative Law (2) Commercial Law (3) Constitutional Law (4) Criminal Law (5) Health Care Law (6) Public International Law (7) Labour Law (8) Environmental Law (9) Intellectual Property Law. A student has to undergo course in two specializations apart from compulsory core courses and elective courses. Students can choose combination of specialization course which will be offered by the department in particular year.

Decision: Academic Council approved the proposal.

2. Dept. of Law, BOS meeting minutes of Law (13/05/2019)

Concerning revision of Syllabus of IPR Criminal Law and Constitution from 2019 onwards – Reg.

The BoS minutes and resolutions on revision of syllabus of IPR (Law and Constitution was placed before the Academic Council. While approving the Syllabus, The AC insisted to follow compulsory core courses.

Regarding valuation many difficulties were expressed by the Department in getting Associate or Professor Cadres for valuation, AC resolved to invite faculties with 8 years of experience as Assistant Professor or Retired Associate Professors for this. This is only to be made applicable for Law department considering the dearth of suitable experts as expressed by HoD, Law.

Decision: Academic Council approved

3. <u>Dept. of Education: BoS meeting minutes and revised Syllabus</u>

Decision: Resolved to approve the syllabus from 2019-20 onwards.

Approved the online MOOC courses by SWAYAM as an enhancement programme for the students.

40 marks for evaluation (both internal & External) & 20 marks for Viva-Voce

4. The CAS Application form Developed by IQAC as per UGC 2018 regulation:

In connection with Agenda 3:05:12 on PBAS of Teachers, the IQAC also proposed before the Academic Council the CAS (Revised PBAS Promotion Proforma) application form approved by the Vice-Chancellor.

Decision: Academic Council approved the proposal.

कुलसचिव / REGISTRAR

Programme: M.Sc. Environmental Science

DEPARTMENT OF ENVIRONMENTAL SCIENCE
SCHOOL OF EARTH SCIENCE SYSTEMS
CENTRAL UNIVERSITY OF KERALA

Revised Syllabus effective from December 2021

M.Sc. Environmental Science Programme Structure

Course Code	Title	L	T	P	Credits
First Semester					
EES 5101	Fundamentals of Ecology and Environmental Science	2	1	0	3
EES 5102	Environmental Toxicology and Health	2	1	0	3
EES 5103	Environmental Techniques	2	1	0	3
EES 5104	Climate Change and Current Issues	2	1	0	3
EES5105	Practical I – Ecology			1	1
EES5106	Practical II – Environmental Toxicology			1	1
EES5107	Practical III – Environmental Techniques			1	1
Total Credits					15
Second Semester					
EES 5208	Environmental Microbiology and Biotechnology	2	1	0	3
EES 5209	Environmental Pollution and Control	2	1	0	3
EES 5210	Waste Management	2	1	0	3
EES 5211	EIA and Environmental Auditing	2	1	0	3
EES 5212	Natural Resources Management	2	1	0	3
EES 5213	Practical IV – Environmental Microbiology and Biotechnology			1	1
EES 5214	Practical V – Environmental Pollution			1	1
EES 5215	Practical VI – Waste Management			1	1
Total Credits					18
Third Semester					
EES 5316	Biodiversity and Conservation	2	1	0	3
EES 5317	Environmental Engineering	2	1	0	3
EES 5318	Research Methodology and Statistical Analysis	2	1	0	3
EES 5319	Disaster Management	2	1	0	3
EES 5320	Practical VII – Biodiversity and Conservation			1	1
EES 5321	Practical VIII – Environmental Engineering			1	1
EES 5322	Practical IX – Statistical Analysis			1	1
Total Credits					15

Programme: M.Sc. Environmental Science

Fourth Semester			
EES 5423	Internship	3	3
EES 5424	Field / Industrial Visits Report and Viva Voce	3	3
EES 5490	Dissertation/Project Work and Viva Voce	6	6
Total Credits			12
Grand Total Credits			60

ELECTIVES			
EES 5001	Aquatic Ecology	3	3
EES 5002	Current Environmental Issues	3	3
EES 5003	Ecotourism	3	3
EES 5004	Energy and Environment	3	3
EES 5005	Environmental Economics	3	3
EES 5006	Environmental Education	3	3
EES 5007	Environmental Geosciences	3	3
EES 5008	Environmental Genetics and Biotechnology	3	3
EES 5009	Environmental Nanotechnology	3	3
EES 5010	Environmental Stress Biology	3	3
EES 5011	Food Safety and Health	3	3
EES 5012	Forestry	3	3
EES 5013	Industrial Ecology	3	3
EES 5014	Marine Environment	3	3
EES 5015	Occupational Health and Industrial Safety	3	3
EES 5016	Principles of Remote Sensing and GIS	3	3
EES 5017	Water Quality and Human Health	3	3
EES 5018	Cell and the Environment	3	3

Programme: M.Sc. Environmental Science

Programme Specific Outcomes

1. To understand the basic concepts of environment and its interactions with the earth and environmental systems and various ecosystems associated with it.

2. Capability to analyse, evaluate and interpret the causes and effects of various environmental problems at local, regional and global scale and to develop management strategies.

3. Capacity to analyse and determine the magnitude of different kinds of environmental pollution, their sources using environmental analytical techniques, quantitative and computational techniques. 4. Acquire interdisciplinary knowledge on the global aspects of climate change, its effects on the environment and its governance

5. Capacity to use biotechnological methods in water and wastewater treatment technology. Ability to apply appropriate techniques for efficient solid waste management practices and to find the solutions to the pollution problems.

6. Ability to use different tools for the management of energy resources, biodiversity conservation, natural disasters and technical knowhow in environment management.

7. Ability to analyse a given research problem, identify research gaps, developing suitable research methodology with suitable research design, data collection, data analysis with suitable statistical tool, interpretation of the findings leading to perfect solution to the problem given.

8. Demonstrate proficiency in quantitative methods, qualitative analysis, critical thinking, and written and oral communication needed to conduct high-level work as interdisciplinary scholars and/or practitioners.

9. Master the core concepts and methods from economic, political, and social analysis as they pertain to the design and evaluation of environmental policies and institutions.

10. Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.

Programme: M.Sc. Environmental Science

Programme Outcomes

On successful completion of the M. Sc. Environmental Sciences program

PO1 Students would acquire knowledge on the fundamental concepts of chemistry, atoms, molecules, bonding phenomenon, chemical reactivity and product outlet related to environmental chemistry. Students would also have more familiar with the classification of various pollutants such as air/water/soil and physical, chemical and biological control methods of above said pollutants in the environment.

PO2 Students could acquire knowledge with reference to designing of methods, way of data collection, analysis of data, interpretation of results to solve the environmental problems through the assessment of qualitative and quantitative characters, by using artificial intelligence, big data, data analysis and internet things.

PO3 Students will get skill development on qualitative and quantitative analysis of environmental samples using different analytical instruments techniques. Students also understand the work place hazards, mitigation by employing safety devices and also aware of environmental safety standards, certification, safety auditing and management perspectives.

PO4 Students gain knowledge about the importance of natural resources, distribution, utilization, conservation strategies, green energy sources and sustainable management perspectives. Further, students will also be able to understand the importance of environmental impact assessment, public participation in environmental impact assessment and EIA report preparation before implementing potential environmental projects in National, International, Regional and Local levels.

PO5 The students could understand the different type of natural disasters, causes, and impact on natural and man-made environments. Further, students gained knowledge will enable to become volunteers themselves in disaster management program for helping the affected community. Nonetheless, students will also acquire knowledge regarding the importance of preparedness in vulnerable areas.

PO6 Students will be able to acquired technical knowledge about the fundamentals of industrial effluent treatments, water and sewage wastewater treatments, environmental protection with pollutants free, zero waste discharge and operating of pollution control devices technology. Students will be able to understand the key features of environmental laws, acts and legal obligations, applying of green auditing tools and techniques, conducting of onsite assessment and preparation of audit reports before implementing the potential public environmental projects.

PO7 Students will be able to gain technical skills and knowledge of the various environmental toxicants, toxicants in food, drugs, weedicides, heavy metals, pesticides, organic and inorganic chemical molecules, exposure routes of toxicants, toxicological test methods and animal ethics to be followed in toxicological testing studies.

PO8 The students will be able to acquire and understand the management strategies of solid and liquid wastes from municipal and industrial sources, remediation measures of recycling, reuse and recovery from wastes, principles and mechanistic role of machines in the degradation of various pollutants. Students will be able to gain knowledge about

the strategic phenomenon of environmental planning, life cycle assessment, material analysis, environmental impact assessment, risk assessment, environmental auditing, issues in various industrial sectors in cooperation with federal, state and local governing body and official work for mitigation strategies in issues pertaining to the environmental protection.

Programme: M.Sc. Environmental Science

EES 5101 Fundamentals of Ecology and Environmental Science

Course Code	EES 5101	Semester	1
Course Title	*Fundamentals of Ecology and Environmental Science*		
Credits	3	Type	Core

Course Description

The course provides an introduction into the basics of Ecology and Environmental Science. The concepts of the different spheres and processes of Environment, ecosystem, population ecology and the interaction of different ecological factors with biotic components are laid out.

Course Outcome

By the end of the course, students are expected to be able to:

- Be well versed with the fundamentals of Ecology and Environmental Science
- Have an in depth understanding into the concepts of ecosystem
- Gain understanding into the population dynamics

Course Structure

The following is a detailed syllabus.

UNIT I: Basics of Environmental Science

Scope and interdisciplinary nature of Environmental Science; Atmosphere- Structure and composition (concepts of homosphere and heterosphere and layers of atmosphere); hydrosphere- marine water, freshwater, concepts of halocline and thermocline in temperate lakes; lithosphere - theory of plate tectonics, constructive, destructive and transform faults, island arcs; biosphere. Environmental factors, concept of limiting factors. Biogeochemical cycles (gaseous and sedimentary). Stoichiometry, Thermodynamics: energy, entropy, enthalpy, Gibb's energy, Acid-Base reactions, redox potential.

UNIT II: Ecosystem

Classification; Biogeographical regions; Biomes; Energy flow; Trophic relations; Ecological pyramids; Productivity and ecological efficiencies: primary and secondary producers. Gaia hypothesis; Niche; Speciation; Ecological Succession and Climax communities, ecotone, edge effect; Biological interactions - Positive and Negative interactions: Mutualism, Proto-cooperation, Commensalism, Competition, Amensalism, Parasitism, Predation, herbivory.

UNIT III: Population Ecology

Characteristics-Population density, natality, mortality, Age Pyramids/Age distribution, Population growth forms/curves (J Shaped and S shaped curves), Population

disturbance, population dispersal (migration, Immigration and emigration), population structure;- Isolation, distribution, population explosion-causes and control measures. r-selection and k-selection. Theory of island biogeography.

UNIT IV: Ecological Factors - Climatic Factors

Light - effect of light on morphology and physiology of plants, distinguishing features of Heliophytes and schiophytes. Temperature – effect of temperature on organisms, classification of vegetation: Megatherms, Microtherms, Mesotherms, Hekisotherms. Wind - Breeze, Storm, Hurricane, westerlies and easterlies, Jetstreams - Morphological and physiological effects of wind on organisms. Humidity and types of humidity – Relative humidity, specific humidity and absolute humidity, mixing ratio, dew point temperature, wet bulb temperature, effect of humidity on organisms. Precipitation- types of precipitation- convectional, orographic and cyclonic. Western disturbance, southwest monsoon and northeast monsoon.

Testing & Evaluation

- Seminar
- Assignment
- Written Exam

References

1. Arora S. (2003). Fundamentals of Environmental Biology, Kalyani Publications, New Delhi.
2. Cotgreave P. and Forseth I. (2002). Introductory Ecology. Blackwell Science, UK
3. Dhaliwal G. S., Sangha G. S. and Raina P. K. (2000) Fundamentals of Environmental Science, Kalyani Publication, India.
4. Freedman B. (1995). Environmental Ecology, Academic Press, USA.
5. Jackson A. R. W. and Jackson J. M. (2000). Environmental Science – The natural environment and human impact, 2nd Edition, Longman Group, UNITed Kingdom.
6. Masters G. M. (2007). Introduction to Environmental Science and Engineering, 3rd Edition, Prentice –Hall of India Pvt Ltd, New Delhi.
7. Odum E.P. (1993). Fundamentals of Ecolgy, W.B.Saunders Co., USA.
8. Rana S.V.S. (2005). Essentials of Ecology and Environmental Science. Prentice –Hall of India Pvt. Ltd. New Delhi
9. Townsend C.R., Begon M. and Harper J.L. (2008). Essentials of Ecology, Blackwell Publications, UK.

Programme: M.Sc. Environmental Science

EES 5102 Environmental Toxicology and Health

Course Code	EES 5102	Semester	I
Course Title	*Environmental Toxicology and Health*		
Credits	3	Type	Core

Course Description

The course proposes to give a wide knowledge on environmental toxicants and its impact on health. The course provides a scope for students to understand the toxicants disposition and metabolism, fate of toxicants in the environment, diseases caused by various pollutants, heavy metals and POP's and occupational health and safety.

Course Outcome

Upon completion of this course, students will be able to
- analyse the different types of toxicants, sources and its effects
- distinguish the toxic and non-toxic ingredients in aby products
- explain the fate of pollutants in the environment
- explain the effect of various types toxicants on human and environmental health
- apply the safety and precautionary measures related to environmental toxicants and occupational exposures

Course Structure

The following is a detailed syllabus

UNIT I: Environmental toxicology

Definition and branches of toxicology, scope and importance of toxicology, Principles of toxicology. Toxicants - Classification, routes of entry, transport, storage, metabolism and excretion. Categories of toxic effects - synergistic, antagonistic and additive effects. Acute and chronic toxic effects. Dose-effect and dose response relationships, LOAEL and NOAEL.

UNIT II: Toxicity of environmental pollutants

Toxicity of Persistant Organic Pollutants – pesticides, insecticides, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans. Toxicity of heavy metals – Chromium, cadmium, mercury, arsenic, lead, iron; Biohazards. Radioactive substances, fluorides and carbon monoxide. Mode of action of toxicants, mechanism of toxicants - Biochemical and molecular effects.

UNIT III: Analytical methods for toxicity testing

Principles of toxicity testing, Measurements of LC_{50} and LD_{50} values. Monitoring approaches - indicator populations and indicator species. Model ecosystems - microcosms and mesocosms; Bioassays – in vitro and in vivo; Biosensors – enzyme based and DNA based, immunosensors; whole-cell based biosensors and bio-markers.– Bioindicators - metabolites, , protein induction, cytochrome P450 enzymes, C reactive proteins and metallothioneins.

UNIT IV: Environmental risk and occupational hazards

Environmental and occupational safety - Definitions, concept and scope, occupational exposure, occupational hazards and diseases- Pneumoconiosis's, bagassorsis,

byssicosiss, asbestosis, anthracosis, siderosis, farmer's lungs. Control of toxic materials and protection measures - air, water and soil. Health effects of selfcare and pharmaceuticals products, Toxicity of engineered nanoparticles. Legislative perspective in ecological risk assessment, human health risk assessment. OSHA and its responsibilities

Testing & Evaluation

- Continuous assessment for 40% will be carried out with 2 internal assessment tests, seminars, assignments, group discussions, etc.
- End semester examination for 60% will be conducted at the end of the semester.

References

- B.M. Francis. (1994.), Toxic Substances in the Environment. New York, John Wiley & Sons.
- Bryan Ballantyne, Timothy C. Marrs, Tore Syversen. (2009), General Applied Toxicology. 6 Volume Set, Third Edition. Queensland, John Wiley & Sons.
- Cockerham L.G., Shane B.S. (1993), Basic Environmental Toxicology. USA, CRC Press.
- Edward A. (2013), Laws. Environmental Toxicology: Selected entries from the encyclopedia of sustainability science and technology. New York, Springer-Verlag.
- Hayes, A. W. (2008), Principles and Methods of Toxicology, 5th Edition, Boca Raton, FL, Taylor and Francis.
- I.C. Shaw and J. Chedwick. (2004), Principles of Environmental Toxicology, Boca Raton, FL, Taylor and Francis.
- Levy B.S., Wegman D.H. (1995), Occupational Health recognizing and preventing work related disease. Boston, MA: Little Brown & Co.
- Walker C.H., Sibly R.M., Hopkin S.P., Peakall D.B. (2012), Principles of Ecotoxicology. Fourth Edition. USA, CRC Press.
- Zakrzewski S.F (2002), Environmental Toxicology. 3rd Edition. New York, Oxford Univeristy Press.
- Landis W, Sofield R, Yu M.H., (2017),Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes, Fifth Edition. Canada, CRC Press.

Programme: M.Sc. Environmental Science

EES 5103 Environmental Techniques

Course Code	EES 5103	Semester	I
Course Title	*Environmental Techniques*		
Credits	3	Type	Core

Course Description

The course will introduce students to the application of some of the modern laboratory analytical techniques used in Environmental Sciences.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand information regarding environmental sampling, analysis and the various techniques associated.
- Understand the importance of proper sampling in environmental research
- Comprehend the various sampling technique and its applications.
- Select sampling methods for making unbiased research.

Course Structure

The following is a detailed syllabus.

UNIT I: Sampling Techniques and Basics

Sampling of air, water, soil and sediments - Preservation, storage and processing. Titrimetry, Complexometry, Gravimetry, Sedimentation - Centrifuge - types and applications. Density gradient methods, Electroanalytical Methods, Potentiometry.

UNIT II: Separation Techniques

Extraction and separation of inorganic and organic compounds; Chromatography: Paper chromatography, Thin layer chromatography, Column chromatography, High Performance Liquid Chromatography (HPLC), Gas Chromatography and Mass Spectrometry (GC-MS), Gas Chromatography-Tandem Mass Spectrometry (GC-MS-MS), Electrophoresis: Agarose Gel electrophoresis, Poly Acrylamide Gel Electrophoresis, ELISA.

UNIT III: Analytical Techniques - Microscopy

Light microscopy, Bright field microscopy, Dark field microscopy, Phase contrast microscopy, Fluorescence microscopy, Confocal microscopy, Electron microscopy: Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM).

UNIT IV*: Analytical Techniques* - Spectroscopy

Ultraviolet -Visible spectroscopy; Infrared spectroscopy, Flame emission spectroscopy; Atomic absorption spectroscopy (AAS); Raman Spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR). Inductively Coupled Plasma – Mass Spectrometry (ICP-MS).

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Seminar
- Assignment

References

1. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
2. APHA (1998) Standards Methods for the examination of water and Waste water, 20th Edition, Washington DC.
3. B.L. Oser (1965). Hawk's Physiological Chemistry. MacGraw Hill Book Co.
4. Clair N. Sawyer (2003). Chemistry for Environmental Engineering and Science. Tata McGraw Hill.
5. Denise R. Ferrier (2013). Lippincott's Illustrated Reviews Biochemistry; Sixth edition, Iippincott Williams & Wilkins.
6. Douglas A. Skoog, F. James Holler and Timothy A. Niemen. (1998). Principles of Instrumental Analysis. 5th Edition, Saunders College Publishing, Philadelphia.
7. F.W. Fifield (2000). Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
8. Khopkar S M (1985). Basic Concepts of Analytical Chemistry. Wiley Eastern Ltd., New Delhi.

Programme: M.Sc. Environmental Science

EES5104 Climate Change and Current Issues

Course Code	EES5104	Semester	I
Course Title	*Climate Change and Current Issues*		
Credits	3	Type	Core

Course Description

The course provides an overarching view of the complex and transdisciplinary subject of climate change in five vastly different but integrated units. The course subtly introduces complex global problems and intertwines the same, but not organically, with climate science, policy, mitigation and adaptation practices, and technologies.

Course Outcome

By the end of the course, students are expected to be able to:

- Illustrate through case study approaches the past global environmental problems
- Demonstrate a deep and scientific understanding of physical basis of climate change
- Differentiate developmental ideologies and policies, and their effect on global climate through IPCC reports, and vulnerability assessments
- Integrate the science, technology, policy, philosophy and ethics of climate change.

Course Structure

The following is a detailed syllabus.

UNIT I: Climate and Meteorology

Weather; Climate; Drivers of Earth's climate system; Energy and material balance; Greenhouse effect and Carbon Cycle; Major Climatic regions of the world based on latitude, with distribution of vegetation; classification of climates; Thornthwaites and koppens classifications; Climatogram studies; El-Nino and La Nino effect. Scale of meteorology; Weather forecasting; Basic numerical modelling approach; Emission inventory.

UNIT II: Energy crisis and impacts

Sources of energy; Conventional energy system – wood, coal, hydro and thermal power energy; Fossil fuels-classification, composition, physico – chemical characteristics and energy content of coal, petroleum and natural gas, nuclear fuel, fission and fusion. Energy use pattern in different parts of the world; Environmental implication; C02 emissions, global warming; Energy conservation and management; Energy audit.

UNIT III: Climate change impacts and measures

Climate change in the past, present and future – trends and causes; Impacts and risks of climate change; Effects on rainfall, forests, glaciers, and oceans; Introduction to climate models; Climate change impact assessment; vulnerability assessments; Scenarios; Climate projections and uncertainty; Role of developed and developing nations;

Multilateral organizations; IPCC; OPEC; Climate change mitigation – global measures, agreements and framework; Kyoto protocol, market based mechanisms and Paris Agreement; The Indian scenario of climate change; NAPCC; Climate change adaptation – sectors and elements; Adaptive capacity and options; Adaptation costs; Climate change and sustainability

UNIT IV: Climate friendly technologies

Non-conventional energy systems – Bioenergy & Anaerobic digestion; Ocean & tidal energy; Nuclear energy; Solar energy – photovoltaics, solar ponds; Hydrogen Energy; Waste to Energy; Wind energy and geothermal energy; Carbon capture and storage (CCS) – ocean and geological injection, scrubbing and mineral carbonation; natural sinks; Environmental impacts of renewable energy and CCS.

Testing & Evaluation

- Case studies, seminars, assignments, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

1. Peake S, 2009. Climate change, Oxford University Press, New York.
2. CABI, 2014. Climate change impact and adaptation in agricultural systems, UK.
3. Armaroli N, Balzani V, 2011. Energy for a Sustainable World – From the Oil Age to a Sun-Powered Future, Wiley-VCH.
4. Armaroli N, Balzani V, Serpone N, 2013. Powering Planet Earth – Energy Solutions for the Future, Wiley-VCH.
5. Chichester, 2010. Renewable Energy and Climate Change. John Wiley & Sons Ltd.
6. Sioshansi FP, 2011. Energy, Sustainability and the Environment, Elsevier.
7. Lee H, 2015. Climate change biology. Elsevier, London.
8. Springer, 2015. Handbook of climate change adaptation, Berlin.
9. Singh D K. (2006). Towards Basics of Natural Disaster Reduction, Research book Centre, New Delhi.
10. Singh T. (2006), Disaster Management approaches and strategies, Akansha Publishing House, New Delhi.

Programme: M.Sc. Environmental Science

EES 5105 PRACTICAL I – ECOLOGY

Course Code	EES 5105	Semester	I
Course Title	*PRACTICAL I – ECOLOGY*		
Credits	1	Type	Core

Course Description

The course provides practical exposure to the different biotic and abiotic components of the ecosystem and their analysis.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain practical knowledge into analysing the effects of ecological factors
- Have practical knowledge of the abiotic-biotic and biotic-biotic interactions

Course Structure

The following is a detailed syllabus.

1. Identification of phytoplankton in fresh water samples.
2. Determination of algae in water samples and Nygaard's Algal Indices.
3. Identification of zooplankton in fresh water samples.
4. Primary producers – Light and Dark bottle method
5. Study on the effects of light and temperature on seed germination.
6. Determination of relative humidity in different indoor and outdoor environment.
7. Identification of organism associated with positive and negative ecological interactions in the campus.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Slingsby, D., Cook, C. 1986. Practical Ecology, Palgrave, London
2. Rao, K.S. 1993. Practical Ecology, Anmol Publications

Programme: M.Sc. Environmental Science

EES 5106 PRACTICAL II – ENVIRONMENTAL TOXICOLOGY

Course Code	EES 5106	Semester	I
Course Title	*PRACTICAL II – ENVIRONMENTAL TOXICOLOGY*		
Credits	1	Type	Core

Course Description

The course provides a practical knowledge on toxicants and their effect on organisms.

Course Outcome

Upon completion of this course, students will be able to
- analyse the different types of toxicants, sources and its effects
-analyse the effect of different toxicant on plant and animal physiology and behaviour through practical module

Course Structure

The following is a detailed syllabus.

1. Toxic effects of xenobiotics on morphological changes of fishes.
2. Toxic effects of xenobiotics on behavioural changes (Swimming pattern, breathing, condition factor) in fishes.
3. Analysis of the toxicants from environmental samples
4. Calculating the LC_{50}/LD_{50} value of the given sample
5. Toxic effect of chemicals on the seed germination.
6. Toxic effect of chemicals on growth of the plants.
7. Determination of solid food adulteration.
8. To determine total leukocyte count (TLC) of the given blood smear.
9. Toxic effect on chlorophyll and carotenoid content of the plants exposed to toxicants/pollutants.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Cockerham L.G., Shane B.S. (1993), Basic Environmental Toxicology. USA, CRC Press.
2. I.C. Shaw and J. Chedwick. (2004), Principles of Environmental Toxicology, Boca Raton, FL, Taylor and Francis.
3. Zakrzewski S.F (2002), Environmental Toxicology. 3rd Edition. New York, Oxford Univeristy Press.

Programme: M.Sc. Environmental Science

EES 5107 PRACTICAL III – ENVIRONMENTAL TECHNIQUES

Course Code	EES 5107	Semester	I
Course Title	*PRACTICAL III – ENVIRONMENTAL TECHNIQUES*		
Credits	1	Type	Core

Course Description

The course provides hands-on training in key analytical methods, data interpretation, researching literature, and scientific reporting of results.

Course Outcome

By the end of the course, students are expected to be able to:

- Practically perform environmental sampling and analyse using appropriate techniques.

Course Structure

The following is a detailed syllabus.

1. Methods of sampling – water, air, soil/sediment
2. Determination of Calcium and Magnesium ions by EDTA Titration
3. Separation of DNA by Gel Electrophoresis.
4. Separation Techniques by Paper chromatography.
5. Elemental Analysis by ICP-MS.
6. Spectrophotometric determination of selective trace elements.
7. Determination of sodium and potassium by flame photometry.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Miroslav Radojevic and Vladimir N. Bashkin (1999), Practical Environmental Analysis, The Royal Society of Chemistry, Cambridge.

Programme: M.Sc. Environmental Science

EES 5208 Environmental Microbiology and Biotechnology

Course Code	EES 5208	Semester	II
Course Title	*Environmental Microbiology and Biotechnology*		
Credits	3	Type	Core

Course Description

The course covers the basic concepts of environmental microbiology, microbial ecology, and the applied aspects of environmental biotechnology and industrial microbiology. The course presents an insight into the diverse roles, functions and applications of microbes.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain insight into the basics of microbiology.
- Apply the diverse uses and roles of microbes in their further study.
- Gain experience in environmental biotechnology and industrial applications for future prospects.

Course Structure

The following is a detailed syllabus.

UNIT I: Fundamentals of Environmental Microbiology

Introduction - autotrophy and heterotrophy, Microbial growth and factors affecting microbial growth, cultivation of microorganisms. Aeromicrobiology –sampling techniques, airborne diseases and allergies. Aquatic microbiology –sampling techniques, eutrophication, water borne pathogens and diseases. Soil microbiology – microbes of rhizosphere. Extremophiles.

UNIT II: Microbial Ecology

Microbial diversity – culturable and non-culturable microorganisms; methods for measuring microbial diversity; habitat relations; microbial interactions (i.e., antibiosis, fungi stasis, exploitation and lysis). Value of microbial diversity- microbial role in biogeochemical cycles, Use of microbes in environmental pollution and management, Use of microbes in wastewater treatment, indicator microorganisms.

UNIT III: Environmental Biotechnology

Microbial remediation - composting, biostimulation, bioaugmentation, bioreactor, bioleaching, bioventing. Biodegradation of xenobiotics. Bioremediation of heavy metals and radio-active wastes. Microbe mediated bioconversion. Role of genetically engineered microbes in pollution control, Biofilms and microbial mats, biofouling and corrosion.

UNIT IV: Industrial Biotechnology

Bioenergy - definition, first generation biofuels- bioethanol, biodiesel, second generation biofuels – lingo-cellulosic biofuels; third generation biofuels- algae biofuels, fourth-generation biofuels. Biohydrometallurgy and biomineralization; role of microbes in

fermentation process in environmental cleanup; Biofertilizers and biopesticides, Biosensors and their application in environmental monitoring.

Testing & Evaluation

- Seminar
- Assignment
- Written Exam

References

1. Eweis J. B., Ergas S. J., Chang D. P. Y., Schrodwer E. D. (1998). Bioremediation Principles. New York, Mc Graw Hill.
2. Fulekar M. H. (2010). Environmental Microbiology. New York, Taylor & Francis.
3. Koukkou A. I. (2011). Microbial Bioremediation of Non-metals: Current Research. Haverhill, U K, Caister Academic Press.
4. Lederberg J. (1992). Encyclopedia of Microbiology, New York: Academic Press.
5. Maier R. M., Pepper I. L., Gerba C. P. (2006). Environmental Microbiology. San Diego, Elsevier Academic Press.
6. Passman F. J. (2003). Fuel and Fuel System Microbiology: Fundamentals, Diagnosis and Contamination Control. West Conshohocken, ASTM International.
7. Prescott L. M., Hareley J. P. Klein D. A. (2005). Microbiology (6th Edition). New York, McGraw-Hill Publishing Co. Ltd.
8. Sangeetha J, Thangadurai D, David M, Abdullah M. A. (2016). Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of Xenobiotics for Sustainable Development, Boca Raton, Florida, USA, CRC Press.
9. Sen K., Ashbolt N. J. (2011). Environmental Microbiology: Current Technology and Water Applications. Norfolk, UK, Caister Academic Press.

Programme: M.Sc. Environmental Science

EES 5209 Environmental Pollution and Control

Course Code	EES 5209	Semester	II
Course Title	*Environmental Pollution and Control*		
Credits	3	Type	Core

Course Description

The modules under this course have been designed to improve the familiarity of the students about different pollution problems and the control strategies in three environmental compartments i.e. air, water and soil. Issues related to noise pollution and their impact on environment and health are dealt with.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the various pollution sources in environment
- Get a clear idea regarding pollution its various effects on humans as well as ecosystem which will make them careful in future.
- Analytical ability to link cause and effect of pollution
- Critical issues of handling pollution vis a vis human beings
- Ability to develop pollution mitigation/abatement strategies

Course Structure

The following is a detailed syllabus.

UNIT I: Air Pollution and Control

Structure and chemistry of atmosphere, Composition of elements in the atmosphere; Temperature inversion, Atmospheric lapse rate, Adiabatic lapse rate. Types and Chemistry of atmospheric pollutants: Photochemical smog-origin and occurrence, Ozone chemistry: Ozone layer, Chemistry of Ozone layer, Ozone depletion, Mitigation of ozone depletion, Montreal protocol; Acid rain- chemical reactions and its ecological effects; Greenhouse effect and global warming, Paris agreement; Effects of air pollutants on plants and animals; Treatment methods, Air quality standards. Air Act, 1981.

UNIT II: Water Pollution and Control

Composition of pure water; Physical and Chemical properties of water. Chemical reactions and equilibria in water; Natural, organic and inorganic components in water - Concepts of DO, BOD and COD; Sources of water pollution; Types of water pollutants and standard limits; Effects of water pollution on plants and animals; Treatment Methods, Water quality standards. Water Act, 1974.

UNIT III: Soil Pollution and Control

Weathering and paedogenesis; Factors affecting soil formation, Development of soil profile; Structure of Soil; Physico-chemical characteristics of soil; Ion-exchange and adsorption processes in the soil; Classification of soil, Fate of chemicals in the soil; sources of soil pollution; Effects of soil pollution on microbes, plants and animals. Control methods.

UNIT IV: Noise, Thermal, Radioactive Pollution and emerging micro and nano pollution and Control

Sources of noise pollution: indoor and outdoor noise pollution; Effects of noise pollution; Thermal and nuclear power plants as sources of thermal pollution. Effects of thermal pollution on aquatic flora and fauna; Control measures of thermal pollution; Sources of marine pollution; Pollution status of coastal and ocean waters; Radioactive pollution: types and sources, half-life period, natural radiation. Control strategies for Noise, Thermal and radioactive Pollution. Source, effect, control strategies of plastic, oil and emerging micro and nano pollutants

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. A. K. De (2001). Environmental Chemistry, New Age International Publishers, New Delhi.
2. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
3. Dara S. S, (1998). A Text Book of Environmental Chemistry and Pollution Control, S. Chand & Company Ltd, New Delhi
4. F. W. Fifield (2000). Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
5. Howard S Peavy (2003). Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
6. Julian E Andrews et al., (2004). An Introduction to Environmental Chemistry, Blackwell Publishing.
7. Sawyer C.N., Mc Carty P. L., and Parkin, G. F (2003). Chemistry for Environmental Engineering and Science, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
8. S. E. Manahan (2009). Fundamentals of Environmental Chemistry, CRC Press, USA.
9. Stanley E. Manahan (2010). Environmental Chemistry, 9th Edition, CRC Press, London.

Programme: M.Sc. Environmental Science

EES 5210 Waste Management

Course Code	EES 5210	Semester	II
Course Title	*Waste Management*		
Credits	3	Type	Core

Course Description

The course highlights the various waste management strategies and technologies in all waste categories. The course deals with waste generation, collection, transportation, processing, and disposal. The course explores existing and sustainable processes, and provides basic knowledge on waste audit and relevant laws.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate a thorough understanding of the waste management sector, issues at global, regional and local scales.
- Illustrate all the steps involved in waste management, and technologies and strategies involved thereof.
- Discriminate the various waste categories and their respective potential for treatment.
- Analyze and integrate various technological options, and conceptualize a management solution for particular waste characteristics.

Course Structure

The following is a detailed syllabus.

UNIT I: Sources, Classification and Regulatory Framework

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management – Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, electronic wastes, plastics and fly ash – Financing waste management.

UNIT II: Municipal Solid Waste Management

Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse Practical: Composition of MSW, Determination of Physical and Chemical Properties of MSW

UNIT III: Storage, Collection and Transport of Wastes

Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes –hazardous waste manifests and transport

UNIT IV: Waste Processing Technologies and Their Disposal

Objectives of waste processing – material separation and processing technologies – biological &chemical conversion technologies – methods and controls of Composting - thermal conversion technologies, energy recovery – incineration – solidification & stabilization of hazardous wastes- treatment of biomedical wastes, Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – Rehabilitation of open dumps – landfill remediation

Testing & Evaluation

- Mini projects, group discussions, seminars, assignments, characterization of unknown wastes, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

1. David H.F. Liu, Bela G. Liptak (1999). Hazardous Waste and Solid, CRC Press
2. Kanti L. Shah(1999). Basics of Solid and Hazardous Waste Management Technology, Prentice hall
3. Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo and Constantine Yapijakis (1992). Handbook of Industrial and hazardous waste treatment, Marcel Dekker, Inc, Basel, New York
4. Michael D. LaGrega, Philip L.Buckingham, Jeffrey C.Evans (2001). Hazardous waste management, Waveland Press, Inc, Long Grove, USA
5. Riser-Roberts, E., (1998). Remediation of Petroleum Contaminated Soils - Biological, Physical and Chemical processes, Lewis Publisher, New York.
6. RusselBoulding, J (1995). Vadose-Zone and Ground Water Contamination - Assessment, Prevention and Remediation, Lewis Publishers, Tokyo.
7. Solid Waste Technology & Management, Thomas H. Christensen (2011). A John Wiley and Sons, Ltd. Publication, UK.
8. Tandon (1995). Recycling of Crop, Animal and Human Waste in Agriculture, Mc Graw Hill Publishing Co.

Programme: M.Sc. Environmental Science

EES 5211 EIA and Environmental Auditing

Course Code	EES 5211	Semester	II
Course Title	*EIA and Environmental Auditing*		
Credits	3	Type	Core

Course Description

This course examines principles, procedures, methods, and applications of environmental impact assessment. The goal of the course is to promote an understanding of how environmental impact assessment is conducted and used as a valuable tool in the engineering project management decision-making process. Also to understand the importance of auditing for the effective resource management.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the concept, historical context and wider importance of
- Be familiar with EIA legislation.
- Know the key steps in the EIA process.
- Understand the importance of Social Impact Assessments and public participation in the EIA process.
- Gain an overview of methods and instruments that are commonly used to develop an EIA.
- Understand the auditing process for the conservation of natural resources.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT I: Importance of EIA

History and objectives – Basis for Environment Impact Assessment, Environmental Protection Act, 1986. EIA Notification 1994 and 2006, Approach to EIA studies – mandatory requirements, project screening, scoping, environmental baselines, Public Participation best practices; terms of reference (ToR); Phases of EIA – Identification, Prediction, Evaluation, Decision making and Post Impact Monitoring, Major limitations of Environmental Impact Assessment.

UNIT II: Methodologies

Impact identification methods – Adhoc Methods – Checklist Methods – Matrix Methods – Network Methods, Overlays, Leopold matrix, Batelle's Environmental Evaluation System (BEES), Cost-Benefit Analysis.

UNIT III: Assessment Procedure

Prediction and Assessment of Impacts on natural Resources – Biota, Surface Water, Ground Water, Air, Noise, Hazards, Historic and Cultural Resources, Transportation, Socio-economic relationships.

Case Studies: Land Clearing Projects – Dam sites – EIA for Aquaculture, Steel, Mines, Hydel, Thermal, Nuclear, Oil and Gas based Power Plants – Highways projects – Industrial Projects.

UNITI IV: Environmental Auditing

Definition of Environment Audit and its importance for industries, Factories Act. Types of Audit and Definitions. Life Cycle Assessment, Environmental audit: Pre-Post audit process; International organization for standardization (ISO), ISO 14000 standards and certification, Environmental Management System (EMS), Eco labelling.

Testing & Evaluation (if any)

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Bregman, J. I., (1999). Environmental Impact Statements, Lewis Publishers, London.
2. Canter, L.W., (1996). Environmental Impact Assessment, Mc Graw Hill, New York.
3. Eccleston, C. H., (2000). Effective Environmental Assessment, Lewis Publishers, London.
4. Eccleston, C.H., (2000). Environmental Impact Assessment- A Comprehensive Guide to Project and Strategic Planning, John Wiley and Sons.
5. M. E. Jensen and P. S. Bourgeron (2001). A guide book for Integrated Ecological Assessments Springer-Verlag, New York, Inc.

Programme: M.Sc. Environmental Science

EES 5212 Natural Resources Management

Course Code	EES 5212	Semester	II
Course Title	Natural Resources Management		
Credits	3	Type	Core

Course Description

This course focuses on the need of sustainable management of the Earth's depleting natural resources such as clean water, energy, minerals and biological resources, in relation to the growth of the human population.

During the programme, students develop a good scientific understanding of how the earth's natural systems work and new approaches to balancing the needs of society.

Course Outcome

By the end of the course, students are expected to be able to:

- Appreciate the role of natural resources in the sustenance of life on earth.
- Explain and discuss the distribution of different natural resources and their sustainable management.
- Develop Skills in recognising and solving environmental and social impacts of resource depletion.
- Enhance the knowledge base and skill sets.
- Be an active and lifelong learner and develop strategies to do so.
- Be innovative by generating new ideas, artefacts, products, interpretations or ways of viewing professional projects and tasks.

Course Structure

The following is a detailed syllabus.

UNIT-I Introduction

Concept of resource, classification of natural resources-renewable and non-renewable resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. ecological economics of provisioning, regulating and cultural ecosystem services as well as theories and concepts in political ecology and critical human approaches. Sustainable use and management of natural resources in a professional role, such as that of policymakers, trainers or practioners in government agencies, private firms or NGOs.

UNIT-II Forest Resources

Forest vegetation, status and distribution, contribution as resource. Use and over-exploitation, deforestation. Timber extraction, mining, dams and their effects on forest and tribal people, Forest products.

UNIT-III Soil and Water Resources

Soil resource, Soil fertility management, Waste Land-National scenario, waste land management through social forestry programme.

Water resources: Sources and utilization, water demand, conflicts over water, conservation of water, dams-benefits and problems, interlinking of river.

UNIT-IV Mineral Resources

Mineral wealth of our planet, non-renewable nature of mineral deposits, the inexhaustible nature of mineral elements, Classification of Minerals, Minerals of India. Economic importance of minerals. Management of Mineral resource, use and exploitation of mineral resources, environmental effects of extracting and using mineral resources. Remedial measures.

Sources of energy and their classification; Energy forms and transformation. Fossil fuel, Solar Energy, Bio energy, Nuclear Energy, Hydro Energy, Wind and Thermal Energy.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Francois Ramade (1984). Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Odum, E.P. (1971). Fundamentals of Ecology. W.B. Saunders Co. USA, 574p
3. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. (2001). Environmental Encyclopedia, Jaico Publishing House.
4. Cunningham, W.P., Cunningham, M.A. & Saigo, B. (2004). Environmental Science, a Global Concern. (8th edition). McGraw-Hill (Boston)
5. Heywood, V.H. and Watson, R.T. (1995). Global Biodiversity Assessment. Cambridge Univ. Press.
6. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
7. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
8. Wright, R.T. (2005). Environmental Science - toward a Sustainable Future. (9th International Edition), Pearson Education International, Prentice Hall Publishers.

Programme: M.Sc. Environmental Science

EES 5213 PRACTICAL IV - ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

Course Code	EES 5213	Semester	II
Course Title	*PRACTICAL IV - ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY*		
Credits	1	Type	Core

Course Description

The practicals in this course fall into an array of techniques used in a basic microbiology laboratory.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain insight into the basics of microbiology from practical aspects.

Course Structure

The following is a detailed syllabus.

1. Inoculation techniques and culture techniques: Pour plate by dilution, streak plate, broth cultures.
2. Gram staining techniques.
3. Sampling, isolation and enumeration of airborne microorganisms.
4. Sampling, isolation and enumeration of microorganisms in soil samples.
5. Assessment of Water Quality by Membrane Filter, Total Coliform, E. coli, Feacal Coliform.
6. MPN technique for coliform analysis.
7. Isolation of DNA from Bacteria.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Green, L.H., Goldman, E. 2021. Practical Handbook of Microbiology, CRC Press, 4th edition.

Programme: M.Sc. Environmental Science

EES 5214 PRACTICAL V - ENVIRONMENTAL POLLUTION

Course Code	EES 5214	Semester	II
Course Title	*PRACTICAL V - ENVIRONMENTAL POLLUTION*		
Credits	1	Type	Core

Course Description

The practical course will train the students to analyse and quantify the pollution parameters from water, air and soil. Help to identify and interpret the results on quality of the water and air environment.

Course Outcome

By the end of the course, students are expected to be able to:

- Analyse the water quality parameters.
- Analyse the air quality parameters.

Course Structure

The following is a detailed syllabus.

1. Determination of pH and Conductivity of different water and soil samples.
2. Determination of total dissolved solids in water samples.
3. Determination of Carbonates and Bicarbonates in water samples.
4. Determination of Chloride in water sample by $AgNO_3$ method.
5. Determination of Total alkalinity of different water samples.
6. Determination of DO in water sample modified Winkler's method.
7. Determination of BOD/COD in water samples.
8. Determination of SO_2 by PRA method.
9. Determination NO_x by spectrophotometric method.
10. Measurement of noise level in different environments by sound level meter (SLM).
11. Determination of particulate matters PM_{10} and $PM_{2.5}$

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
2. Dara S. S, (1998). A Text Book of Environmental Chemistry and Pollution Control, S. Chand & Company Ltd, New Delhi

Programme: M.Sc. Environmental Science

EES 5215 PRACTICAL VI - WASTE MANAGEMENT

Course Code	EES 5215	Semester	II
Course Title	*PRACTICAL VI - WASTE MANAGEMENT*		
Credits	1	Type	Core

Course Description

The practical course highlights the various waste management strategies and technologies in all waste categories.

Course Outcome

By the end of the course, students are expected to be able to:

- Quantify and perform qualitative analysis of different categories of waste.
- Analyze and integrate various technological options, and conceptualize a management solution for particular waste characteristics.

Course Structure

The following is a detailed syllabus.

1. Characterization of solid waste from different sources.
2. Vermi-Composting technology - Analysis
3. Designing of secured/sanitary landfills.
4. To study of methods of management of biomedical waste.
5. Determination of organic carbon in compost.
6. Determination of inorganic phosphate in leachate samples.
7. Determination of total nitrogen in leachate samples.
8. Determination of TSS/TDS in leachate samples

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Kanti L. Shah(1999). Basics of Solid and Hazardous Waste Management Technology, Prentice hall

Programme: M.Sc. Environmental Science

EES 5316 Biodiversity and Conservation

Course Code	EES 5316	Semester	3
Course Title	*Biodiversity and Conservation*		
Credits	3	Type	Core

Course Description

This course focuses the biodiversity concepts, values, threats to biodiversity, issues involved, and the concepts of conservation. It gives an insight into important organizations and programmes involved like IUCN, MAB programme, CBD. The different laws connected with both biodiversity and conservation are given emphasis.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain understanding into the concepts of measuring biodiversity.
- Understand the importance of biodiversity in their life.
- Follow the activities of CBD and MAB in a more scientific manner.
- Understand the various conservation strategies being undertaken
- Follow the laws connected with biodiversity and conservation.

Course Structure

The following is a detailed syllabus.

UNIT-I: Introduction

Biodiversity – Definition; Genetic diversity, Species diversity and ecosystem diversity; alpha, beta, and Gamma diversity; Latitudinal and altitudinal gradients of biodiversity; Methods of measuring biodiversity; values of Biodiversity – Direct and indirect use values, consumptive use value, productive use value, optional value, social value. Endemism, significance of the endemism; Hotspots of Biodiversity.

UNIT-II: Threats to Biodiversity

Global estimates of species loss. Threats to biodiversity: habitat loss, habitat fragmentation, deforestation, invasive species, over exploitation, pollution and climate change, Man- Wildlife conflicts. Ecological consequences of reduction in biodiversity. Red data book and IUCN categories- criteria for categorization. Threatened species. Keystone species. Brief account of endangered flora and fauna of India.

UNIT III: Conservation of Biodiversity: Approaches and Strategies

Historical perspective of conservation, Importance of conservation, Conservation and sustainable development, Role of CBD and MAB, Ecosystem people and traditional conservation mechanisms, In situ conservation: Biosphere reserves, National parks, Wild life sanctuaries, Protected area management. Ex situ conservation: Botanical gardens, Zoological parks, Herbaria, cryopreservation, seed banks, gene banks.

UNIT IV: Conservation Policies and Law

The Biological Diversity Act, 2002. Biological Diversity Rules, 2003. Intellectual Property Rights (IPR), TRIPS, Indigenous Knowledge Systems, The protection of plant varieties and farmer's rights (PVPFR) Act, 2001, 2007. Forest (conservation) Act, 1980 and its amendments. Wildlife Protection Act. National Green Tribunal Act 2010. National and International conservation policies and conservation challenges.

Testing & Evaluation

- Seminar
- Assignment
- Written Exam

References

1. Dadhich L. K. and A. P. Sharma (2002). Biodiversity-Strategies for Conservation, APH publishing corp. New Delhi,
2. Khan. T. I and Dhari, N (1999). Global Biodiversity Conservation measures –Al-Ajmi Pointer Publishers, Jaipur.
3. Krishnamurthy K. V (2003). An Advanced Text book on Biodiversity – Principles and Practice – Oxford and IBH publishing, New Delhi.
4. Chiras D. D and Reganold J. P. (2011). Natural Resource Conservation: Management for a sustainable future, 10/E Prentice Hall.
5. Gaston K. J. and Spicer J. (2004). Biodiversity an introduction. Blackwell Publications, UK
6. Krishnamurthy K. V. (2003). Advanced text book on Biodiversity. Oxford & IBH, New Delhi
7. Maiti P. K. and Maiti P. (2011). Biodiversity- Perception, Peril and Preservation. PHI Learning. New Delhi.

Programme: M.Sc. Environmental Science

EES 5317 Environmental Engineering

Course Code	EES 5317	Semester	III
Course Title	*Environmental Engineering*		
Credits	3	Type	Core

Course Description

The goal of environmental engineering is to ensure that societal development and the use of water, land and air resources are sustainable. This goal is achieved by managing these resources so that environmental pollution and degradation is minimized.

Course Outcome

By the end of the course, students are expected to be able to:

- Plan and of water distribution systems.
- Plan, design, and operation of water and wastewater treatment facilities in municipalities and industries.
- plan to dispose and reuse of wastewaters and sludges,
- Plan and design the air pollution control systems.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT – I: Hydraulics

Hydraulics – Pressure- Hydrostatic Pressure, Pressure Head, Measurement of Pressure, Static Head, Flow, Friction Head, Velocity Head, Design of Pressure Pipes – Darcy Weisbach Formula, Manning's Formula, Hazen William's Formula – limiting velocities, Minimum and Maximum Test Pressure and Working Pressure in pipes – selection of pipe material – Pump types, Horse power, Characteristic Curves – selection and determination of capacity.

UNIT – II: Designing of Water and Wastewater Treatment Plant

Water Quality, water demand, Stages of water treatment, Screening, Flash Mixer – Design – Clariflocculator – parameters for design – Filtration - Rapid sand filter and Pressure filter; Disinfection – chlorination process, chlorine demand, and residual chlorine, Ozonation, UV process. Physical and Chemical Unit Operations and Applications, Design Parameters and Design of Primary and Secondary Settling Tanks – Activated Sludge – Design of Aeration Tanks– Diffusers and Mechanical Aerators. Design criteria for Trickling Filters.

UNIT – III: Sludge Processing and Disposal Methods

Sludge Processing and Disposal Methods- Sludge thickening, Sludge stabilization, Sludge dewatering, Design of Anaerobic Digester and Sludge Drying Bed – Reverse Osmosis – Ion Exchange; Incinerators and Multiple Evaporators.

UNIT – IV: Air Pollution Control Design

Minimum Stack Height – Plume Rise, Ground Level Concentration of Pollutants. Design of Settling Chamber, Cyclones, Fabric filters and Electrostatic Precipitators. Wet Scrubber. Case studies: Distillery, Dyeing, Electroplating, Paper and Pulp, Steel, Tannery - Industrial Effluent Treatments.

Testing & Evaluation

- Class room assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Environmental Engineering: A Design Approach, Sincero A. P and Sincero G. A. (1999). Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Gilbert M. Masters (2004). Introduction to Environmental Engineering and Science, Prentice-Hall of lndia Pvt. Ltd., New Delhi.
3. Howard S Peavy (2003). Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
4. Frank R. Spellman, (2003). Handbook of Water and Wastewater Treatment Plant Operations, Lewis Publishers, London.
5. Metcalf and Eddy (2003). Wastewater Engineering: Treatment and Reuse, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
6. Hammer M.J. and Hammer Jr M. J. (2001). Water and Wastewater Technology, Prentice Hall of lndia Pvt. Ltd., New Delhi.

Programme: M.Sc. Environmental Science

EES 5318 Research Methodology and Statistical Analysis

Course Code	EES 5318	Semester	III
Course Title	*Research Methodology and Statistical Analysis*		
Credits	3	Type	Core

Course Description

The course deals with the theory of statistical analysis, and study of various scientific methods and processes involved for performing sound research. The course offers students basic and advanced understanding of scientific research through real-time research problems, statistical data, and so forth. The course imparts students with scientific inquiry, temper, vigour and research ethics.

Course Outcome

By the end of the course, students are expected to be able to:

- Develop strong scientific temperament, vigour and research ethics
- Illustrate the basic steps in research by analyzing research publications
- Execute specific hypotheses by developing sampling, experimental and research plan on their own
- Profound understanding of advanced statistical concepts, calculations, and relevant, available softwares

Course Structure

The following is a detailed syllabus.

UNIT – I: Research Documentation and Ethics

Scientific documentation, literature collection, hypothesis, design, planning and execution of investigation, Preparation of scientific documents, general articles, research papers, review articles, editing of research papers, methods of citation and thesis writing. Stakeholders in research, Publication and research industry, Publication process; Ethics in Environmental Research; Plagiarism and its consequences; Good laboratory practice and Laboratory safety.

UNIT II: Descriptive statistics

Fundamentals of Statistics– Collection of Data – Classification and Tabulation- Diagrammatic Representation – Measures of Central Tendencies and Dispersion – Moments, Skewness and Kurtosis – Normal, Poisson and Binomial Distributions.

UNIT III: Standard distributions

Tests of Significance – Mass and alternative hypothesis – error level of significance – Equal and Unequal Sampling – f, t, z, Chi-square test, Analysis of variance – One-way ANOVA – Two-way ANOVA – Regression and correlation - simple and multiple. Cluster analysis – PCA, Graph Plotting.

UNIT – IV: Environmental Models

Lotka – Volterra Model, Leslie's Matrix Model – Point Source Stream Pollution Model – Air Quality Model. Thermal Plume and Dispersion models. Decision Support Systems – Data Analysis using packages (SPSS, Systat, Matlab Simulink).

Testing & Evaluation

- Data analysis, research designs for real-time research questions, seminars, written examinations (Continuous Assessment)
- Written examination for theory and practical component (End Semester Assessment)

References

1. Bliss, G.I. (1970). Statistics in Biology. Mc Graw Hill Book Company, Vol. I and II. New Delhi.
2. Vittal, R.R. (1986). Business Mathematics and Statistics, Murgham Publications.
3. Haynes, R (1982). Environmental Science Methods, Chapman & Hall, London.
4. Khan, I.A and Kanum, A., (1994). Fundamentals of Bio-Statistics, Ukaaz Publication, Hyderabad.
5. Gupta, S. P. (1996). Statistical Methods, Sultan Chand & Sons Publications, New Delhi.
6. Byron S Gottfried (1996). Programming with C, Hill Publishing Co, New Delhi.
7. Wardlaw, A.C. (1985). Practical Statistics for Experimental Biologists. Wiley Chichester.
8. Kothari, C.R (1996). Quantitative Techniques, Vikas Publishing Housing Pvt Ltd, Hyderabad
9. Miller, J, (1989). Statistics for Advanced Level, Cambridge University Press

Programme: M.Sc. Environmental Science

EES 5319 Disaster Management

Course Code	EES 5319	Semester	III
Course Title	*Disaster Management*		
Credits	3	Type	Core

Course Description

Disaster Management modules described offer theoretical and practical management skills in preparation, response and recovery from natural and man-made disasters

Course Outcome

By the end of the course, students are expected to be able to:

- Get a basic understanding about disasters and how to deal with disasters.
- Gain basic conceptual understanding of disasters and its relationships with development.
- Understand the approaches of Disaster Risk Reduction (DRR) and the relationship between vulnerability, disasters, disaster prevention and risk reduction.
- Understand Medical and Psycho-Social Response to Disasters.
- Prevent and control Public Health consequences of Disasters
- Enhance awareness of Disaster Risk Management institutional processes in India
- Build skills to respond to disasters.

This course is modelled towards employability, entrepreneurship and skill development.

This is a value added course.

Course Structure

The following is a detailed syllabus.

UNIT I: Introduction on Disaster

Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc., Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures(Building and Bridge), War & Terrorism etc. Causes, effects and practical examples for all disasters.

UNIT II: Risk and Vulnerability Analysis

Risk: Its concept and analysis, Risk Reduction, Vulnerability - concept and analysis, Strategic Development for Vulnerability Reduction.

UNIT III: Disaster Preparedness and Response Preparedness

Disaster Preparedness: Concept and Nature, Disaster Preparedness Plan, Prediction, Early Warnings and Safety Measures of Disaster. Role of Information, Education, Communication, and Training, Role of Government, International and NGO Bodies. Role of IT in Disaster Preparedness, Role of Engineers on Disaster Management.

Disaster Response: Introduction Disaster Response Plan, Communication, Participation, and Activation of Emergency Preparedness Plan, Search, Rescue, Evacuation and Logistic Management, Role of Government, International and NGO Bodies Psychological Response

and Management (Trauma, Stress, Rumor and Panic), Relief and Recovery, Medical Health Response to Different Disasters.

UNIT IV: Rehabilitation, Reconstruction and Recovery

Reconstruction and Rehabilitation as a Means of Development. Damage Assessment, Post Disaster effects and Remedial Measures. Creation of Long-term Job Opportunities and Livelihood Options, Disaster Resistant House Construction, Sanitation and Hygiene, Education and Awareness, Dealing with Victims' Psychology, Long-term Counter Disaster Planning, Role of Educational Institute.

Preamble – Expected outcome and goal - Guiding principles, Priorities for action.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Bryant Edwards (2005). Natural Hazards, Cambridge University Press, U.K.
2. Carter, N W. ((1992). Disaster Management: A disaster Manager's Handbook, Asian Development Bank, Manila.
3. Disaster Planning: The Preservation of Life and Property, Harold D. Foster (1980). Springer Verlay, New York.
4. Disaster Management, Shailendra K Singh, Subash C. Kundu and Shobu Singh (1998). Mittal Publications, New Delhi.
5. Gautam Ashutosh. (1994). Earthquake: A Natural Disaster. Ashok Publishing House. New Delhi.
6. Natural Disasters – A Guide for Relief Workers, (1980). JAC Adhyatma Sadhna Kendra-Mehrauli, New Delhi.
7. Roy, P.S. (2000). Space Technology for Disaster management: A Remote Sensing & GIS Perspective, Indian Institute of Remote Sensing (NRSA), Dehradun.
8. Sharma, R.K. & Sharma, G. (2005). (ed) Natural Disaster, APH Publishing Corporation, New Delhi.
9. Singh D K. (2006). Towards Basics of Natural Disaster Reduction, Research book Centre, New Delhi,
10. Singh T. (2006), Disaster Management approaches and strategies, Akansha Publishing House, New Delhi.

Programme: M.Sc. Environmental Science

EES 5320 PRACTICAL VII - BIODIVERSITY AND CONSERVATION

Course Code	EES 5320	Semester	III
Course Title	PRACTICAL VII - BIODIVERSITY AND CONSERVATION		
Credits	1	Type	Core

Course Description

The course provides practical knowledge of measuring biodiversity. An account of the endangered species of India is also provided.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain practical skills to measure biodiversity
- Understand the status of endangered species in India

Course Structure

The following is a detailed syllabus.

1. Determination of species density using quadrat method.
2. Determination of abundance of species in a given area.
3. Determination of frequency and relative frequency of species in a given area.
4. Determination of diversity indices – Shanaon wiener, Simpson Index, IVI.
5. Identification of endangered flora and fauna of India.
6. Flora and fauna of biodiversity hotspots of India.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Henderson, P.A. 2003. Practical methods in Ecology, Blackwell Publishing, USA

Programme: M.Sc. Environmental Science

EES 5321 PRACTICAL VIII - ENVIRONMENTAL ENGINEERING

Course Code	EES 5321	Semester	III
Course Title	*PRACTICAL VIII - ENVIRONMENTAL ENGINEERING*		
Credits	1	Type	Core

Course Description

This course provides the practical on hand experiences on calculation, design and identification of treatment processes.

Course Outcome

By the end of the course, students are expected to be able to:

- Design the treatment processes
- Solve the problems related to treatment processes

Course Structure

The following is a detailed syllabus.

1. Calculation of Hydrostatic Pressure, flow rate
2. Calculation of Horse power and Pumping
3. Calculation and optimization of coagulant using Jar test apparatus
4. Calculation and designing of Sedimentation Tank
5. Calculation and designing of Activated Sludge Processes
6. Calculation and designing of Trickling Filter
7. Calculation and designing of Disinfection Process
8. Calculation and designing of sludge drying beds, windrow
9. Calculation and designing of minimum stack height
10. Calculation and designing of Cyclone, Electrostatic Precipitator

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Jerry A. Nathanson, 2002. Basic Environmental technology, Prentice Hall of India Publications, India
2. Krikpatrick, 1977. Advanced Mathematics for water and wastewater treatment plant operators, Ann Arbor Science Publishers, Inc, USA

Programme: M.Sc. Environmental Science

EES 5322 PRACTICAL IX - STATISTICAL ANALYSIS

Course Code	EES 5322	Semester	III
Course Title	*PRACTICAL IX - STATISTICAL ANALYSIS*		
Credits	1	Type	Core

Course Description

Course Outcome

By the end of the course, students are expected to be able to:

- Collect, analyze, visualize and interpret data for environmental research

Course Structure

The following is a detailed syllabus.

1. Collection of Data: Primary data – Secondary data – Classification and Tabulation – Diagrammatic Representation
2. Mean, median, mode, Standard Deviations, Errors.
3. Data Analysis using software: SPSS, Systat and Excel stat: Editing,
4. Data Tabulation Analysis: Descriptive statistics – Correlation – Regression
5. Factor analysis and Cluster analysis
6. Principal Component Analysis (PCA)
7. One-way ANOVA and Two-way ANOVA
8. Graph Plotting with different software's

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Kothari, C.R (1996). Quantitative Techniques, Vikas Publishing Housing Pvt Ltd, Hyderabad.
2. Khan, I.A and Kanum, A., (1994). Fundamentals of Bio-Statistics, Ukaaz Publication, Hyderabad

Programme: M.Sc. Environmental Science

EES 5423 Internship

Course Code	EES 5423	Semester	IV
Course Title	*Internship*		
Credits	3	Type	Core

Course Description

The course provides an opportunity to do the internship at industries, factories, research institutes, NGO's and related field work.

Course Outcome

By the end of the course, students are expected to be able to:

- Get experienced in an industry or factory processes.
- Demonstrate the ability to solve the pollution problem on the environment
- Students will get the feel for the work environment which boost their confidence.

Course Structure

- Students must undergo a minimum 3 weeks either at Industries/factories/Research institutes/ NGOs or the field work.

Testing & Evaluation

- Continuous assessment
- Visit report evaluation
- Viva voce

Programme: M.Sc. Environmental Science

EES 5424 Field / Industrial Visits Report and Viva Voce

Course Code	EES 5424	Semester	IV
Course Title	*Field / Industrial Visits Report and Viva Voce*		
Credits	3	Type	Core

Course Description

The course provides an opportunity to visit different industries, factories, research institutes and nature laden areas.

Course Outcome

By the end of the course, students are expected to be able to:

- Illustrate how a process takes place in an industry or factory.
- Demonstrate the impact of the industrial processes on environment
- Understand the concepts with clarity

Course Structure

The following is a detailed syllabus.

- Field visits to different nature laden areas.
- Visits to research institutes.
- Industrial visits to several factories and industries.

Testing & Evaluation

- Continuous assessment during the visit
- Visit report evaluation
- Viva voce

Programme: M.Sc. Environmental Science

EES 5490 Dissertation/Project Work and Viva Voce

Course Code	EES 5490	Semester	IV
Course Title	*Dissertation/Project Work and Viva Voce*		
Credits	6	Type	Core

Course Description

The course provides an insight into the good research practices and hand-on experience of a specific topic of research.

Course Outcome

By the end of the course, students are expected to be able to:

- demonstrate skills required for carrying out research
- Analyse the data obtained
- Write dissertation
- Present the research findings

Course Structure

The following is a detailed syllabus.

- Carrying out research project work on a specific topic
- Writing a dissertation on the topic of research

Testing & Evaluation

- Continuous assessment of research progress
- Seminars
- Dissertation evaluation
- Viva voce

Programme: M.Sc. Environmental Science

EES 5001 Aquatic Ecology

Course Code	EES 5001	Semester	I & III
Course Title	*Aquatic Ecology*		
Credits	3	Type	Elective

Course Description

The course offers tremendous scope for all biologists for learning the multidisciplinary concepts of these fascinating and important ecosystems. The course delves into the physical, chemical, biological, and environmental aspects of the aquatic ecosystems. It emphasizes through its content the need for conservation of aquatic bodies.

Course Outcome

By the end of the course, students are expected to be able to:

- Advocate strongly the need for aquatic ecosystems, and the services they offer to mankind
- Discriminate between lentic, lotic, wetlands, transitionary zones, and marine ecosystems
- Classify, characterize, analyze and research on various aspects of aquatic ecosystems
- Develop strategies and action plans for conservation of aquatic ecosystems

Course Structure

The following is a detailed syllabus.

Unit I: Water

Nature of Water, Chemical and physical properties, Movement of water, Basic principles of fluid dynamics. Movement of light and heat in water, Diffusion of chemicals. Hydrological cycle, interaction of water with other ecosystems.

Unit II: Aquatic Physiography and Chemistry

Basics of oceanography, Geography and types of aquatic habitats, intermediate habitats – significance. Physiography of marine, lentic and lotic ecosystems, formation, characterization, and flow types. Unique and extreme aquatic habitats. Types of elements and chemicals in water, physical chemistry of chemical transformations, oxygen – photosynthesis and respiration, carbon – forms and transformations. Nutrient cycling – carbon, nitrogen, sulphur, phosphorus, silicon, iron and trace nutrient cycles, and interactions.

Unit III: Aquatic Biology

Types of organisms, major taxonomic groups, classification of organisms by habitat, function and level of interaction. Unicellular and Multicellular organisms in aquatic habitats and their role. Trophic states. Food web, prey and predator interactions.

Complex interactions. Species diversity, measures of diversity, and threat perception. Ecosystem services of key aquatic organisms.

Unit IV: Aquatic Pollution

Global change and its effect on aquatic habitats and vice-versa. Types of pollutants – sources and effect, eutrophication, toxins – natural and artificial, anthropogenic chemicals and metals pollution. Toxicology in aquatic habitats, bioassessment and mitigation measures. Chemical and Biomarkers of pollution. Water and wastewater treatment. Wetland conservation.

Testing & Evaluation

- Classroom discussions, seminars, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

- American Public Health Association, et al. 1996. Standard Methods for Examination of Water and Wastewater (19th Edition). American Public Health Assoc., New York.
- Barnes, R.S.K. and K. H. Mann. (1980). Fundamentals of Aquatic Ecosystems. Blackwell Scientific Publications, Oxford.
- Brönmark, C. and L.-A. Hansson. (1998). The Biology of Lakes and Ponds. Oxford UniversityPress, Oxford.
- Cole, G. A. (1983). A Textbook of Limnology.3rd edition.C.V. Mosby, Co., St Louis.
- Dodds, W. K. and M. R. Whiles (2010). Freshwater Ecology (Second Edition). Academic Press, London.
- Gopal, B. and R. G. Wetzel. 1995. Limnology of Developing Countries. Vol. 1-4. Int. Assoc.Theor. Appl. Limnology.
- Lerman, A., D. M. Imboden, and J. R. Gat, Editors. (1995). Physics and Chemistry of Lakes (2nd.Edition). Springer-Verlag, New York.
- National Research Council. (1992). Restoration of Aquatic Ecosystems. The National Academies Press, Washington, DC.
- Wetzel, R. G. (2001). Limnology: Lake and River Ecosystems. 3rd Edition Academic Press, New York.

Programme: M.Sc. Environmental Science

EES 5002 Current Environmental Issues

Course Code	EES 5002	Semester	
Course Title	*Current Environmental Issues*		
Credits	3	Type	Elective

Course Description

The course provides an investigation of the scientific principles behind global environmental issues. The course focuses on key ecological concepts and the changing relationship of humans with the natural world including the different approaches to understanding and solving environmental problems, from local to global scales. It investigates such issues as human populations and environmental impact; loss of species biodiversity; air, water, and soil pollution; energy use; climate change; and waste management.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the global environment from a geographer's "perspective".
- Examine environmental issues from multiple, and often competing, perspectives.
- Examine environmental issues as "conflicts" between natural and human systems.
- Examine specific issues that include atmospheric issues, aquatic issues, terrestrial issues, biodiversity issues, waste issues, and energy issues.

Course Structure

The following is a detailed syllabus.

UNIT I: Population

Population explosion, Malthusian theory, Population distribution, population unsustainability, population growth, population pyramids, pattern of India population, scale of urbanization, migration trends- rural and urban, Population displacement due to developmental projects. International initiatives on population related issues.

UNIT II: Environmental and human health

Hazardous chemicals, pesticides and their impact, polychlorinated biphenyls (PCBs), Lead, mercury, arsenic, cadmium, asbestos, dioxins. Environment and development, poverty and environmental degradation, water requirement, CommUNITy participation in water conservation, Water harvesting, role of NGOs in environmental protection. Social consequences of development and environmental changes

UNIT III: Global Issues

Acid rain and its effects on ecosystems (flora, fauna and human beings). Ozone layer depletion, causes and consequences of Ozone depletion, CFCs, Montreal Protocol. Climate change, global warming- causes and impact of global warming, International initiatives to control global warming, Kyoto Protocol.

UNIT IV: Natural Resources

Depletion and regeneration of natural resources, Renewable and non-renewable resources, Biotic Resources- Forests, agriculture, fisheries, livestock, biodiversity and its conservation, Abiotic Resources- Surface and ground water, Energy, non-energy mineral resources, land resources, soil erosion, ecosystem services. Sustainable development

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Botkin, Daniel B. and Keller, Edward A. (2007), Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA.
- Cunningham, W. P. and Cunningham, M. A. Principles of Environment Science.
- Enquiry and Applications. 2nd ed. Tata McGraw Hill, New Delhi. 2004.
- Rajagopalan, R. (2008), Environmental Studies: From crisis to cure, Oxford University Press, New Delhi.
- Richards, I. S. (2008), Principles and Practice of Toxicology in Public Health. Jones and Bartlett Publishers, London.
- Singh, J.S., Singh, S.P. and Gupta, S.R. (2006), Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi, India.
- UNEP. Global Environment Outlook 3. Geneva: UNEP, Global Resource Information Division. 2003.
- World Commission on Environment and Development (WCED): Our Common Future, Oxford University Press, London. 1987

Programme: M.Sc. Environmental Science

EES 5003 Ecotourism

Course Code	EES 5003	Semester	
Course Title	*Ecotourism*		
Credits	3	Type	Elective

Course Description

The course introduces the importance of incorporating environment friendly practices into the tourism industry. It gives an insight into the sustainable and responsible tourism and also the various alternative tourisms that are developed recently. The course also focuses on the sustainable management of ecotourism projects.

Course Outcome

By the end of the course, students are expected to be able to:

- Develop ecotourism projects
- Have a thorough understanding of the certifications required for the purpose
- Follow sustainable and responsible tourism practices
- Conduct awareness programmes on ecotourism

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT I: Introduction

Ecosystem processes, goods and services with special reference to tourism activities; an overview of Tourism-Environment linkages – 'Intangibility', 'Heterogeneity', 'Perishability' and 'Inseparability' of Tourism and their Ecological, Environmental, social, economic, cultural, ethical implications; impacts of mass tourism, environmental concerns, need for environmental conservation, alternative tourism strategies.

UNIT II: Alternative tourism: typology & strategies

Alternative tourism typology- Ecotourism, Ecocultural Tourism, Heritage Tourism, Adventure Tourism, Health Tourism, Farm Tourism, Urban Eco-tourism, Fishing Tourism- definitions, strategies, potentials and constraints; Responsible tourism, incorporation of pro-poor, community run/based, gender balanced tourism strategies.

UNIT III: Ecotourism and Sustainable development

Evolution and characteristics of ecotourism; Eco-development, Sustainable development, carrying capacity and development, Adaptive and sustainable management of ecosystem and its resources with reference to Ecotourism; Eco-tourism industry in India; Potentials and constraints for promoting Eco-tourism in India; Eco-labels, Ecotels and Ecotourism certification programmes.

UNIT IV: Ecotourism Policy & Planning- a futuristic perspective

Eco-tourism components and impact monitoring – Ecotourism opportunity spectrum (ECOS), Ecological foot print analysis, Limits of acceptable change (LAC), Visitor activity management (VAM), Visitor impact management (VIM), World Ecotourism Summit; suggestions for long term sustainable Eco-tourism initiatives.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Buckley, R.C. (2009). Ecotourism: Principles and Practices. CAB International, Oxford, 368pp
- Fennell, D. A. (2008). Ecotourism: An introduction. New York, NY: Routledge.
- Weaver, David, (2008). Ecotourism, John Wiley & Sons; 2nd Edition Paper back, pp.360.
- Brent Ritchie J R & G I Crouch, (2005). The Competitive destination: A sustainable tourism perspective, CABI, UK.
- Eagles, P.F.J, S.F. McCool, & Haynes, Christopher,D.A. Christopher. (2002). Sustainable tourism, in protected areas: guidelines for planning and management, IUCN, Gland, Switzerland.
- Honey, M, (2008). Ecotourism and Sustainable Development Who Owns Paradise? Second Edition, Island Press, USA, Paperback pp.558.
- Wood, M, E, (2003). Eco-tourism: principles, practices and policies for sustainability, UNEP, DTIE/ TIES, 61 pp. accessed at uneptie.org/ tourism/home.html

Programme: M.Sc. Environmental Science

EES 5004 Energy and Environment

Course Code	EES 5004	Semester	
Course Title	*Energy and Environment*		
Credits	3	Type	Elective

Course Description

The course covers environmental impact of energy production and consumption. Further aspects studied are energy, energy efficiency, consumption patterns and sustainability.

Course Outcome

By the end of the course, students are expected to be able to:

- Summarize the basic concepts of energy, its distribution and general Scenario.
- Explain different energy storage systems, energy management, audit and economic analysis.
- Summarize the environment eco system and its need for awareness.
- Identify the various types of environment pollution and their effects.
- Discuss the social issues of the environment with associated acts.

Course Structure

The following is a detailed syllabus.

UNIT I: Non-renewable Energy resources

Fossil fuels-classification, composition, physico – chemical characteristics and energy content of coal, petroleum and natural gas, nuclear fuel, fission and fusion.

UNIT II: Renewable Energy Resources

Biomass, bio-fuel, hydroelectric power; Non-conventional energy resources: tidal energy, wind energy, geothermal energy, solar energy, solar radiation and its spectrum, solar collectors, photovoltaics, solar ponds, hydrogen energy.

UNIT III: Energy Resource Management

Energy crisis; Energy Conservation and Management; Energy audit; Recycling of wastes**:** Types - sources - composition of waste - recycling of waste for Industrial, Agricultural and Domestic Purposes.

UNIT IV: Energy Use and its Environmental Impact

Energy use pattern in different parts of the world; Environmental implication; CO_2 emissions, global warming; thermal pollution, air pollution; radioactive waste, radioactivity from nuclear reactors, radioactivity risk assessment and criteria for safe exposure; impacts of large-scale exploitation of Solar, Hydro and Wind energy.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Armaroli N, Balzani V, 2011. Energy for a Sustainable World – From the Oil Age to a Sun-Powered Future, Wiley-VCH.
- Armaroli N, Balzani V, Serpone N, 2013. Powering Planet Earth – Energy Solutions for the Future, Wiley-VCH
- Chichester, 2010. Renewable Energy and Climate Change. John Wiley & Sons Ltd.
- Sioshansi FP, 2011. Energy, Sustainability and the Environment, Elsevier

EES 5005 Environmental Economics

Course Code	EES 5005	Semester	
Course Title	*Environmental Economics*		
Credits	3	Type	Elective

Course Description

This course focuses on economic causes of environmental problems. In particular, economic principles are applied to environmental questions and their management through various economic institutions, economic incentives and other instruments and policies. Economic implications of environmental policy are also addressed as well as valuation of environmental quality, quantification of environmental damages, tools for evaluation of environmental projects such as cost-benefit analysis and environmental impact assessments. Selected topics on international environmental problems are also discussed.

Course Outcome

By the end of the course, students are expected to be able to:

- Enhance their ability to conduct professional economic research
- Develop and present professional proposals, papers, and presentations;
- Increase their ability to analyze environmental policies through a deeper understanding of economic behaviour and incentives; economic institutions, property rights and contracts.

Course Structure

The following is a detailed syllabus.

UNIT I: Economy and the Environment

World environmental history and economic development, valuation of natural resources, Inter-linkages between the economy and the environment. Economics of Natural Resource Exploitation

– Renewable and Non-Renewable Resources – Methods of valuation of Environmental Costs and Benefits. Entropy- Principle and law of entropy. Material flow in economy.

UNIT II: Environmental Policy

Design of Environmental Policy. Economic Instruments for Environmental Protection: Command & Control versus Incentives and Subsidies. Effectiveness of these instruments. Indian scenario and comparisons with China and developed countries.

UNIT III: Sustainable Development

Concept and objectives. Strategic Planning for Sustainable Development, Natural resource based economic and social development. Climate Change, India:Vulnerability of regions and populations – Adaptation options.

UNIT IV: Green Economy

New model for development, Green economy and green economy initiatives, Role of UNEP. Brundtland Commission. ecological economics Economic Growth and the Environment: Environmental Kuznets' curve, Foreign Direct Investment and the Environmental quality.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Allen V. Kneese and James L. Sweeney, eds. (1985), Handbook of Natural Resource and Energy Economics, Chapters 2,12,14,17, North Holland.
- Bohm, P. and Russell, C., `Comparative Analysis of Alternative Policy Instruments',Chap. 10 in Handbook of Natural Resource and Energy Economics, Vol.I Ed. A.V.
- Field, B.C., (1994), Environmental Economics: An Introduction, McGraw Hill.
- Fisher, A.C., (1995), Environment and Resource Economics, Selected readings, New Horizon in Environmental Economics, Ed. W.E. Oates,.
- Hanley, Nick, Jason F. Shogren & Ben White (1997), : Environmental Economics in Theory and Practice, New Delhi: Macmillan –India.
- James, D.E., (1978), Economic Approaches to Environmental Problems: Techniques and Results of Empirical Analysis, Elsevier Scientific Publishing Co..
- Kolstad Charles., (2010), Environmental Economics, New Delhi: Oxford University Press.

Programme: M.Sc. Environmental Science

EES 5006 Environmental Education

Course Code	EES 5006	Semester	I
Course Title	*Environmental Education*		
Credits	3	Type	Elective

Course Description

This course is designed to prepare students to implement environmental education opportunities in formal and non-formal education settings.

Course Outcome

By the end of the course, students are expected to be able to:

- Develop a foundational knowledge of environmental education.
- Understand the importance of developing an environmentally literate populace.
- Critically examine environmental issues in the Indian context.
- Understand how local, regional, state, national, and international laws and regulations influence environmental decisions.
- Locate and use environmental education teaching and learning materials.
- Integrate instructional technology into environmental education settings.

Course Structure

The following is a detailed syllabus.

UNIT –I Introduction

Objectives, Scope and Nature of Environmental Education a) Meaning, definition and characteristics of environmental education – content. b) Importance, objectives, scope and guiding principles of environmental education. c) Factors of degradation of environment – adverse socio – economic impacts of degradation of environment.

UNIT – II Environmental Policies

India and Environmental Issues and Policies Major environmental problems in India – Environmental protection and polices in India – Need and objectives of conservation – Environmental conservation measures taken in India – Constitutional amendments made and Environmental laws

UNIT -III Environmental Movements

Environmental Movements and Developments Environmental movements in India: Silent Valley movement, Chipko movement, Narmada Bachao, Andolon, National Test Range at Baliupal, Orissa – conditions for achieving the goals of sustainable development – Strategies for sustainable development in India.

International Efforts for Environmental Protection The Stockholm conference 1972 – Brundtland commission 1983 – Nairobi conference 1982 – The Rio Summit 1992 – the Rio Declaration at the earth charter – Major achievements of the Rio Summit – Main features of the Rio Declaration – Kyoto conference and part on Global Warming.

UNIT - IV Role of Education

Environmental Education in the School Curriculum, major constraints for its implementation, Teacher's role – national resource centre for environmental education, role of individual in conservation of natural resources - Role of information technology.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

- KK Shrivastava (2016) Environmental Education: Principles, Concepts and Management,Kanishka Publishing House.
- KC Jain (2016) Environment Education, Tandon Publications.
- Sharma, R. A. (2008). Environmental Education. R. Lall Books Depot. Meerut.
- Singh,Y. K. (2009). A text book of environmental science. APH Publishing Corporation , New Delhi.
- Depot. Kumar, A. (2009), Education for Environmental and Human value, R. Lall Books Publications, Meerut, India
- Reddy, P. K., & Reddy, N. D. (2001). Environmental education. Anmol publications, New Delhi.
- Kelu, P. (2000). Environmental Education. Neelkamal Publications, Hyerabad.
- Sharma, R. G. (1986). The handbook of environmental education., Metropolitan Book, New Delhi.

Programme: M.Sc. Environmental Science

EES 5007 Environmental Geosciences

Course Code	EES 5007	Semester	
Course Title	*Environmental Geosciences*		
Credits	3	Type	Elective

Course Description

The course covers a broad range of topics, ranging from Earth materials and their use to Earth processes, including natural hazards and their impact on human lives. It also deals with using geological knowledge to address interactions between humans and the physical environment: the biosphere, the lithosphere, the hydrosphere, and, to some degree, the atmosphere.

Course Outcome

By the end of the course, students are expected to be able to:

- Outline how geoscience relates to the environment.
- Explain the mechanisms behind plate tectonics and plate motion; describe the basic internal structure of the Earth as well as the Earth's composition.
- Outline the major groups of the main rock-forming minerals; describe igneous, metamorphic and sedimentary rocks; and explain the roles rocks and minerals play in the environment.
- Describe the conditions that make some natural Earth processes hazardous to people and discuss the role of science in evaluating natural hazards.
- Outline the mechanisms behind geological processes that include earthquakes, volcanoes, and landslides and identify associated hazards and ways of minimizing their effects.
- Discuss the factors that control the distribution of mineral resources, including fossil fuels, and explain the environmental impact of mineral development. Describe the basics of Earth system science and how it can be used to study global climate change.

Course Structure

The following is a detailed syllabus.

UNIT I: Basic concepts

Evolution of earth and it's environment; components of the physical environment, atmosphere, hydrosphere and lithosphere. Internal structure of earth; Geological maps, Geological time scale, Hydrological cycle, the concept of rock cycle; Agents, types and products of weathering; Rocks and mineral, classification, soil formation, soil profile, soil classification, soils of India.

UNIT II: Environmental geology

Environmental factors of deep seated processes of lithosphere volcanic, seismic and diastrophic tectonic processes with special reference to Indian sub-continent, reservoir induced seismicity, environmental geologic mapping, geological aspects of environmental impact of dredging, mining, river-sand mining, quarrying , deforestation, resettlement, farming, and other types of land use, environmental factors of ground water depletion, bore wells, siltation of reservoirs, Geo environmental changes associated with highway construction, bridges, tunnels, high rise buildings.

UNIT III: Plate tectonics and geological hazards

Concept of plate tectonics; Major and minor lithospheric plates, plate margins and types, causes of plate movement, sea floor spreading and continental drift; geodynamic elements of earth: Mid-ocean ridges, trenches, transform faults and Island arcs. Interrelation of topo sheet – contour, gradient, dip, strike; Geological structures: Joints, fold, fault and unconformities.

UNIT IV: Application of geology in engineering

Geological time scale of rocks; properties of rocks, Geological and environmental investigations for the construction of dams, bridges, highways and tunnels; Impact of major geotechnical projects on the environment.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Bell, F.G., (1999). Geological Hazards, Routledge, London.
- Brownlow, A.N., (1979). Geochemistry, Prentice Hall.
- Bryant, E., (1985). Natural Hazards, Cambridge University Press.
- Keller, E.A., Environmental Geology & Turk and Turk.
- Krynine, D.S. and Judd, W.R., (1998) Principles of Engineering Geology, CBS, New Delhi.
- Lahee, (1987) Field Geology. Sixth Edition. Mc Graw Hall Co..
- Sawkins,J.S.,Chase,C.G., Darby,D.G. and Rapp,G., (1978).The evolving earth, Mac Millan Publishing Co., New York.
- Smith, K., (1992). Environmental Hazards, Routledge, London.
- Spencer, Structure of the Earth. Wiley. Brian Mason, 1966, Principles of Geochemistry, Wiley.

Programme: M.Sc. Environmental Science

EES 5008 Environmental Genetics and Biotechnology

Course Code	EES 5008	Semester	
Course Title	*Environmental Genetics and Biotechnology*		
Credits	3	Type	Elective

Course Description

The course proposes to cover the modern biotechnological tools for environmental applications and sustainable development.

Course Outcome

At the end of the course, students should be able to

- associate the biotechnology tools in environmental applications
- articulate the available modern tools of biotechnology for environmental remediation
- apply the biotechnological tools for sustainable environment

Course Structure

The following is a detailed syllabus.

UNIT I: Genetic Engineering

Introduction to genetic engineering, Restriction endonucleases, properties of restriction enzymes, introduction of cloned genes into new hosts using plasmid and phage vector systems, isolation of plasmids, DNA – cloning of DNA fragments, Cloning of single stranded DNA, Shuttle vectors and their environmental applications.

UNIT II: Biotechnology for environment

Recombinant DNA Technology, development of genetically engineered microorganisms (GEMs), Polymerase Chain Reaction (PCR) and development of gene probes for environmental remediation, Uses of GEMs in bioremediation, Genosensor technology.

UNIT III: Genetically modified microorganisms

Genetically modified microbes & their uses in Environmental, Microbial reactors, management of recycling & up gradation technologies, Bioenergy from waste, Biogas technology – process and biogas from organic waste.

UNIT IV: Biotechnology for Management of Resources

Bio-transformation of heavy metals, improved oil recovery, role of environmental biotechnology in management of resources, reclamation of wasteland, biomass production, microorganisms in mineral and energy recovery, nanotechnology for control of pollution.

Testing & Evaluation

- Continuous assessment for 40% will be carried out with 2 internal assessment tests, seminars, assignments, group discussions, etc.
- End semester examination for 60% will be conducted at the end of the semester.

References

- Environmental Biotechnology and Cleaner Bioprocesses. Boca Raton, Taylor & Francis.
- Evano, G.H. and Furlong, J.C. (2004), Environmental Biotechnology - Theory and Application. USA, John Wiley and Sons.
- Jjemba, P.K. (2004), Environmental Microbiology - Theory and Application. USA, Science Pub. Inc..
- Kuhad R.C., Singh A. (2013), Biotechnology for Environmental Management and Resource Recovery. New York, Springer-Verlag.
- Martin C.C. (2008), Environmental Genomics. Totowa, NJ, USA, Humana Press.
- Pepper, I.L. and Gerba, C.P. (2005), Environmental Microbiology - Laboratory Manual. USA, Elsevier.
- Ratledge, C. and Kristiansen, B. (2002), Basic Biotechnology. 2nd ed. Cambridge, Cambridge University Press.
- Rittman, B. and McCarty, P. L. (2000), Environmental Biotechnology: Principles and Applications. 2nd edition. USA, Tata McGraw-Hill.
- Rittmann, B.E. and McCarty, P.L. (2001), Environmental Biotechnology – Theory and Application. USA, McGraw Hill.

Programme: M.Sc. Environmental Science

EES 5009 Environmental Nanotechnology

Course Code	EES 5009	Semester	I
Course Title	*Environmental Nanotechnology*		
Credits	3	Type	Elective

Course Description

The primary goal of the course is to increase student awareness of how nanomaterials interact in natural and engineered environments. We will examine both the potential benefits of nanomaterials/nanotechnology for environmental applications (groundwater remediation, drinking water production) and the potential environmental and toxicological hazards associated with nanomaterials/nanotechnology.

Course Outcome

By the end of the course, students are expected to be able to:

- Describe the basic concepts of nanoscience and nanoengineering and have the ability to convey those concepts to the general public.
- Evaluate mechanisms that define nanomaterial fate and transport, nanomaterial toxicity, and ecological effects in natural and engineered environments.
- Understand the near term and future applications of nanomaterials and nanoscience, as well as the benefits and pitfalls of widespread use of these materials in society.
- Actively and collaboratively engage in the discussion of environmental nanotechnology.

Course Structure

The following is a detailed syllabus.

UNIT-I Introduction

Environmental Nanotechnology- An introduction, Concept of Nano pollution, Nanotechnology for Reduced waste and improved energy efficiency, Nanotechnology based water treatment strategies.

UNIT-II Synthesis of Nano materials

Microorganisms for synthesis of Nano materials and for toxicity detection: Natural and artificial synthesis of Nano particles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of Nano particles using microorganisms.

UNIT-III Applications in Waste Management

Waste remediation: Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification. Energy conversion; Hierarchical self-assembled nanostructures for adsorption of heavy metals, Nano-pesticide formulations, Nanoparticles for dye removal and water filtration.

UNIT-IV Safety of Nanomaterials

Pollution by Nano-particles- Health impact, Safety and Toxicological effects. Societal impact & Ethical issues in Nanoscience and Nanotechnology, Problems and possible solutions, Regulation, Green Nanotechnology.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Seminar
- Assignment

References

- Hambleton, P.; Salusbury, T. (Eds.) (1994), Biosafety in Industrial Biotechnology. Springer.
- Mark Wiesner, Jean-Yves Bottero (2007), Environmental Nanotechnology: Applications and Impacts of Nanomaterials: Applications and Impacts of Nanomaterials, McGraw Hill Professional.
- Jo Anne Shatkin (2013), Nanotechnology: Health and Environmental Risks, Second Edition, CRC Press, Taylor and Francis.
- Vicki H. Grassian (Ed) (2008), Nanoscience and Nanotechnology: Environmental and Health Impacts, John Wiley & Sons, Inc.
- Berube, D. M. (2006), Nano-hype: The Truth Behind the Nanotechnology Buzz. New York: Prometheus Books.
- Jean-Yves Bottero (2007), Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill Education.
- Mukesh K Burman (2012), Nanotechnology: Emerging Issues and Application,Sarup Book Publishers.
- Geoffrey B. Smith, Claes-Goran S. Granqvist (2010), Green Nanotechnology: Solutions for Sustainability and Energy in the Built Environment, CRC press.

Programme: M.Sc. Environmental Science

EES 5010 Environmental Stress Biology

Course Code	EES 5010	Semester	
Course Title	*Environmental Stress Biology*		
Credits	3	Type	Elective

Course Description

The course provides an insight into the different types of environmental stresses and the response of different groups of organisms to the stresses. Also, the role of chemical molecules in the biotic-biotic interactions is covered in this course.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate a linkage between a stress factor and an effect on the organism
- Understand and appreciate the role of chemical molecules in signalling in several organisms.

Course Structure

The following is a detailed syllabus.

Unit I: Introduction to Environmental Stresses

Introduction to environmental stresses, Types of stresses, Abiotic factors: temperature, water, salinity, UV radiation, Biotic factors: competitors, pathogens, pests.

Unit II: Plant Responses to Environmental Stress

Adaptations of plants to environmental stress, Eco-physiological responses of extremophiles, tolerance of plants to pollutants, tolerance index of plants, Use of stress indicators for biomonitoring.

Unit III: Animal Responses to Environmental Stress

Biological responses to high altitude and deep sea environment; Osmoregulation in fish, water conservation and adaptive mechanisms in desert habitats; hibernation and aestivation, Circadian rhythms and biological clock; Bioindicators and biomonitors of pollution.

Unit IV: Chemical Ecology

Chemical interactions between biota of an ecosystem, Allelopathy, Chemotaxis, Chemical messages during insect herbivory, Volatiles for chemical communication, Chemistry behind Plant pathogen interactions.

Testing & Evaluation

- Seminars
- Written tests
- Group discussions

- Assignments

References

- Plant Physiological Ecology 2008.Lambers, Hans,Chapin III, F. Stuart,Pons, ThijsL., Springer
- Plant Ecophysiology. 1996. (Ed) M.N.V Prasad. John Wiley & Sons
- Physiological Animal Ecology 1996.Gideon N Louw. Prentice Hall
- Physiology and Molecular Biology of Stress Tolerance in Plants. 2006.(Eds) K.V. MadhavaRao, A.S. Raghavendra, K. Janardhan Reddy. Springer.
- Physiological Plant Ecology(Eds)Lange, O.A., Nobel,P.S., Osmond, C.B. and Ziegel, H. Encyclopedia(Vol. I-IV) Springer Verlag
- Environmental Physiology of Plants.2002. By Alastair H. Fitter, Robert K.M. Hay Academic Press
- Animal Physiology: Adaptation and Environment 5thedition, 2002. By Knut Schmidt-Nielsen

Programme: M.Sc. Environmental Science

EES 5011 Food Safety and Health

Course Code	EES 5011	Semester	I
Course Title	*Food Safety and Health*		
Credits	3	Type	Elective

Course Description

This course aims to equip the learners with the basic food safety knowledge to enable them to work with food in a safe and hygienic manner. The course is a comprehensive coverage of Food borne diseases, including surveillance and investigation; Foodborne hazards, including microbiological and chemical agents; Substances added to food, both directly and indirectly; Food technologies, including the latest developments; Food commodities, including their potential hazards and controls; Food safety management systems, including their elements and the roles of stakeholders

Course Outcome

By the end of the course, students are expected to be able to:

- Define food hygiene.
- List the responsibilities of a food worker.
- Identify various foodborne pathogens.
- Understand the importance of food safety preparedness.
- Understand the requirements of HACCP.
- Identify food regulations and procedural analysis in food industry.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT –I Introduction

Concepts of food safety, establishing the problems, susceptibilities within the food chain, Food borne pathogens and outbreaks, seafood and shell fish, mercury and toxins

UNIT –II Regulations

Food safety regulations: the roles of federal, state, and international agencies, Hormones and antibiotics: antibiotic resistance, contamination of foods. Organic food, chemical contamination of food, Genetically modified foods. Food safety preparedness: Perspective from the food industry

UNIT –III Procedural Analysis

Risk perception and analysis; Globalization, sustainable agriculture, local food networks, slow foods; Restaurant and food service inspections, food safety in the home

UNIT –IV Food safety

Bioterrorism and food safety, Over-nutrition: food marketing, supersizing, obesity. Legal consequences of food outbreaks, Dietary Supplements.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar

Assignment References

- Food Safety Management, A Practical guide for the food industry, 2013 Elsevier Publishers (1st Edition, 2013).
- Food Safety and Standards Act, Rules & Regulations, 2015, Akalank Publications (13th Edition edition), India.
- P K Das (2006). Handbook on the Food Safety & Standards Act, 2006 Universal-Law-Publishing-Co-Ltd, India
- SN Mahindru (2007) Food and Nutrition Education KSK Publishers & Distributors.
- Punam Chopra (2005) Food and Nutrition Education APH Publishing Corporation, India
- Steier, Gabriela, Patel, Kiran (Eds.) (2016) International Food Law and Policy, Springer, Germany
- Alok Bhargava (2008) Food Economics and Health, Oxford University Press, New Delhi.
- PS George (2002) Some Reflections on Food Security in India, Academic Foundation, New Delhi.

Programme: M.Sc. Environmental Science

EES 5012 Forestry

Course Code	EES 5012	Semester	
Course Title	*Forestry*		
Credits	3	Type	Elective

Course Description

The course provides an introduction into the forest ecosystem and the different ways and techniques that can applied in silviculture. The vast resources available in the forests and their uses are discussed in detail. And, the laws and acts pertaining to forests and forestry are discussed in detail.

Course Outcome

By the end of the course, students are expected to be able to:

- Appreciate the significance of forests in well-being of the human beings
- Follow the acts and legislations in connection with the proper upkeep of the forests and forested land
- Understand the various steps in silviculture practices in different ecosystems.

Course Structure

The following is a detailed syllabus.

Unit I: Introduction

Definition of forestry, Concepts, terminologies, need and scope. Forest as an ecosystem: Biotic and abiotic components, ecological and physiological factors influencing vegetation, productivity, nutrient cycling, stresses, Forest types in India and conservation initiatives: forest genetic resources and gene conservation in situ and ex-situ, REDD+, Research and Extension needs, Tribal community participation in forestry programme, Joint Forest Management.

Unit II: Silviculture

General principles, nursery system, Silvicultural systems - wood selection, felling, establishment and management of stands, technical methods and constraints, Silviculture practices in specialized ecosystems like Mangroves and Cold deserts.

Unit III: Forest resources and utilization

Sustainable harvest of forest resources, Timber- logging and extraction techniques and principles, transportation system, storage and sale, Need and importance of wood seasoning and preservation; Non-Timber Forest Products (NTFPs) definition and scope - collection; processing and disposal/sale.

Unit IV: Forest legislation

Pre- and post-independence forest policies in India: 1894 & 1952. National Forest Policy: 1988. Forestry Policies and issues related to land use, timber and non-timber products. Indian Forest Act 1927; Forest Conservation Act, 1980; Application of Indian Penal Code to Forestry.

Testing & Evaluation

- Seminars
- Written tests
- Group discussions
- Assignments

References

- The Silviculture of Indian trees by R.S. Troup (2011) Volume 1, 2 & 3. Nataraj Publishers, Delhi.
- Forest Ecology by J.P. Kimmins (2003) 3rd Edition. Benjamin Cummings Publisher, USA.
- Perspectives on social forestry by B.L. Sharma and R. Vishnoi (2000). Daya Publishing house, Delhi.
- Ensuring sustainability in Forestry: Certification of Forests by H.S. Gupta, M. Yadav, D. K. Sharma and A.M. Singh (2013). TERI Press, Delhi.
- The practice of silviculture: Applied forest ecology by M.S. Ashton and M.J. Kelty (2018) 10th Edition. Wiley, USA.
- Forest Ecosystems by D.A. Perry (1994). The Johns Hopkins University Press, USA.
- Forest Ecology in India by N.A. Rao (2007). Cambridge University Press, UK.
- Forest wildlife ecology and habitat management by D.R. Patton (2010). CRC Press, Boca Raton.
- Silviculture in the tropics by S. Guenter, M. Weber, B. Stimm and R. Mosandl (2011). Springer-Verlag, Berlin.

Programme: M.Sc. Environmental Science

EES 5013 Industrial Ecology

Course Code	EES 5013	Semester	
Course Title	*Industrial Ecology*		
Credits	3	Type	Elective

Course Description

This course aims to introduce the concepts underlying industrial ecology and some tools used in it. It will also discuss eco-industrial development, the key issues involved and some cases from India. It will, therefore, expose students to the multidisciplinary nature of environmental issues and integrate pollution prevention with sustainable development.

Course Outcome

By the end of the course, students are expected to be able to:

- Evaluate environmental impact from materialand energy flows in a life cycle perspective based on thermodynamics and suggest improvements with the
- Awareness of the risk for problem shifting
- Apply material strategies such as dematerialisation, substitution and waste hierarchies regarding different products
- Describe the usability of different tools and strategies for optimising materialand energy flows in a life cycle perspective
- Describe and use life cycle assessment to quantify environmental impacts from a system,
- Search and analyse information regarding a societal environmental problem, propose realistic system approches for increased resource efficiency and present the results both orally and in written form

Course Structure

UNIT I: The Environment and the Anthrosphere

Definition – Environment and Anthrosphere, Components of the anthrosphere, effects of the anthrosphere on earth, integration of the anthrosphere into the total environment, the anthrosphere and industrial ecology.

UNIT II: Industrial ecology and industrial systems

Levels of material utilization, links to other environmental spheres, consideration of environmental impacts in industrial ecology, Key attributes – energy, materials and diversity. Life cycle, consumable, recyclable and service products. Societal factors and environmental ethics.

UNIT III: Industrial Metabolism and waste disposal

Networks of Nutrient and Energy transfer. Industrial metabolism, ion exchange, photolytic reactions, thermal treatment methods, biodegradation of wastes, treatment methods for solid and liquid wastes.

UNIT IV: Industrial ecosystems

Components of the industrial ecosystem, overview of an integrated industrial ecosystem, examples of symbiotic industrial ecosystems, designing and developing of symbiotic industrial ecosystem. Industrial Ecology and the Legal System.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Bourg D., Erkman S. (2003), Perspectives of Industrial Ecology. Texas, Greenleaf.
- Graedel T.E., Allenby B.R. (2010), Industrial Ecology and Sustainable Engineering. New Jersey, USA, Prentice Hall.
- Graedel T.E., Allenby B.R. (2003), Industrial Ecology. New Jersey, USA, Printice Hall.
- Manahan S.E. (1999), Industrial Ecology: Environmental Chemistry and Hazardous Wastes, Boca Raton, CRC Press,.
- Socolow R., Andrews C., Berkhout F, Thomas V. (2010), Industrial Ecology and Global Change. Cambridge, Cambridge University Press,.
- Suh S. (2009), Handbook of Input-Output Economics in Industrial Ecology. New York, Springer-Verlag.

Programme: M.Sc. Environmental Science

EES 5014 Marine Environment

Course Code	EES 5014	Semester	
Course Title	*Marine Environment*		
Credits	3	Type	Elective

Course Description

The course proposes to provide a deeper knowledge on marine ecosystems, marine biodiversity and effect of environmental changes on marine biodiversity.

Course Outcome

At the end of the course, students should be able to

- recall the roles and importance of different ecosystems in the marine environment
- discuss the marine biodiversity and necessity of marine biodiversity conservation
- appraise the different available renewable marine resources for sustainable environment
- correlate the pollution and environmental factors on marine environment and its biodiversity.

Course Structure

The following is a detailed syllabus.

UNIT I: Introduction to Marine ecosystem

Marine ecosystem – estuaries, rocky and sandy shores, pelagic ecosystems, continental shelf seabed, deep sea, mangroves forests, seagrass meadows, coral reefs, Polar Regions.

UNIT II: Marine Biodiversity

Distribution of marine biodiversity, relationship between global climate and marine biodiversity, hypoxia and dead zone, significance of marine biodiversity, marine ecosystem functioning. Extinct and endangered marine species, fisheries management and conservation.

UNIT III: Marine Resources and Energy

Fossil records, fishing, mining – minerals and crude oil, tourism, Energy from Marine Environment – Renewable – marine wind power, osmotic power, tidal power, wave power, ocean thermal energy; Non renewable energy.

UNIT IV: Marine Pollution

Sources and types of marine pollution, effects of marine pollution – physicochemical and biological effects, impact of climate and environmental factors on marine environment and biodiversity. Mitigation measures for marine pollution.

Testing & Evaluation

- Continuous assessment for 40% will be carried out with 2 internal assessment tests, seminars, assignments, group discussions, etc.
- End semester examination for 60% will be conducted at the end of the semester.

References

- Farmer A. (1997), Managing Environmental Pollution. New York, Routledge.
- Hofer T.N. (2008.), Marine Pollution: New Research, New York, Nova Science Publishers,
- Iversen E.S. (1996), Living Marine Resources: Their Utilization and Management. New York, Chapman Hall,
- Kaiser M.J., Attrill M.J. (2011), Marine Ecology: Process, Systems and Impacts. Oxford, Oxford University Press.
- Multon B. (2012), Marine Renewable Energy Handbook. Philippines,Wiley-ISTE.
- Polunin V.C. (2008), Aquatic ecosystems: Trends and Global Prospects. Cambridge, Cambridge University Press.

Programme: M.Sc. Environmental Science

EES 5015 Occupational Health and Industrial Safety

Course Code	EES 5015	Semester	I
Course Title	*Occupational Health and Industrial Safety*		
Credits	3	Type	Elective

Course Description

This course examines occupational safety and health practices needed to address occupational safety and health issues in the workplace. Students will utilize regulatory standards as a guide to apply policies, procedures, standards and occupational safety and health principles. Industry recognized best practices, origin of the standards, the process and rules of inspections, citations and penalties and polices will be covered.

Course Outcome

By the end of the course, students are expected to be able to:

- Evaluate workplace to determine the existence of occupational safety and health hazards
- Identify relevant regulatory and national consensus standards along with best practices that are applicable.
- Select appropriate control methodologies based on the hierarchy of controls
- Analyse injury and illness data for trends.
- Provide industry with inputs on health and safety.
- Learn and disseminate issues related to occupational health and hazards.
- Develop protocol for an industry on disaster prevention, health issues, safety measures and environment management.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT I: Occupational Health

Hazards and Safety–Physical, Chemical and Biological hazards. Occupational Diseases and Occupationally induced illness - Prevention and Control. Health problems in different types of industries. Measures for Workers. Health Education Medical First Aid and Management of Medical Emergencies. Epidemiological approaches. Ergonomics.

UNIT II: Industrial Safety Management Techniques

Industrial Safety Standards. Dispersion of Radioactive material and release of Toxic and inflammable materials. Work Study - Method of Study and Measurement. Measurement of Skills. Safety - Cost of Expenses. Principles and Functions in Safety Management.

UNIT III: Hazards Exposure evaluation

Sampling techniques, Personal monitoring, Biological monitoring; Threshold Limit Values (TLV), STEL; List of Industries involving Hazardous process Occupational Hazards under the First Schedule of the Factories Act,1948; Permissible Limits of certain Chemical substances in work environment under the Second Schedule of the Factories Act,1948.

UNIT IV: Hazards Control

Causes of Accident – Theory of accidents, Accident Reporting system, Safety Audit, Accident prevention, Safety Committee, Case studies on Bhopal, Chernobyl and similar disasters - Control of Hazards Substitutions, Isolation, Personal Protective Equipment (PPE).

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

- A B C of Industrial Safety, Walsh, W and Russell, L, (1984), Pitma Publishing United Kingdom.
- Della D.E., and Giustina, (1996), "Safety and Environmental Management", Van Nostrand Reinhold International Thomson Publishing Inc.
- Environmental and Industrial Safety, Hommadi, A. H. (1989), I.B.B Publication, New Delhi.
- Environmental Strategies–Hand Book, Kolluru R. V, (1994) Mc Graw Hill Inc., New York.
- Goetsch D.L., (1999), "Occupational Safety and Health for Technologists", Engineers and Managers", Prentice Hall.

Programme: M.Sc. Environmental Science

EES 5016 Principles of Remote Sensing and GIS

Course Code	EES 5016	Semester	
Course Title	*Principles of Remote Sensing and GIS*		
Credits	3	Type	Elective

Course Description

The purpose of this course is to introduce the students the basic concepts and principles of various components of remote sensing and also provide an exposure to GIS and its practical applications

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the concepts of Photogrametry and compute the heights of objects
- Understand the principles of aerial and satellite remote sensing, able to comprehend the energy interactions with earth surface features, spectral properties of water bodies .
- Understand the basic concept of GIS and its applications, know different types of data representation in GIS
- Understand and Develop models for GIS spatial Analysis and will be able to know what the questions that GIS can answer are
- Apply knowledge of GIS software and able to work with GIS software in various application fields
- Illustrate spatial and non spatial data features in GIS and understand the map projections and coordinates systems
- Apply knowledge of GIS and understand the integration of Remote Sensing and GIS

Course Structure

The following is a detailed syllabus.

UNIT-I: Introduction

Principles of Remote sensing: Electromagnetic Radiation (EMR),interaction of EMR-earth's surface-reflection-transmission, Spectral signatures and characteristics, spectral reflectance curves. Process of data acquisition, storage, analysis and visualization.

UNIT II: Remote Sensing System

Remote Sensing observations and platforms: Air borne and space borne platforms. Active, Passive and Optical remote sensing, Concept of Microwave remote sensing and microwave remote sensors. Multi-Spectral Imagery (MSI) - Hyperspectral Imagery (HSI)-Thermal Scanner Imagery. Scattrometer and Altimeter.

Remote sensing satellites; Land observation satellites, IRS series, LANDSAT series, SPOT series; High resolution satellites, Weather/Meteorological satellites, NIMBUS Applications, Marine observation satellites OCEANSAT.

UNIT III: Aerial Photography

Elements of photographic system, Geometric characteristics of aerial photographs, Photogrammetry, Visual and digital image processing, Digital image interpretation: Pattern recognition, shape analysis, texture analysis. Integration with GIS.

UNIT IV: Principles and application of GIS

Introduction to GIS, Components of GIS, Geospatial data architecture, operations, Layers and features, Raster and Vector. Types of data –Spatial, Attribute data-types of attributes-scales/ levels of measurements. Data File Formats, Datum Projection and re projection, Topology. Global positioning System (GPS). Spatial database Management Product Generation: Types of output products. Application of Remote sensing: Land Use / Land Cover Mapping, Geologic and Soil Mapping, Agricultural applications, Forestry applications, Water Resource applications, Urban and Regional Planning application, Wetland Mapping, Wildlife Ecology applications, Archaeological applications, Environmental and Disaster Assessment. Applications of GIS: Resources mapping, Inventory and monitoring of natural resources, Land cover mapping, Wetland mapping, Applications to Agriculture, Water Management, Ground Water Modelling, Coastal and Marine applications.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Anji Reddy, M. 2004: Geoinformatics for Environmental Management. B.S. Publications.
- Chang. T.K. 2002: Geographic Information Systems. Tata McGraw Hill.
- Clarke, Keith C., Bradley O. Parks, and Michael P. Crane, 2002. Geographic Information Systems and Environmental Modeling, Upper Saddle River, NJ: Prentice Hall.
- Heywood. I, Cornelius S, CrverSteve. 2003: An Introduction to Geographical Information Systems, Pearson Education.
- Jensen, J.R., 2000. Remote Sensing of the Environment - An Earth Resources Perspective, Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi.
- Lillesand, Thomas M. and Kiefer, Ralph, W. 2000. Remote Sensing and Image Interpretation, John Wiley and Sons, New York.
- Muralikrishna, I.V. 1995. Remote Sensing and GIS for Environmental Planning. Tata- McGraw Hill.
- Ram Mohan Rao. 2002: Geographical Information Systems. Rawat Publication.

- Skidmore A. 2002: Environmental modeling with GIS and Remote Sensing. Taylor and Francis Tar Bernhardsen. Geographical Information Systems. John Wiley.
- Thomas M. Lilesand, Ralph W.Kiefer, Jonathan W. Chapman, 2007. Remote sensing and Image interpretation, Wiley India publication, New Delhi.

Programme: M.Sc. Environmental Science

EES 5017 Water Quality and Human Health

Course Code	EES 5017	Semester	I
Course Title	*Water Quality and Human Health*		
Credits	3	Type	Elective

Course Description

Provide a broad, in-depth overview of important relationship between water quality and human health (e.g., point and non-point source pollution, infectious diseases, human impact on water quality, preventative measures) and how the quality of water determines the health of people both in the developed and developing world.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the relationship between human behaviour and water quality
- Develop remediation strategies for several types of microbial water quality contamination.
- Understand epidemiological studies related to water quality and public health
- Understand various water sources and transmission mechanisms of infectious agents from those sources to humans
- Organize and present well-synthesized scientific discussions on topics relevant to waterborne disease and public health
- Critically evaluate the scientific literature on waterborne diseases

Course Structure

The following is a detailed syllabus.

UNIT –I Introduction

Understanding the significance of the environment for human health,-Human population pressures and pollution dynamics, Common terms and definitions in water quality, Aquatic resources of the world, Sources of drinking water, Common contaminants of drinking water and linkages to disease. Non-point source pollution, Agricultural runoff, TMDLs, Best management practices (BMPs) and Numeric vs narrative standards.

UNIT –II Water Pollution and the Evolution of Microbial Pathogens and Waterborne diseases

Virulence evolution, Subpopulation selection of Bacterial Pathogens

(Protozoa- Cryptosporidiosis, Giardiasis, *Toxoplasma gondii,* Bacteriology- *Shigella, Vibrio cholearae, Pseudomonas)* Virology - survival and persistence of viruses, (Adenovirus, Norovirus and Rota virus)

UNIT–III Sewage Treatment

Sewage treatment in developed countries, Primary, secondary, and tertiary treatments, Land application of sewage, Sewage treatment in developing Countries

UNIT – IV Influence of Climate Change on Water Quality

Climate Change, Change the Dynamics of Human Pathogens in Water, Water sanitation practices - Biofilms, Antibiotic resistance, Case studies, Vaccines, Water sanitation practices- preventive measures, Education and proper hygiene, Proper waste disposal, Water chlorination, improving surveillance, Changes in human behavior, Human population growth, Modern lifestyle effects on the water quality and human health, Predicative models- Modelling infectious diseases

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

- Edward A. Laws (1993). Aquatic Pollution: An Introductory Text. 3rd Edition, Wiley Publishers.
- Steven Percival, Rachel Chalmers, Martha Embrey, Paul Hunter, Jane Sellwood and Peter Wyn-Jones (2003). Microbiology of Waterborne Diseases, Academic Press.
- Guidelines for drinking water quality (1993), 4th Edition by WHO Geneva.
- Howard G, Bartram J (2003), Domestic water quantity, service level and health. World Health Organization, Geneva.
- Ainsworth R, ed. (2004) Safe piped water: Managing microbial water quality in piped distribution systems. IWA Publishing, London, for the World Health Organization, Geneva.
- MN Maulik (2011), Water Supply, Waste Water Treatment & Sewage Disposal, Standard Book House, New Delhi, India.
- Satinder Ahuja (ED) (2013), Pollution Assessment, Analysis, and Remediation, Elsevier.

Programme: M.Sc. Environmental Science

EES 5018 Cell and the Environment

Course Code	EES 5018	Semester	II & IV
Course Title	*Cell and the Environment*		
Credits	3	Type	Elective

Course Description

The course articulates the interaction of prokaryotic and eukaryotic cells with the environmental factors at cellular and molecular scale for all students of biology. The course deals with basics of cell biology, and cellular communication and its ecological importance and environmental applications. The course also integrates significant cellular pathways with environmental signals, and presents an overview of environmental stress at sub-cellular, organismal and ecosystem scales.

Course Outcome

By the end of the course, students are expected to be able to:

- Articulate the basics of cellular biology, and environmental stress biology
- Discriminate between prokaryotic and eukaryotic stress response mechanisms
- Corroborate cellular communications and their environmental applications
- Acquire a thorough understanding of environmental stressors, mechanisms thereof, and its implications at sub-cellular, organismal and ecosystem scales

Course Structure

The following is a detailed syllabus.

Unit I: Cell Biology – Basics

Overview of the cell and its origin, composition of prokaryotic and eukaryotic cells, cell organelles – structure and function – nucleus, chloroplast, mitochondria, lysosome and vacuoles, endoplasmic reticulum, golgi apparatus, cell wall. Cell metabolism – photosynthesis, lipid metabolism, carbohydrate metabolism and protein synthesis

Unit II: Cellular Communication

Membrane vesicle trafficking, extracellular matrix, apoptosis, autophagy, quorum sensing, cell adhesion – importance in biofilms and wastewater treatment, role of cell to cell communication at an ecosystem scale

Unit III: Environmental Stressors

Environmental stress at cellular levels – sensing, processing and response – mechanism. Abiotic stressors – nutrients, light, temperature, oxidative stress, osmotic pressure. Biotic stressors – predator, pathogens & toxins. Environmental stressors at ecosystem scale and environmental issues.

Unit IV: Environmental Interactions & Cell Signalling

Concept of signal transduction, Protein kinases and phosphatases, Signal transduction pathways – mTOR signalling, MAP kinase signalling, PI3K signalling. Reactive oxygen,

nitrogen species and redox signalling. Environmental signals and disease, Overview of environmental signals and response – at cellular, organismal and ecosystem scale.

Testing & Evaluation

- Classroom discussions, seminars, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

- Lodish, H. and Baltimore, D. 2000. Molecular Cell Biology, 3rd Edition. Scientific American Books, W H Freeman, New York.
- Hancock, J.T. 2017. Cell signalling. Oxford University Press.
- Singh, D.P. 2003, Stress physiology. New Age International.
- O'Toole, G.A. and Ghannoum, M.A. 2004. Microbial Biofilms. American Society of Microbiology.
- Winans, S.C. and Bassler, B.L. 2008. Chemical Communication among Bacteria. American Society of Microbiology.

DEPARTMENT OF ENVIRONMENTAL SCIENCE
CENTRAL UNIVERSITY OF KERALA

(Established under The Central Universities Act, 2009)

Minutes of BOS meeting

The Second Board of Studies meeting was held on 07th July, 2017 at 10.30 AM in the Department of Environmental Sciences, School of Earth Sciences System, Central University of Kerala, Padanakkad to revise and restructure the syllabus for M.Sc., Environmental Science curriculum. The following members were present.

Dr. Muthukumar Muthuchamy, Professor and Head	Chairperson
Dr. A.G. Devi Prasad, Associate Professor (Subject Expert)	Member
Dr. G.Annadurai, Professor (Subject expert)	Member
Dr. Ranjith Kumavath Assisstant Professor (other Department)	Member
Dr. Jaya, Associate Professor and Head (Subject Expert)	Member (Absent)
Dr. N. Nandhini, Professor (Subject Expert)	Member (Absent)

The chairperson has welcomed the members and briefed the existing syllabus of Environmental Science course being offered in this University and resolved to make necessary changes in the course subjects and contents.

The board has discussed in detail about the contents of the Core and Elective papers, revised and restructured the syllabus of M.Sc. Environmental Science.

The board members have thanked the Honourable Vice Chancellor, Central University of Kerala for being offered the members of the Committee to revise and restructure the syllabus.

The meeting came to close by 4.45 pm with the vote of thanks by the Chair person.

Dr. Muthukumar Muthuchamy

Dr. A.G. Devi Prasad 7/7/2017

Dr. G.Annadurai 7/7/17

Dr. Ranjith Kumavath 7/7/2017

Revised Syllabus Effective from JULY 2017

M.Sc. ENVIRONMENTAL SCIENCE

Semester-wise Schedule

SEMESTER- I			
Course Code	**Title**	**Credits**	
EES-511	Fundamentals of Ecology and Environmental Science	3	
EES-512	Environmental Microbiology and Biotechnology	3	
EES-513	Environmental Pollution	3	
EES-514	Environmental Monitoring and Instrumentation	3	
EES-515	Practical-I (Ecology, Microbiology, Instrumentation, Pollution)	4	
Total Credits			**16**
SEMESTERII			
EES-521	Toxicology and Environmental Health	3	
EES-522	Climate Change and Current Issues	3	
EES-523	EIA and Environmental Auditing	3	
EES-524	Waste Management	3	
EES-525	Environmental Laws and Policy	3	
EES-526	Practical-II (Environmental Toxicology and Waste Management)	3	
Total Credits			**18**
SEMESTER III			
EES-531	Biodiversity and Conservation	3	
EES-532	Environmental Engineering	3	
EES-533	Natural Resource Management	3	
EES-534	Research Methodology and Statistics	3	

EES-535	Practical-III (Biodiversity, Environmental Engineering, Statistical Analysis)	4	
Total Credits			**16**
SEMESTERIV			
EES-541	Dissertation	**8**	
EES-542	Field Visit	**2**	
Total Credits			**10**
ELECTIVES			
EES - 501	Aquatic Ecology	3	
EES - 502	Current Environmental Issues	3	
EES - 503	Ecotourism	3	
EES - 504	Energy and Environment	3	
EES - 505	Environmental Economics	3	
EES – 506	Environmental Education	3	
EES – 507	Environmental Geosciences	3	
EES – 508	Environmental Genetics and Biotechnology	3	
EES – 509	Environmental Nanotechnology	3	
EES - 5010	Environmental Stress Biology	3	
EES - 5011	Food Safety and Health	3	
EES- 5012	Forestry Management	3	
EES – 5013	Industrial Ecology	3	
EES – 5014	Marine Environment	3	
EES – 5015	Natural Hazards and Disaster Management	3	
EES - 5016	Occupational Health and Industrial Safety	3	
EES – 5017	Principles of Remote Sensing and GIS	3	
EES – 5018	Water Quality and Human Health	3	

EES-511: FUNDAMENTALS OF ECOLOGY AND ENVIRONMENTAL SCIENCE

UNIT I: Basics of Environmental Science

Scope and interdisciplinary nature of Environmental Science; Environmental factors; Global environment and its segments; Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Tolerance ranges and limiting factors. Stoichiometry, Thermodynamics: energy, entropy, enthalpy, Gibb's energy, Acid-Base reactions, redox potential.

UNIT II: Ecosystem

Classification; Biogeographical regions; Biomes; Biogeochemical cycles; Energy flow; Trophic relations; Ecological pyramids; Productivity and ecological efficiencies: primary and secondary producers. Gaia hypothesis, Niche, Speciation, Ecological Succession and Climax; Biological interactions - Mutualism, Parasitism, Predator- Prey relations, Competition, Positive and Negative interaction, Proto-cooperation, Commensalism,

Parasitism, Predation.

UNIT III: Population Ecology

Characteristics-Population density, Natality, mortality, Age Pyramids/Age distribution, Population growth forms/curves, Population disturbance, population dispersal (migration, Immigration and emigration), population structure;- Isolation, distribution, population explosion-causes and control measures.

UNIT IV: Ecological Factors - Climatic Factors

Light - effect of light on morphology and physiology of plants, distinguishing features of Heliophytes and schiophytes.

Temperature – effect of low and high temperature on organismsclassification of vegetation - Megatherms, Microtherms, Mesotherms, Hekisotherms.

Wind - Breeze, Storm, Hurricans-Morphological and physiological effects of wind.

Humidity – hydrological cycle, Relative humidity, effect of humidity on organism.

REFERENCES:

1. Arora S. (2003). Fundamentals of Environmental Biology, Kalyani Publications, New Delhi.

2. Cotgreave P. and Forseth I. (2002). Introductory Ecology. Blackwell Science,UK
3. Dhaliwal G. S., Sangha G. S. and Raina P. K. (2000) Fundamentals of Environmental Science, Kalyani Publication, India.
4. Freedman B. (1995). Environmental Ecology, Academic Press, USA.
5. Jackson A. R. W. and Jackson J. M. (2000). Environmental Science – The natural environment and human impact, 2nd Edition, Longman Group, UNITed Kingdom.
6. Masters G. M. (2007). Introduction to Environmental Science and Engineering, 3rd Edition, Prentice –Hall of India Pvt Ltd, New Delhi.
7. Odum E.P. (1993). Fundamentals of Ecolgy, W.B.Saunders Co., USA.
8. Rana S.V.S. (2005). Essentials of Ecology and Environmental Science. Prentice –Hall of India Pvt. Ltd. New Delhi
9. Townsend C.R., Begon M. and Harper J.L. (2008). Essentials of Ecology, Blackwell Publications, UK.

EES – 512: ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

UNIT I: Fundamentals of Environmental Microbiology

Introduction - autotrophy and heterotrophy, cultivation of microorganisms. Microbial growth and factors affecting microbial growth. Aeromicrobiology –sampling techniques, airborne diseases and allergies. Aquatic microbiology –sampling techniques, MPN technique, eutrophication, water borne pathogens and diseases. Soil microbiology – microbes of rhizosphere, microbial role in biogeochemical cycle. Microorganisms of extreme environmentExtremophiles. Role of microbes in environmental pollution and management.

UNIT II: Microbial Ecology

Important microorganisms in sewage treatment plant-nitrifying bacteria, ammonia-oxidizing bacteria, nitrite-oxidizing bacteria, indicator microorganisms. Microbial diversity – culturable and non-culturable microorganisms – physiological and molecular methods.

UNIT III: Environmental Biotechnology

Microbial remediation - composting, biostimulation, bioaugmentation, bioreactor, bioleaching, bioventing. Biodegradation of xenobiotics. Bioremediation of heavy metals and radio-active wastes. Microbial mediated bioconverstion. Role of genetically engineered microbes in pollution control, Biofilms and microbial mats, biofouling and corrosion.

UNIT IV: Industrial Biotechnology

Bioenergy - definition, first generation biofuels - bioethanol, biodiesel, second generation biofules - lignocelulosic biofuels; biohydrometallurgy and biomineralization; role of microbes in fermentation process in environmental cleanup; Types and role of biofertilizers and biopesticides, Biosensors and their application in environmental monitoring.

REFERENCES

1. Eweis J.B., Ergas S.J., Chang D.P.Y., Schrodwer E.D. (1998.), Bioremediation Principles. New York, Mc Graw Hill.
2. Fulekar M.H. (2010), Environmental Microbiology. New York, Taylor & Francis.
3. Koukkou A.I. (2011), Microbial Bioremediation of Non-metals: Current Research. Haverhill, UK, Caister Academic Press.
4. Lederberg J. (1992), Encyclopedia of Microbiology, New York: Academic Press.
5. Maier R.M., Pepper I.L., Gerba C.P. (2006), Environmental Microbiology. San Diego, Elsevier Academic Press.
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8. Sangeetha J, Thangadurai D, David M, Abdullah MA. (2016.), Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of Xenobiotics for Sustainable Development, Boca Raton, Florida, USA, CRC Press.
9. Sen K., Ashbolt N.J. (2011), Environmental Microbiology: Current Technology and Water Applications. Norfolk, UK, Caister Academic Press.

EES 513: ENVIRONMENTAL POLLUTION

UNIT I: Air Pollution

Structure and chemistry of atmosphere, Composition of elements in the atmosphere; Temperature inversion, Atmospheric lapse rate, Adiabatic lapse rate. Chemistry of atmospheric pollutants: Photochemical smog-origin and occurrence, Ozone chemistry: Ozone layer, Chemistry of Ozone layer, Ozone depletion, Mitigation of ozone depletion; Acid rain- chemical reactions and its ecological effects; Green house effect and global warming; Effects of air pollutants on plants and animals; Air quality standards.

UNIT II: Water Pollution

Composition of pure water; Physical and Chemical properties of water. Chemical reactions and equilibria in water; Natural organic components in water - Concepts of DO, BOD and COD; Sources of water pollution; Effects of water pollution on plants and animals; Water quality standards.

UNIT III: Soil Pollution

Weathering and paedogenesis; Factors affecting soil formation, Development of soil profile; Structure of Soil; Physico-chemical characteristics of soil; Ion-exchange and adsorption processes in the soil; Classification of soil, Fate of chemicals in the soil; sources of soil pollution; Effects of soil pollution on microbes, plants and animals.

UNIT V: Noise, Thermal and Radioactive Pollution

Sources of noise pollution: indoor and outdoor noise pollution; Effects of noise pollution; Thermal and nuclear power plants as sources of thermal pollution. Effects of thermal pollution on aquatic flora and fauna; Control measures of thermal pollution; Sources of marine pollution; Pollution status of coastal and ocean waters; Radioactive pollution: types and sources, half-life period, natural radiation.

REFERENCES

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   International Publishers, New Delhi.
2. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the

Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.

3. Dara S S,.(1998), A Text Book of Environmental Chemistry and Pollution Control, S. Chand & Company Ltd, New Delhi
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6. Julian E Andrews et al., (2004) An Introduction to Environmental Chemistry, Blackwell Publishing.
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9. Stanley E. Manahan (2010). Environmental Chemistry, 9th Edition, CRC Press, London.

EES-514: ENVIRONMENTAL MONITORING AND INSTRUMENTATION

UNIT 1: Separation Techniques

Extraction and separation of inorganic and organic compounds; Chromatography: Paper chromatography, Thin layer chromatography, Column chromatography, High Performance Liquid Chromatography (HPLC), Gas chromatography and Mass Spectrometry (GC-MS), Electrophoresis: Agarose Gel electrophoresis, Poly Acrylamide Gel Electrophoresis, ELISA.

UNIT II: Analytical Methods

Microscopy: Light microscopy, Bright field microscopy, Dark field microscopy, Phase contrast microscopy, Fluorescence microscopy, Confocal microscopy, Electron microscopy: Transmission electron microscopy (TEM) and Scanning electron microscopy (SEM). Spectroscopy: Ultraviolet -Visible spectroscopy; Infrared spectroscopy, Flame emission spectroscopy; Atomic absorption spectroscopy (AAS); Raman Spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR)

UNIT III: Assays

Assays of sugars, amino acids, proteins, carbohydrates, lipids, enzymes: alkaline phosphatase, acid phosphatase, peroxidase, Biomonitoring: tolerance levels, multiple level assessment, community level biomonitoring, assessment indices.

UNIT IV: Principles of GIS and Remote Sensing

Introduction and components of GIS, Nature of geographic information, Data sources, Data organization and storage, Data analysis, Global positioning system(GPS), Remote Sensing- Principles of remote sensing-spectral signatures, resources mapping

REFERENCES:

1. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
2. APHA (1998) Standards Methods for the examination of water and Waste water, 20th Edition, Washington DC.
3. B.L. Oser (1965). Hawk's Physiological Chemistry. MacGraw Hill Book Co.
4. Clair N. Sawyer (2003). Chemistry for Environmental Engineering and Science. Tata McGraw Hill.
5. Denise R. Ferrier (2013) Lippincott's Illustrated Reviews Biochemistry; Sixth edition, Iippincott Williams & Wilkins.
6. Douglas A. Skoog, F. James Holler and Timothy A. Niemen.(1998). Principles of Instrumental Analysis. 5th Edition, Saunders College Publishing, Philadelphia.
7. F.W. Fifield (2000). Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
8. Khopkar S M (1985). Basic Concepts of Analytical Chemistry. Wiley Eastern Ltd., New Delhi.
9. Miroslav Radojevic and Vladimir N.Bashkin (1999), Practical Environmental Analysis,The Royal Society of Chemistry, Cambridge**.**

EES-515: Practical – I (Ecology, Microbiology, Instrumentation, Pollution)

1. Plankton Analysis – Shanon Weiner Diversity Index
2. Primary Productivity - Light and Dark bottle method & Chlorophyll method
3. Staining and inoculation techniques

4. Assessment of Water Quality by Membrane Filter/Total Coliform /E.coli/ Feacal Coliform
5. MPN Technique
6. Sampling and enumeration of airborne microorganisms
7. Heterotrophic plate count for soil microorganisms
8. Water Quality analysis
9. Spectrophometric and flamephotometric analysis of water and soil pollutants
10. Air sampling and analysis
11. Microscopy – light, phase contrast and fluorescence microscopes
12. Separation of DNA by Gel Electrophoresis
13. Determination of Bio assays
14. TLC and paper Chromatography

EES-521: TOXICOLOGY AND ENVIRONMENTAL HEALTH

UNIT I: Environmental toxicology

Definition and branches of toxicology, scope and importance of toxicology, Principles of toxicology. Toxicants - Classification, routes of entry, transport, storage, metabolism and excretion. Categories of toxic effects - synergistic, antagonistic and additive effects. Acute and chronic toxic effects. Dose-effect and doseresponse relationships, LOAEL and NOAEL.

UNIT II: Hazardous waste and metabolism of toxicants

Hazardous effect – Polychlorinated biphenyls (PCBs), Persistent organic pollutants (POPs) and biohazards. Toxicity of pesticides, insecticides, fertilizers, heavy metals, radioactive substance, fluorides and carbon monoxide. Mode of action of toxicants, mechanism of toxicants - Biochemical and molecular effects. Bioconcentration, bioaccumulation and biomagnification of toxicants.

UNIT III: Analytical methods for toxicity testing

Principles of toxicity testing, Measurements of LC_{50} and LD_{50} values. Monitoring approaches - indicator populations and indicator species. Model ecosystems - microcosms and mesocosms, Biosensors and bio-markers in toxicology. Molecular marker to toxicants - metabolites as

indicators, protein induction, cytochrome P450 enzymes, stress proteins and metallothioneins.

UNIT IV: Environmental risk and health

Environmental and occupational safety - Definitions, concept and scope, occupational exposure, occupational hazards and diseases. Control of toxic materials and protection measures - air, water and soil. Health effects of cosmetics and pharmaceuticals products, occupational health hazards-Pneumoconiosis's, Bagassorsis, Byssicosiss, Asbestosis, Anthracosis, Siderosis, farmers lungs. Legislative perspective in ecological risk assessment, human health risk assessment.

REFERENCES

1. B.M. Francis. (1994.), Toxic Substances in the Environment. New York, John Wiley & Sons.
2. Bryan Ballantyne, Timothy C. Marrs, Tore Syversen. (2009), General Applied Toxicology. 6 Volume Set, Third Edition. Queensland, John Wiley & Sons.
3. Cockerham L.G., Shane B.S. (1993), Basic Environmental Toxicology. USA, CRC Press.
4. Edward A. (2013), Laws. Environmental Toxicology: Selected entries from the encyclopedia of sustainability science and technology. New York, Springer-Verlag.
5. Hayes, A. W. (2008), Principles and Methods of Toxicology, 5th Edition, Boca Raton, FL, Taylor and Francis.
6. I.C. Shaw and J. Chedwick. (2004), Principles of Environmental Toxicology, Boca Raton, FL, Taylor and Francis.
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   recognizing and preventing work related disease. Boston, MA: Little Brown & Co.
8. Walker C.H., Sibly R.M., Hopkin S.P., Peakall D.B. (2012), Principles of Ecotoxicology. Fourth Edition. USA, CRC Press.

EES-522 CLIMATE CHANGE AND CURRENT ISSUES

UNIT-I Global Environmental problems

Ozone depletion, causes and effects. Acid Rain – formatioon, adverse effects. Photochemical smog, Factors responsible for photochemical

smog. Green house gases – green house effect and climate change, Global warming, Drought, Water crisis, Minamata, Itai-Itai, Flurosis and Cyanosis, Bhopal gas tragedy,

Chernobyl accident, Wetland conservation

UNIT-II Sources of Energy

Sources of energy, Conventional/non-conventional energy system - Wood, Coal, Thermal power energy, Hydro, Wind, Solar, Nuclear energy, Tidal energy - a brief account.

UNIT-III Basic concepts and mechanisms

Science of climate change, global warming and greenhouse effect, radiative balance, earth's carbon reservoirs and carbon cycle, ElNino and La Nino, greenhouse gases in the atmosphere – sources, levels and mechanisms of action. Effects: Rise in earth's temperature; effects on forests; effects on agro ecosystems; desertification; effects on freshwater ecosystems; effects on oceans; sea level rise; melting of polar ice and glaciers; effects on rainfall patterns; extreme events, socio-economic and public health consequences.

UNIT-IV National and International responses

National Action Plan on climate change; India's position and actions vis-a-vis international programmes, Intergovernmental panel for climate change (IPCC) and its role; United Nations framework convention on climate change (UNFCCC), CDM and Kyoto Protocol; the bali road map; The Copenhagen Accord; future actions; ethics of climate change.

REFERENCES:

1. J. T. Hardy (2003). Climate Change: Causes, effects and solutions, John Wiley and Sons.
2. Egbert Boeker and Rienk van Grondelle (2013). Environmental Science Physical Principles and Applications, John Wiley & Sons Ltd., New York.
3. Akimasa Suni, Kensuke, F., and Ai, Hiramatsu.(2010). Adaptation and mitigation strategies for climate change. Springer.
4. Burroughs, W.J. (2007). Climate change: A multidisciplinary approach (2nd edition.). Cambridge University Press. Dash, 6.

Sushil Kumar. (2007). Climate change: An Indian perspective. Cambridge University Press India Pvt. Ltd., New Delhi.
5. IPCC (2007): Summary for policymakers. In: Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7- 22.
6. Nordhaus, W.D. (1994). Managing the Global Commons: The Economics of Climate Change, MIT Press.
7. Tyler Miller Jr. G (1996) Living in the Environment – Principles, Connections and Solutions, Wadsworth Publishing Co. New York.
8. Botkin, D.B. (1989) Changing the Global Environment, Academic Press, San Diago.

EES - 523: EIA AND ENVIRONMENTAL AUDITING

UNIT I: Importance of EIA

History and objectives – Basis for Environment Impact Assessment, Notification 1994 and 2006, Approach to EIA studies – mandatory requirements, project screening, scoping, environmental baselines, Public Participation best practices; terms of reference (ToR); Phases of EIA – Identification, Prediction, Evaluation, Decision making and Post impact Monitoring, Major limitations of Environmental Impact Assessment.

UNIT II: Methodologies

Environmental Impact Statement Process, EIA Methodologies – Adhoc Methods – Checklist Methods – Matrix Methods – Network Methods, Cost-Benefit Analysis.

UNIT III: Assessment procedure

Prediction and Assessment of Impacts on natural Resources – Biota, Surface Water, Ground Water, Air, Noise, Hazards, Historic and Cultural Resources, Transportation, Socio-economic relationships. Case studies - Land Clearing Projects – Dam sites – EIA for Aquaculture, Steel, Mines, Hydel, Thermal, Nuclear, Oil and Gas based Power Plants – Highways projects – Industrial Projects.

UNITI V: Environmental auditing

Definition of Environment Audit and its importance for industries. Types of Audit and Definitions. Life Cycle Assessment, Environmental audit: Pre-Post audit process; International organization for standardization (ISO), ISO 14000 standards and certification, Eco labelling.

REFERENCES

1. Bregman, J. I., (1999), Environmental Impact Statements, Lewis Publishers, London.
2. Canter, L.W., (1996), Environmental Impact Assessment, Mc Graw Hill, New York.
3. Eccleston, C. H., (2000) Effective Environmental Assessment, Lewis Publishers, London.
4. Eccleston, C.H., (2000) Environmental Impact Assessment- A Comprehensive Guide to Project and Strategic Planning, John Wiley and Sons.
5. M. E. Jensen and P. S. Bourgeron (2001), A guide book for Integrated Ecological Assessments, Springer-Verlag, New York, Inc.

EES – 524: WASTE MANAGEMENT

UNIT I: Wastes – Sources, effects and management principles

Wastes – Classification and Quantification – Types – sources – composition of waste. Waste generation status – quantity and characterization. Issues and strategies in waste management – Waste as resource – 3Rs – Waste reduction at source – municipal and industrial wastes. Sustainable recycling - medical wastecharacteristics.

Unit II: Municipal solid waste management

Methods of waste collection, collection techniques, waste container compatibility, waste storage requirements, transportation of solid wastes. Material and resource recovery/recycling from solid wastes. Treatment and disposal techniques for solid wastes– composting, vermin-composting, autoclaving, microwaving, incineration, non-incineration, thermal techniques, use of refuse derived fuels, landfilling.

UNIT III: Industrial solid waste management

Types – sources – composition of waste – Waste Audit – recycling of waste for Industrial, Agricultural and Domestic Purposes; Recycling of Metals, Reuse, recovery and reduction of paper and plastics; Recycling in Food Manufacturing, Beverages, Apparel, Leather, Paper, Pulp, Chemical and other industries; Fly ash management. E-waste and biomedical waste management. Waste disposal methods – anaerobic digestion, composting, incineration, pyrolysis.

UNIT IV: Hazardous waste management

Characteristics and sources – Hydrocarbons, Phenols, Chlorophenolic compounds, Polycyclic Aromatic hydrocarbons (PAH), Heterocyclic Compounds, Cyanide, Dioxins. Waste Minimization approaches – Monitoring and Management strategies. Radioactive waste **–** Sources, half-life of radioactive elements, modes of decay. Effects on Plants, Animals and Man. Low and Highlevel Radioactive Waste Management – Waste Minimization and Treatment, Radiation standards. Remediation measures – microbial and phytoremediation.

REFERENCES:

1. David H.F. Liu, Bela G. Liptak (1999), Hazardous Waste and Solid, CRC Press
2. Kanti L. Shah(1999), Basics of Solid and Hazardous Waste Management Technology, Prentice hall
3. Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo and Constantine Yapijakis (1992), Handbook of Industrial and hazardous waste treatment, Marcel Dekker, Inc, Basel, New York
4. Michael D. LaGrega, Philip L.Buckingham, Jeffrey C.Evans (2001), Hazardous waste management, Waveland Press, Inc, Long Grove, USA
5. Riser-Roberts, E., (1998), Remediation of Petroleum Contaminated Soils - Biological, Physical and Chemical processes, Lewis Publisher, New York.
6. RusselBoulding, J (1995), Vadose-Zone and Ground Water Contamination - Assessment, Prevention and Remediation, Lewis Publishers, Tokyo.
7. Solid Waste Technology & Management, Thomas H. Christensen (2011),A John Wiley and Sons, Ltd., Publication,UK
8. Tandon (1995), Recycling of Crop, Animal and Human Waste in Agriculture, Mc Graw Hill Publishing Co

EES – 525 ENVIRONMENTAL LAWS AND POLICY

UNIT I: Environmental Policies

Environmental policy in Ancient India, Medieval India, British India, during post independent era, the seventies, eighties and nineties. International environmental policy –the instruments of international environmental policy – international law, soft law, scientific cooperation - fund support, dispute settlement procedures, non-state actors and international environmental policy - Transnational environmental policies – the Indus river basin, the Ganga – Brahmaputra river basin system.

UNIT II: International Environmental Laws and Conventions

International Environmental laws - hazardous wastes-Basal convention – Necessity for International Environmental Court. United Nations Environment Programme [UNEP] role on international environment laws. Case studies for International environmental disputes.

UNIT III: Pollution Control Acts and Rules

The water act 1974, the water cess act 1977, the air act 1981, Solid Waste Management Rules, 2016; Biomedical Waste Management Rules, 2016; Fly ash Management Rules, 1999. Hazardous and

Other Waste Management Rules, 2016, E-Waste Management Rules, 2016, Plastic wastes management and handling rules, 2016.

UNIT IV: Acts, Rules and Notifications on Environmental Protection

The Environmental Protection Act 1986,The Public Liability insurance act 1991, National Green Tribunal Act 2010.The Factories Act 1948, The Mines And Minerals Act 1957,The Atomic Energy Act 1962, The Motor Vehicles Act 1988 (amendment 2016). Case studies one each in the protection of forests, rivers and wild life.

REFERENCES:

1. Gurudeep Singh (2005). Environmental law in India, Mc Millan, New Delhi.
2. ShyamDiwan and Armin Rosencrany (2001), Environmental law and policy in India, Oxford University Press, New Delhi.
3. Pollution Control Legislations, Vol. I and II, 1999, Tamilnadu Pollution Control Board, Chennai.

4. Nath B., Hens, L., Compton, P and D. Devuyst (1998), Environmental Management in Practice, Vol I, Routledge, London and New York.
5. Pollution control acts, rules and notifications issued there under, CPCB, 2010, New Delhi, PCLS/ 02/ 2010.
6. K. Thakur (2013), Environmental protection law and policy in India, Deep and Deep Publications, New Delhi.

EES-526 PRACTICAL II (Environmental Toxicology and Waste Management)

1. Toxic effects of xenobiotics on behaviour and physiological changes in fish
2. Determination of lethal concentration of pollutants
3. Toxic effect on the seed germination and growth of plants
4. Toxic effect on chlorophyll and carotenoid content of the plants
5. Calculation of Carrying capacity of land
6. Vermi-Composting
7. Analysis of micro and macronutrients in composting

EES-531 BIODIVERSITY AND CONSERVATION

UNIT-I: Introduction

Biodiversity – Genetic diversity, Species diversity and ecosystem diversity, alpha, beta, and Gamma diversity, values of Biodiversity – consumptive use value, optional values, productive use value, social value. Biowealth**,** endemism, significance of the endemism, Hot spots of Biodiversity,

UNIT-II: Threats to Biodiversity

Brief account of endangered flora and fauna of India. Red data book and IUCN categories, endangered species, vulnerable species. Rare species. Man- Wildlife conflicts. Ecological consequences of reduction

in biodiversity. Biodiversity issues – Deforestation and its impact. Two paradigms of Biodiversity, Convention on Biological diversity (CBD), Man and biosphere programme (MAB).

UNIT-III: Issues

Causes for depletion of biodiversity in India, Biodiversity of Western Ghats, conservation measures of biodiversity, Sacred grooves. Prospects and Perspectives of keystone species with special reference to Tiger.

UNIT-IV: Conservation Strategies

Biosphere Reserves – concept of conservation – objectives and management, Nilgiri Biosphere Reserve - Biosphere Reserves in India, *In situ* and *ex situ* conservation, Role of Zoos, National

Parks and Sanctuaries in conservation, Biological Diversity Act of India

REFERENCES:

1. Dadhich. L.K. and A.P. Sharma (2002), Biodiversity – Strategies for Conservation, APH publishing corp. New Delhi,
2. Khan. T.I and Dhari. N (1999), Global Biodiversity Conservation measures –Al-Ajmi Pointer Publishers, Jaipur.
3. Krishnamurthy. K.V (2003), An Advanced Text book on Biodiversity – Principles and Practice – Oxford and IBH publishing, New Delhi.
4. Chiras D. D and Reganold J. P. (2011), Natural Resource Conservation: Management for a sustainable future, 10/E Prentice Hall.
5. Gaston K.J. and Spicer J. (2004), Biodiversity an introduction. Blackwell Publications, UK
6. Henry RJ. (1997), Practical Application of Plant Molecular Biology. Chapman and Hall Publication, London
7. Krishnamurthy K.V. (2003), Advanced text book on Biodiversity. Oxford & IBH, New Delhi
8. Maiti P.K. and Maiti P. (2011), Biodiversity- Perception, Peril and Preservation. PHI Learning. New Delhi

EES – 532: ENVIRONMENTAL ENGINEERING

UNIT – I: Hydraulics

Hydraulics – Pressure- Hydrostatic Pressure, Pressure Head, Measurement of Pressure, Flow, Design of Pressure Pipes – Darcy – Weisbach Formula, Manning's Formula, Hazen – William's Formula – limiting velocities, Minimum and Maximum Test Pressure and Working Pressure in pipes – selection of pipe material – Pump types, Characteristic Curves – selection and determination of capacity.

UNIT – II: Designing of Water and Wastewater Treatment Plant Flash Mixer – Design – Clariflocculator – parameters for design – Filtration - Rapid sand filter and Pressure filter; Disinfection calculation of chlorine dosage, chlorine demand, and residual chlorine. Physical and Chemical unit Operations and Applications Design Parameters and Design of Primary and Secondary Settling Tanks – Activated Sludge Process – types and modifications –

Design of Aeration Tanks– Diffusers and Mechanical Aerators. Design criteria for Trickling Filters.

UNIT – III: Sludge Processing and Disposal Methods

Sludge Processing and Disposal Methods- Design of Anaerobic Digester and Sludge Drying Bed – Reverse Osmosis – Ion Exchange – Incinerators and Multiple Evaporators.

UNIT – IV: Air Pollution Control Design

Minimum Stack Height – Plume Rise, Ground Level Concentration of Pollutants. Design of Settling Chamber, Cyclones, Fabric filters and Electrostatic Precipitators. Wet Scrubber. Case studies: Distillery, Dyeing, Electroplating, Paper and Pulp, Steel, Tannery - Industrial Effluent Treatments.

REFERENCES

1. Environmental Engineering: A Design Approach, Sincero A. P and Sincero G. A. (1999), Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Gilbert M. Masters (2004), Introduction to Environmental Engineering and Science, Prentice-Hall of lndia Pvt. Ltd., New Delhi.
3. Howard S Peavy (2003), Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.

4. Frank R. Spellman, (2003), Handbook of Water and Wastewater Treatment Plant Operations, Lewis Publishers, London.
5. Metcalf and Eddy (2003), Wastewater Engineering: Treatment and Reuse, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
6. Hammer M.J. and Hammer Jr M. J. (2001), Water and Wastewater Technology, Prentice Hall of lndia Pvt. Ltd., New Delhi.

EES - 533: NATURAL RESOURCES MANAGEMENT

UNIT-I Introduction

Concept of resource, classification of natural resources-renewable and non renewable resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. Ecological, social and economic dimension of resource management Natural resources and development.

UNIT-II Forest resources

Forest vegetation, status and distribution, contribution as resource. Use and over-exploitation, deforestation. Timber extraction, mining, dams and their effects on forest and tribal people, Forest products.

UNIT- III Problems on resources

Food and energy resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.

UNIT-IV Soil, Water and Mineral resources

Soil resource, Soil fertility management, waste land-National scenario, waste land management through social forestry programmes.

Water resources: Sources and utilization, water demand, conflicts over water, dams-benefits and problems, conservation of water

Mineral resources: Use and exploitation, environmental effects of mining ,conservation of minerals.

REFERENCES:

1. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co. USA, 574p
3. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publishing House.
4. Cunningham, W.P., Cunningham, M.A. & Saigo, B. (2004) Environmental Science, a Global Concern. (8th edition). McGraw-Hill (Boston)
5. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment.Cambridge Univ. Press.
6. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
7. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
8. Wright, R.T. (2005) Environmental Science - toward a Sustainable Future. (9th International Edition), Pearson Education International, Prentice Hall Publishers.

EES – 534 RESEARCH METHODOLOGY AND STATISTICS

UNIT – I: Research Documentation and Ethics

Scientific documentation, literature collection, design, planning and execution of investigation, Preparation of scientific documents, general articles, research papers, review articles, editing of research papers, methods of citation and thesis writing. Stakeholders in research, Publication and research industry, Publication process; Ethics in Environmental Research; Plagiarism and its consequences; Good laboratory practice and Laboratory safety.

UNIT II: Descriptive statistics

Fundamentals of Statistics– Collection of Data – Classification and Tabulation – Diagrammatic Representation – Measures of Central

Tendencies and Dispersion – Moments, Skewness and Kurtosis – Normal, Poisson and Binomial Distributions.

UNIT III: Standard distributions

Tests of Significance – Mass and alternative hypothesis – error level of significance – Equal and Unequal Sampling - t, z, x2 test, Analysis of variance – One way ANOVA – Two way ANOVA – Regression and correlation - simple and multiple. Cluster analysis – PCA, Graph Plotting.

UNIT – IV: Environmental Models

Lotka – Volterra Model, Leslie's Matrix Model – Point Source Stream Pollution Model – Air Quality Model. Thermal Plume and Dispersion models. Decision Support Systems – Data Analysis using packages (SPSS).

REFERENCES

1. Bliss, G.I. (1970). Statistics in Biology. Mc Graw Hill Book Company, Vol. I and II. New Delhi.
2. Vittal, R.R. (1986), Business Mathematics and Statistics, Murgham Publications.
3. Haynes, R (1982), Environmental Science Methods, Chapman & Hall, London.
4. Khan, I.A and Kanum, A., (1994), Fundamentals of Bio-Statistics, Ukaaz Publication, Hyderabad.
5. Gupta, S.P. (1996),Statistical Methods, Sultan Chand & Sons Publications, New Delhi.
6. Byron S Gottfried (1996), Programming with C, Hill Publishing Co, New Delhi.
7. Wardlaw, A.C. (1985), Practical Statistics for Experimental Biologists. Wiley Chichester.
8. Kothari, C.R (1996), Quantitative Techniques, Vikas Publishing Housing Pvt Ltd, Hyderabad
9. Miller, J., (1989), Statistics for Advanced Level, Cambridge University Press.

EES-535 Practical-III (Biodiversity, Environmental Engineering, Statistical Analysis)

1. Determination of density of species using quadrat method
2. Determination of suitability point of a vegetation
3. Determination of frequency and relative frequency of species in a given area
4. Determination of abundance of species in a given area
5. Identification of endangered species of flora and fauna
6. Calculation and designing of Sedimentation Tank
7. Calculation and designing of Activated Sludge Processes
8. Calculation and designing of Trickling Filter
9. Calculation and designing of Disinfection Process
10. Calculation and Designing of minimum stack height
11. Calculation and Designing of Cyclone, Electrostatic Precipitator
12. Collection of Data: Primary data – Secondary data – Classification and Tabulation – Diagrammatic Representation
13. Data Analysis using software: SPSS and Excel stat: Editing, Data Tabulation
14. Analysis: Descriptive statistics – Correlation – Regression – Factor analysis – Cluster analysis – Principal Component Analysis (PCA), Graph Plotting - One way ANOVA – Two way ANOVA.

EES-501: AQUATIC ECOLOGY

Unit I: Water

Nature of Water, Chemical and physical properties, Movement of water, Basic principles of fluid dynamics. Movement of light and heat in water, Diffusion of chemicals. Hydrological cycle, interaction of water with other ecosystems.

Unit II: Aquatic Physiography and Chemistry

Basics of oceanography, Geography and types of aquatic habitats, intermediate habitats – significance. Physiography of marine, lentic and lotic ecosystems, formation, characterization, and flow types. Unique and extreme aquatic habitats. Types of elements and chemicals in water, physical chemistry of chemical transformations, oxygen – photosynthesis and respiration, carbon – forms and transformations. Nutrient cycling – carbon, nitrogen, sulphur, phosphorus, silicon, iron and trace nutrient cycles, and interactions.

Unit III: Aquatic biology

Types of organisms, major taxonomic groups, classification of organisms by habitat, function and level of interaction. Unicellular and Multicellular organisms in aquatic habitats and their role. Trophic states. Food web, prey and predator interactions. Complex interactions. Species diversity, measures of diversity, and threat perception. Ecosystem services of key aquatic organisms.

Unit IV: Aquatic pollution

Global change and its effect on aquatic habitats and vice-versa. Types of pollutants – sources and effect, eutrophication, toxins – natural and artificial, anthropogenic chemicals and metals pollution. Toxicology in aquatic habitats, bioassessment and mitigation measures. Chemical and Biomarkers of pollution. Water and wastewater treatment. Wetland conservation.

REFERENCES:

1. American Public Health Association, et al. 1996. Standard Methods for Examination of Waterand Wastewater (19th Edition).American Public Health Assoc., New York.

2. Barnes, R.S.K. and K. H. Mann. (1980). Fundamentals of Aquatic Ecosystems. Blackwell Scientific Publications, Oxford.
3. Brönmark, C. and L.-A. Hansson. (1998). The Biology of Lakes and Ponds. Oxford UniversityPress, Oxford.
4. Cole, G. A. (1983). A Textbook of Limnology.3rd edition.C.V. Mosby, Co., St Louis.
5. Dodds, W. K. and M. R. Whiles (2010). Freshwater Ecology (Second Edition). Academic Press, London.
6. Gopal, B. and R. G. Wetzel. 1995. Limnology of Developing Countries. Vol. 1-4. Int. Assoc.Theor. Appl. Limnology.
7. Lerman, A., D. M. Imboden, and J. R. Gat, Editors. (1995). Physics and Chemistry of Lakes (2nd.Edition). Springer-Verlag, New York.
8. National Research Council. (1992). Restoration of Aquatic Ecosystems. The National Academies Press, Washington, DC.
9. Wetzel, R. G. (2001). Limnology: Lake and River Ecosystems. 3rd Edition Academic Press, New York.

EES – 502: CURRENT ENVIRONMENTAL ISSUES

UNIT I: Population

Population explosion, Malthusian theory, Population distribution, population unsustainability, population growth, population pyramids, pattern of India population, scale of urbanization, migration trends- rural and urban, Population displacement due to developmental projects. International initiatives on population related issues.

UNIT II: Environmental and human health

Hazardous chemicals, pesticides and their impact, polychlorinated biphenyls (PCBs), Lead, mercury, arsenic, cadmium, asbestos, dioxins. Environment and development, poverty and environmental degradation, water requirement, CommUNITy participation in water conservation, Water harvesting, role of NGOs in environmental protection. Social consequences of development and environmental changes

UNIT III: Global Issues

Acid rain and its effects on ecosystems (flora, fauna and human beings). Ozone layer depletion, causes and consequences of Ozone depletion, CFCs, Montreal Protocol. Climate change, global warming-causes and impact of global warming, International initiatives to control global warming, Kyoto Protocol.

UNIT IV: Natural Resources

Depletion and regeneration of natural resources, Renewable and non-renewable resources, Biotic Resources- Forests, agriculture, fisheries, livestock, biodiversity and its conservation, Abiotic Resources- Surface and ground water, Energy, non-energy mineral resources, land resources, soil erosion, ecosystem services. Sustainable development

REFERENCES

1. Botkin, Daniel B. and Keller, Edward A. (2007), Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA.
2. Cunningham, W. P. and Cunningham, M. A. Principles of Environment Science.
3. Enquiry and Applications. 2nd ed. Tata McGraw Hill, New Delhi. 2004.
4. Rajagopalan, R. (2008), Environmental Studies: From crisis to cure, Oxford University Press, New Delhi.
5. Richards, I. S. (2008), Principles and Practice of Toxicology in Public Health. Jones and Bartlett Publishers, London.
6. Singh, J.S., Singh, S.P. and Gupta, S.R. (2006), Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi, India.
7. UNEP. Global Environment Outlook 3. Geneva: UNEP, Global Resource Information Division. 2003.
8. World Commission on Environment and Development (WCED): Our Common Future, Oxford University Press, London. 1987

EES-503: ECOTOURISM

UNIT I: Introduction & overview

Ecosystem processes, goods and services with special reference to tourism activities; an overview of Tourism-Environment linkages –

the 'Intangibility', 'Heterogeneity', 'Perishability' and 'Inseparability' of Tourism and their Ecological/ Environmental/ social/economic/cultural/ethical implications; impacts of mass tourism and the need for alternative tourism strategies; Adaptive/ Sustainable management of Ecosystems with special reference to Tourism

UNIT II: Alternative tourism typology & strategies

Alternative/Appropriate tourism typology- Eco-tourism, Ecocultural Tourism, Heritage Tourism, Adventure Tourism, Health Tourism, Farm Tourism, Urban Eco-tourism, Eco-development Tourism, Fishing Tourism- definitions, strategies, potentials and constraints; incorporation of pro-poor, community run/based, gender balanced and responsible tourism strategies.

UNIT III: Eco-tourism and Sustainable development

Paradigm shifts in Tourism Ecology; Eco-development / Sustainable development-definitions and their relevance for Ecotourism; common property resources and their management for Eco-tourism; Potentials and constraints for promoting Eco-tourism in our country – authenticity and commodification of ecotourism-case studies; Eco-labels, Ecotels and Tourism certification programmes; codes of conduct for different stake-holders.

UNIT IV: Eco-tourism Policy & Planning- a futuristic perspective:

Eco-tourism components and impact monitoring – Ecotourism opportunity spectrum (ECOS), Ecological foot print analysis, Limits of acceptable change (LAC),Visitor activity management (VAM), Visitor impact management (VIM),Tourism optimization management model (TOMM); suggestions for long term sustainable Eco-tourism initiatives.

REFERENCES

1. Buckley, R.C. (2009). Ecotourism: Principles and Practices. CAB International, Oxford, 368pp
2. Fennell, D. A. (2008). Ecotourism: An introduction. New York, NY: Routledge.
3. Weaver, David, (2008). Ecotourism, John Wiley & Sons; 2nd Edition Paper back, pp.360.

4. Brent Ritchie J R & G I Crouch, (2005). The Competitive destination: A sustainable tourism perspective, CABI, UK.
5. Eagles, P.F.J, S.F. McCool, & Haynes, Christopher,D.A. Christopher. (2002). Sustainable tourism, in protected areas: guidelines for planning and management, IUCN, Gland, Switzerland.
6. Honey, M, (2008). Ecotourism and Sustainable Development Who Owns Paradise? Second Edition, Island Press, USA, Paperback pp.558.
7. Wood, M, E, (2003). Eco-tourism: principles, practices and policies for sustainability, UNEP, DTIE/ TIES, 61 pp. accessed at uneptie.org/ tourism/home.html

EES – 504: ENERGY AND ENVIRONMENT

UNIT I: Non renewable Energy resources

Fossil fuels-classification, composition, physico – chemical characteristics and energy content of coal, petroleum and natural gas, nuclear fuel, fission and fusion.

UNIT II: Renewable energy resources

Biomass, bio-fuel, hydroelectric power; Non-conventional energy resources: tidal energy, wind energy, geothermal energy, solar energy, solar radiation and its spectrum, solar collectors, photovoltaics, solar ponds, hydrogen energy.

UNIT III: Energy resource management

Energy crisis; Energy Conservation and Management; Energy audit; Recycling of wastes**:** Types - sources - composition of waste - recycling of waste for Industrial, Agricultural and Domestic Purposes.

UNIT IV: Energy use and its Environmental impact

Energy use pattern in different parts of the world; Environmental implication; CO_2 emissions, global warming; thermal pollution, air pollution; radioactive waste, radioactivity from nuclear reactors, radioactivity risk assessment and criteria for safe exposure; impacts of large-scale exploitation of Solar, Hydro and Wind energy.

REFERENCES

1. Armaroli N, Balzani V, 2011. Energy for a Sustainable World – From the Oil Age to a Sun-Powered Future, Wiley-VCH.
2. Armaroli N, Balzani V, Serpone N, 2013. Powering Planet Earth – Energy Solutions for the Future, Wiley-VCH
3. Chichester, 2010. Renewable Energy and Climate Change. John Wiley & Sons Ltd.
4. Sioshansi FP, 2011. Energy, Sustainability and the Environment, Elsevier

EES – 505: ENVIRONMENTAL ECONOMICS

UNIT I: Economy and the Environment

World environmental history and economic development, valuation of natural resources, Inter-linkages between the economy and the environment. Economics of Natural Resource Exploitation – Renewable and Non-Renewable Resources – Methods of valuation of Environmental Costs and Benefits. Entropy- Principle and law of entropy. Material flow in economy.

UNIT II: Environmental Policy

Design of Environmental Policy. Economic Instruments for Environmental Protection: Command & Control versus Incentives and Subsidies. Effectiveness of these instruments. Indian scenario and comparisons with China and developed countries.

UNIT III: Sustainable Development

Concept and objectives. Strategic Planning for Sustainable Development, Natural resource based economic and social development. Climate Change, India:Vulnerability of regions and populations – Adaptation options.

UNIT IV: Green Economy

New model for development, Green economy and green economy initiatives, Role of UNEP. Brundtland Commission. ecological economics Economic Growth and the Environment: Environmental Kuznets' curve, Foreign Direct Investment and the Environmental quality.

REFERENCES

1. Allen V. Kneese and James L. Sweeney, eds. (1985), Handbook of Natural Resource and Energy Economics, Chapters 2,12,14,17, North Holland.
2. Bohm, P. and Russell, C., `Comparative Analysis of Alternative Policy Instruments',Chap. 10 in Handbook of Natural Resource and Energy Economics, Vol.I Ed. A.V.
3. Field, B.C., (1994), Environmental Economics: An Introduction, McGraw Hill.
4. Fisher, A.C., (1995), Environment and Resource Economics, Selected readings, New Horizon in Environmental Economics, Ed. W.E. Oates,.
5. Hanley, Nick, Jason F. Shogren & Ben White (1997), : Environmental Economics in Theory and Practice, New Delhi: Macmillan –India.
6. James, D.E., (1978), Economic Approaches to Environmental Problems: Techniques and Results of Empirical Analysis, Elsevier Scientific Publishing Co..
7. Kolstad Charles., (2010), Environmental Economics, New Delhi: Oxford University Press.

EES 506: ENVIRONMENTAL EDUCATION

UNIT –I Introduction

Objectives, Scope and Nature of Environmental Education a) Meaning, definition and characteristics of environmental education – content. b) Importance, objectives, scope and guiding principles of environmental education. c) Factors of degradation of environment – adverse socio – economic impacts of degradation of environment.

UNIT – II Environmental policies

India and Environmental Issues and Policies Major environmental problems in India – Environmental protection and polices in India – Need and objectives of conservation – Environmental conservation measures taken in India – Constitutional amendments made and Environmental laws

UNIT -III Environmental Movements

Environmental Movements and Developments Environmental movements in India: Silent Valley movement, Chipko movement, Narmada Bachao, Andolon, National Test Range at Baliupal, Orissa – conditions for achieving the goals of sustainable development – Strategies for sustainable development in India.

International Efforts for Environmental Protection The Stockholm conference 1972 – Brundtland commission 1983 – Nairobi conference 1982 – The Rio Summit 1992 – the Rio Declaration at the earth charter – Major achievements of the Rio Summit – Main features of the Rio Declaration – Kyoto conference and part on Global Warming.

UNIT - IV Role of education

Environmental Education in the School Curriculum, major constraints for its implementation, Teacher's role – national resource centre for environmental education, role of individual in conservation of natural resources - Role of information technology.

REFERENCES

1. KK Shrivastava (2016) Environmental Education: Principles, Concepts and Management,Kanishka Publishing House.
2. KC Jain (2016) Environment Education, Tandon Publications.
3. Sharma, R. A. (2008). Environmental Education. R. Lall Books Depot. Meerut.
4. Singh,Y. K. (2009). A text book of environmental science. APH Publishing Corporation , New Delhi.
5. Depot. Kumar, A. (2009), Education for Environmental and Human value, R. Lall Books Publications, Meerut, India
6. Reddy, P. K., & Reddy, N. D. (2001). Environmental education. Anmol publications, New Delhi.
7. Kelu, P. (2000). Environmental Education. Neelkamal Publications, Hyerabad.
8. Sharma, R. G. (1986). The handbook of environmental education., Metropolitan Book, New Delhi.

EES – 507: ENVIRONMENTAL GEOSCIENCES

UNIT I: Basic concepts

Evoluion of earth and it's environment; components of the physical environment, atmosphere, hydrosphere and lithosphere. Internal structure of earth; Geological maps, Geological time scale,

Hydrological cycle, the concept of rock cycle; Agents, types and products of weathering; Rocks and mineral, classification, soil formation, soil profile, soil classification, soils of India.

UNIT II: Environmental geology

Environmental factors of deep seated processes of lithospherevolcanic, seismic and diastrophic tectonic processes with special reference to Indian sub-continent, reservoir induced seismicity, environmental geologic mapping, geological aspects of environmental impact of dredging, mining, river-sand mining, quarrying , deforestation, resettlement, farming, and other types of land use, environmental factors of ground water depletion, bore wells, siltation of reservoirs, Geoenvironmental changes associated with highway construction, bridges, tunnels, high rise buildings.

UNIT III: Plate tectonics and geological hazards

Concept of plate tectonics; Major and minor lithospheric plates, plate margins and types, causes of plate movement, sea floor spreading and continental drift; geodynamic elements of earth: Mid-ocean ridges, trenches, transform faults and Island arcs. Interrelation of toposheet – contour, gradient, dip, strike; Geological structures: Joints, fold, fault and unconformities.

UNIT IV: Application of geology in engineering

Geological time scale of rocks; properties of rocks, Geological and environmental investigations for the construction of dams, bridges, highways and tunnels; Impact of major geotechnical projects on the environment.

REFERENCES

1. Bell, F.G., (1999). Geological Hazards, Routledge, London.
2. Brownlow, A.N., (1979). Geochemistry, Prentice Hall.
3. Bryant, E., (1985). Natural Hazards, Cambridge University Press.
4. Keller, E.A., Environmental Geology & Turk and Turk.
5. Krynine, D.S. and Judd, W.R., (1998) Principles of Engineering Geology, CBS, New Delhi.
6. Lahee, (1987) Field Geology. Sixth Edition. Mc Graw Hall Co..
7. Sawkins,J.S.,Chase,C.G., Darby,D.G. and Rapp,G., (1978).The evolving earth, Mac Millan Publishing Co., New York.
8. Smith, K., (1992). Environmental Hazards, Routledge, London.
9. Spencer, Structure of the Earth. Wiley. Brian Mason, 1966, Principles of Geochemistry, Wiley.

EES – 508: ENVIRONMENTAL GENETICS AND BIOTECHNOLOGY

UNIT I: Genetic Engineering

Introduction to genetic engineering, Restriction endonucleases, properties of restriction enzymes, introduction of cloned genes into new hosts using plasmid and phage vector systems, isolation of plasmids, DNA – cloning of DNA fragments, Cloning of single stranded DNA, Shuttle vectors and their environmental applications.

UNIT II: Biotechnology for environment

Recombinant DNA Technology, development of genetically engineered microorganisms (GEMs), Polymerase Chain Reaction (PCR) and development of gene probes for environmental remediation, Uses of GEMs in bioremediation, Genosensor technology.

UNIT III: Genetically modified microorganisms

Genetically modified microbes & their uses in Environmental, Microbial reactors, management of recycling & up gradation technologies, Bioenergy from waste, Biogas technology – process and biogas from organic waste.

UNIT IV: Biotechnology for Management of Resources

Bio-transformation of heavy metals, improved oil recovery, role of environmental biotechnology in management of resources, reclamation of wasteland, biomass production, microorganisms in mineral and energy recovery, nanotechnology for control of pollution.

REFERENCES

1. Environmental Biotechnology and Cleaner Bioprocesses. Boca Raton, Taylor & Francis.
2. Evano, G.H. and Furlong, J.C. (2004), Environmental Biotechnology - Theory and Application. USA, John Wiley and Sons.
3. Jjemba, P.K. (2004), Environmental Microbiology - Theory and Application. USA, Science Pub. Inc..
4. Kuhad R.C., Singh A. (2013), Biotechnology for Environmental Management and Resource Recovery. New York, Springer-

Verlag.
5. Martin C.C. (2008), Environmental Genomics. Totowa, NJ, USA, Humana Press.
6. Pepper, I.L. and Gerba, C.P. (2005), Environmental Microbiology - Laboratory Manual. USA, Elsevier..
7. Ratledge, C. and Kristiansen, B. (2002), Basic Biotechnology. 2nd ed. Cambridge, Cambridge University Press.
8. Rittman, B. and McCarty, P. L. (2000), Environmental Biotechnology: Principles and Applications. 2nd edition. USA, Tata McGraw-Hill.
9. Rittmann, B.E. and McCarty, P.L. (2001), Environmental Biotechnology – Theory and Application. USA, McGraw Hill.

EES 509: ENVIRONMENTAL NANOTECHNOLOGY

UNIT-I Introduction

Environmental Nanotechnology- An introduction, Concept of Nano pollution, Nanotechnology for Reduced waste and improved energy efficiency, Nanotechnology based water treatment strategies.

UNIT-II Synthesis of nano materials

Microorganisms for synthesis of Nano materials and for toxicity detection: Natural and artificial synthesis of Nano particles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of Nano particles using microorganisms.

UNIT-III Applications in waste management

Waste remediation: Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification. Energy conversion; Hierarchical self-assembled nanostructures for adsorption of heavy metals, Nano-pesticide formulations, Nanoparticles for dye removal and water filtration.

UNIT-IV Safety of nanomaterials

Pollution by Nano-particles- Health impact, Safety and Toxicological effects. Societal impact & Ethical issues in Nanoscience and

Nanotechnology, Problems and possible solutions, Regulation, Green Nanotechnology.

REFERENCES

1. Hambleton, P.; Salusbury, T. (Eds.) (1994), Biosafety in Industrial Biotechnology. Springer.
2. Mark Wiesner, Jean-Yves Bottero (2007), Environmental Nanotechnology : Applications and Impacts of Nanomaterials: Applications and Impacts of Nanomaterials, McGraw Hill Professional.
3. Jo Anne Shatkin (2013), Nanotechnology: Health and Environmental Risks, Second Edition, CRC Press, Taylor and Francis.
4. Vicki H. Grassian (Ed) (2008), Nanoscience and Nanotechnology: Environmental and Health Impacts, John Wiley & Sons, Inc.
5. Berube, D. M. (2006), Nano-hype: The Truth Behind the Nanotechnology Buzz. New York: Prometheus Books.
6. Jean-Yves Bottero (2007), Environmental Nanotechnology: Applications and Impacts of Nanomaterials ,McGraw-Hill Education.
7. Mukesh K Burman (2012), Nanotechnology: Emerging Issues and Application,Sarup Book Publishers.
8. Geoffrey B. Smith, Claes-Goran S. Granqvist (2010), Green Nanotechnology: Solutions for Sustainability and Energy in the Built Environment, CRC press.

EES 5010: ENVIRONMENTAL STRESS BIOLOGY

Unit I: Introduction to environmental stresses

Introduction to environmental stresses, Types of stresses, Abiotic factors: temperature, water, salinity, UV radiation, Biotic factors: competitors, pathogens, pests.

Unit II: Plant responses to environmental stress

Adaptations of plants to environmental stress, Eco-physiological responses of extremophiles, tolerance of plants to pollutants, tolerance index of plants, Use of stress indicators for biomonitoring.

Unit III: Animal responses to environmental stress

Biological responses to high altitude anddeep sea environment; Osmoregulation in fish, water conservation and adaptive mechanisms indesert habitats; hibernation and aestivation, Circadian rhythms and biological clock;Bioindicators and biomonitors of pollution.

Unit IV: Chemical ecology

Chemical interactions between biota of an ecosystem, Allelopathy, Chemotaxis, Chemical messages during insect herbivory, Volatiles for chemical communication, Chemistry behind Plant pathogen interactions.

REFERENCES:

1. Plant Physiological Ecology 2008.Lambers, Hans,Chapin III, F. Stuart,Pons, ThijsL., Springer
2. Plant Ecophysiology. 1996. (Ed) M.N.V Prasad. John Wiley & Sons
3. Physiological Animal Ecology 1996.Gideon N Louw. Prentice Hall
4. Physiology and Molecular Biology of Stress Tolerance in Plants. 2006.(Eds) K.V. MadhavaRao, A.S. Raghavendra, K. Janardhan Reddy. Springer.
5. Physiological Plant Ecology(Eds)Lange, O.A., Nobel,P.S., Osmond, C.B. and Ziegel, H. Encyclopedia(Vol. I-IV) Springer Verlag
6. Environmental Physiology of Plants.2002. By Alastair H. Fitter, Robert K.M. Hay Academic Press
7. Animal Physiology: Adaptation and Environment 5thedition, 2002. By Knut Schmidt-Nielsen

EES 5011: FOOD SAFETY AND HEALTH

UNIT –I Introduction

Concepts of food safety, establishing the problems, susceptibilities within the food chain , Food borne pathogens and outbreaks, seafood and shell fish, mercury and toxins

UNIT –II Regulations

Food safety regulations: the roles of federal, state, and international agencies, Hormones and antibiotics: antibiotic resistance, contamination of foods. Organic food, chemical contamination of food, Genetically modified foods. Food safety preparedness:

Perspective from the food industry

UNIT –III Procedural Analysis

Risk perception and analysis; Globalization, sustainable agriculture, local food networks, slow foods; Restaurant and food service inspections, food safety in the home

UNIT –IV Food safety

Bioterrorism and food safety, Over-nutrition: food marketing, supersizing, obesity. Legal consequences of food outbreaks, Dietary Supplements.

REFERENCES

1. Food Safety Management, A Practical guide for the food industry, 2013 Elsevier Publishers (1st Edition, 2013) .
2. *Food Safety and Standards Act, Rules & Regulations, 2015, Akalank Publications (13th Edition edition), India.*
3. P K Das (2006). Handbook on the Food Safety & Standards Act, 2006 Universal-Law-Publishing-Co-Ltd, India
4. SN Mahindru (2007) Food and Nutrition Education KSK Publishers & Distributors.
5. Punam Chopra (2005) Food and Nutrition Education APH Publishing Corporation, India
6. Steier, Gabriela, Patel, Kiran (Eds.) (2016) International Food Law and Policy, Springer, Germany
7. Alok Bhargava (2008) Food Economics and Health, Oxford University Press, New Delhi.
8. PS George (2002) Some Reflections on Food Security in India, Academic Foundation, New Delhi.

EES 5012: FORESTRY MANAGEMENT

Unit I: Forestry: Introduction

Definition of forestry and habitat management, Concepts, terminologies, need and scope. Forest as an ecosystem, Biotic and abiotic components, productivity, nutrient cycling, stresses, Forest types in India and conservation initiatives. Research and Extension needs, stages of tribal economy, education, cultural tradition, customs, ethos and participation in forestry programme, forest

genetic resources and gene conservation in situ and ex-situ. Joint Forest Management.

Unit II: Silviculture

General principles, ecological and physiological factors influencing vegetation, nursery system, Silvicultural systems - wood selection, felling, establishment and management of standards, technical methods and constraints, Silviculture practices in specialized ecosystems like Mangroves and Cold desert:

Unit III: Forest resources and utilization

Direct and indirect Environmentally sound forest harvesting practices, logging and extraction techniques and principles, transportation system, storage and sale, Need and importance of wood seasoning and preservation; Non-Timber Forest Products (NTFPs) definition and scope - collection; processing and disposal.

Unit IV: Forest legislation

Indian Forest Policy of 1894, 1952 and 1990. National Forest Policy, Forestry Policies and issues related to land use, timber and non-timber products. Indian Forest Act 1927; Forest Conservation Act, 1980; Application of Indian Penal Code to Forestry.

REFERENCES:

1. Dehradun (original 3 vol. by RS Troup).
2. Forest and forestry by KP Sagaraya.
3. Forest Ecology by AS Puri.
4. Forest Mensuration by LS Khanna.
5. Forest Utilization by Tribhuwan Mehta.
6. Forestry in India by AP Dwiwedi.
7. India's Forest Policies: Analysis and Appraisal by LK Jha.
8. Introduction to Forest Genetics by Wright.
9. Manual of Joint Forest Management Training Manual.

10. Minor Forest Products of India by T Krishnamoorthy.

11. Principal and Practices of Silviculture by L S Khanna.

12. Revised Survey of Forest Types of India by Champian and Seth.
13. Silviculture of Indian Trees (Revised Ed.) Vol 1-7 Editorial Board of Forest Research Institute.

14. Social Forestry by KM Tiwari.

EES – 5013: INDUSTRIAL ECOLOGY

UNIT I: The Environment and the Anthrosphere

Definition – Environment and Anthrosphere, Components of the anthrosphere, effects of the anthrosphere on earth, integration of the anthrosphere into the total environment, the anthrosphere and industrial ecology.

UNIT II: Industrial ecology and industrial systems

Levels of material utilization, links to other environmental spheres, consideration of environmental impacts in industrial ecology, Key attributes – energy, materials and diversity. Life cycle, consumable, recyclable and service products. Societal factors and environmental ethics.

UNIT III: Industrial Metabolism and waste disposal

Networks of Nutrient and Energy transfer. Industrial metabolism, ion exchange, photolytic reactions, thermal treatment methods, biodegradation of wastes, treatment methods for solid and liquid wastes.

UNIT IV: Industrial ecosystems

Components of the industrial ecosystem, overview of an integrated industrial ecosystem, examples of symbiotic industrial ecosystems, designing and developing of symbiotic industrial ecosystem. Industrial Ecology and the Legal System.

REFERENCES

1. Bourg D., Erkman S. (2003), Perspectives of Industrial Ecology. Texas, Greenleaf.

2. Graedel T.E., Allenby B.R. (2010), Industrial Ecology and Sustainable Engineering. New Jersey, USA, Prentice Hall.
3. Graedel T.E., Allenby B.R. (2003), Industrial Ecology. New Jersey, USA, Printice Hall.
4. Manahan S.E. (1999), Industrial Ecology: Environmental Chemistry and Hazardous Wastes, Boca Raton, CRC Press,.
5. Socolow R., Andrews C., Berkhout F, Thomas V. (2010), Industrial Ecology and Global Change. Cambridge, Cambridge University Press,.
6. Suh S. (2009), Handbook of Input-Output Economics in Industrial Ecology. New York, Springer-Verlag.

EES – 5014: MARINE ENVIRONMENT

UNIT I: Introduction to Marine ecosystem

Marine ecosystem – estuaries, rocky and sandy shores, pelagic ecosystems, continental shelf seabed, deep sea, mangroves forests, seagrass meadows, coral reefs, Polar Regions.

UNIT II: Marine biodiversity

Distribution of marine biodiversity, relationship between global climate and marine biodiversity, hypoxia and dead zone, significance of marine biodiversity, marine ecosystem functioning. Extinct and endangered marine species, fisheries management and conservation.

UNIT III: Marine Resources and Energy

Fossil records, fishing, mining – minerals and crude oil, tourism, Energy from Marine Environment – Renewable – marine wind power, osmotic power, tidal power, wave power, ocean thermal energy; Non renewable energy.

UNIT IV: Marine Pollution

Sources and types of marine pollution, effects of marine pollution – physicochemical and biological effects, impact of climate and environmental factors on marine environment and biodiversity. Mitigation measures for marine pollution.

REFERENCES

1. Farmer A. (1997), Managing Environmental Pollution. New York, Routledge.

2. Hofer T.N. (2008.), Marine Pollution: New Research, New York, Nova Science Publishers,
3. Iversen E.S. (1996), Living Marine Resources: Their Utilization and Management. New York, Chapman Hall,
4. Kaiser M.J., Attrill M.J. (2011), Marine Ecology: Process, Systems and Impacts. Oxford, Oxford University Press..
5. Multon B. (2012), Marine Renewable Energy Handbook. Philippines,Wiley-ISTE.
6. Polunin V.C. (2008), Aquatic ecosystems: Trends and Global Prospects. Cambridge, Cambridge University Press.

EES – 5015: NATURAL HAZARDS AND DISASTER MANAGEMENT

UNIT I: Introduction to natural Disasters

Nature and Extent and Educative – trends in climatology, meteorology and hydrology. Seismic activities. Changes in Coastal zone, coastal erosion, beach protection. Coastal erosion due to natural and manmade structures.

UNIT II: Disasters and their impacts

Disasters - Cyclone – Tornadoes – Avalanches – Flood –Drought – Valconic – Earthquakes – Fire – Landslides. Forecasting and Warning System: Cyclone Disaster Education - Cyclone Safety – Earthquake – Avalanche – Safety and Flood Safety – Impact on
Environment

UNIT III: Disaster management

Disaster Management. Predisaster Planning-Toning of Disaster – prone areas – prioritization – regulations – protection measures during disaster - Post disaster. Relief Camp Organization – Survey and Assessment. Disaster Management Cycle – Vulnerability Analysis – Warning system – Disaster Training – Legal Aspects – case studies for disasters and management, Safety Measures – a general account, Disaster Management plans

UNIT IV: Importance of Disaster Preparedness and Training

Disaster Preparedness and Training. Community Preparedness in Natural Disasters- Role of information, education, communication and training- Roles and responsibilities of different national and international agencies and government - NGO, Armed forces,

Paramilitary forces, Community based organizations (CBO) - Army Training for Disaster Reduction –Role of team and co-ordination Training needs – Target Groups – Local Condition.

REFERENCES

1. Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2. Carter, N W. ((1992), Disaster Management: A disaster Manager's Handbook, Asian Development Bank, Manila.
3. Disaster Planning: The Preservation of Life and Property, Harold D. Foster (1980), Springer Verlay, New York.
4. Disaster Management, Shailendra K Singh, Subash C. Kundu and Shobu Singh (1998), Mittal Publications, New Delhi.
5. Gautam Ashutosh. (1994), Earthquake: A Natural Disaster. Ashok Publishing House. New Delhi.
6. Natural Disasters – A Guide for Relief Workers, (1980), JAC Adhyatma Sadhna Kendra-Mehrauli, New Delhi.
7. Roy, P.S. (2000): Space Technology for Disaster management: A Remote Sensing & GIS Perspective, Indian Institute of Remote Sensing (NRSA), Dehradun.
8. Sharma, R.K. & Sharma, G. (2005) (ed) Natural Disaster, APH Publishing Corporation, New Delhi.
9. Singh D K. (2006), Towards Basics of Natural Disaster Reduction, Research book Centre, New Delhi, Singh T. (2006), Disaster Management approaches and strategies, Akansha Publishing House, New Delhi.

EES – 5016: OCCUPATIONAL HEALTH AND INDUSTRIAL SAFETY

UNIT I: Occupational Health

Hazards and Safety–Physical, Chemical and Biological hazards.

Occupational Diseases and Occupationally induced illness - Prevention and Control. Health problems in different types of industries. Measures for Workers. Health Education Medical FirstAid and Management of Medical Emergencies. Epidemiological approaches. Ergonomics.

UNIT II: Industrial Safety Management Techniques

Industrial Safety Standards. Dispersion of Radioactive material and release of Toxic and inflammable materials. Work Study - Method of Study and Measurement. Measurement of Skills. Safety - Cost of Expenses. Principles and Functions in Safety Management.

UNIT III: Hazards Exposure evaluation

Sampling techniques, Personal monitoring, Biological monitoring; Threshold Limit Values (TLV), STEL; List of Industries involving Hazardous process Occupational Hazards under the First Schedule of the Factories Act,1948; Permissible Limits of certain Chemical substances in work environment under the Second Schedule of the Factories Act,1948.

UNIT IV: Hazards Control

Causes of Accident – Theory of accidents, Accident Reporting system, Safety Audit, Accident prevention, Safety Committee, Case studies on Bhopal, Chernobyl and similar disasters - Control of Hazards Substitutions, Isolation, Personal Protective Equipment (PPE).

REFERENCES

1. A B C of Industrial Safety, Walsh, W and Russell, L, (1984), Pitma Publishing United kingdom
2. Della D.E., and Giustina, (1996), "Safety and Environmental Management", Van Nostrand Reinhold International Thomson Publishing Inc.
3. Environmental and Industrial Safety, Hommadi, A. H. (1989), I.B.B Publication, New Delhi.
4. Environmental Strategies–Hand Book, Kolluru R. V, (1994) Mc Graw Hill Inc., New York.
5. Goetsch D.L., (1999), "Occupational Safety and Health for Technologists", Engineers and Managers", Prentice Hall.

EES- 5017: PRINCIPLES OF REMOTE SENSING AND GIS

UNIT-I: Introduction

Principles of Remote sensing: Electromagnetic Radiation (EMR),interaction of EMR- earth's surface-reflection-transmission,

Spectral signatures and characteristics, spectral reflectance curves. Process of data acquisition, storage, analysis and visualisation

UNIT II: Remote Sensing System

Remote Sensing observations and platforms: Air borne and space borne platforms. Active, Passive and Optical remote sensing, Concept of Microwave remote sensing and microwave remote sensors. Multi-Spectral Imagery (MSI) - Hyperspectral Imagery (HSI)-Thermal Scanner Imagery. Scattrometer and Altimeter.

Remote sensing satellites; Land observation satellites, IRS series, LANDSAT series, SPOT series ; High resolution satellites, Weather/Meteorological satellites, NIMBUS Applications, Marine observation satellites OCEANSAT.

UNIT III: Aerial Photography

Elements of photographic system, Geometric characteristics of aerial photographs, Photogrammetry, Visual and digital image processing, Digital image interpretation: Pattern recognition, shape analysis, texture analysis. Integration with GIS.

UNIT IV: Principles and application of GIS

Introduction to GIS, Components of GIS, Geospatial data architecture, operations, Layers and features, Raster and Vector. Types of data – Spatial, Attribute data-types of attributes-scales/ levels of measurements. Data File Formats, Datum Projection and re projection, Topology. Global positioning System (GPS). Spatial database Management Product Generation: Types of output products. Application of Remote sensing: Land Use / Land Cover Mapping, Geologic and Soil Mapping, Agricultural applications, Forestry applications, Water Resource applications, Urban and Regional Planning application, Wetland Mapping, Wildlife Ecology applications, Archaeological applications, Environmental and Disaster Assessment. Applications of GIS: Resources mapping, Inventory and monitoring of natural resources, Land cover mapping, Wetland mapping, Applications to Agriculture, Water Management, Ground Water Modelling, Coastal and Marine applications.

REFERENCES

1. Anji Reddy, M. 2004: Geoinformatics for Environmental Management. B.S. Publications.
2. Chang. T.K. 2002: Geographic Information Systems. Tata McGraw Hill.
3. Clarke, Keith C., Bradley O. Parks, and Michael P. Crane, 2002. Geographic Information Systems and Environmental Modeling, Upper Saddle River, NJ: Prentice Hall.
4. Heywood. I, Cornelius S, CrverSteve. 2003: An Introduction to Geographical Information Systems, Pearson Education.
5. Jensen, J.R., 2000. Remote Sensing of the Environment - An Earth Resources Perspective, Pearson Education, Inc.
   (Singapore) Pvt. Ltd., Indian edition, Delhi.
6. Lillesand, Thomas M. and Kiefer, Ralph, W. 2000. Remote Sensing and Image Interpretation, John Wiley and Sons, New York.
7. Muralikrishna, I.V. 1995. Remote Sensing and GIS for Environmental Planning. Tata- McGraw Hill.
8. Ram Mohan Rao. 2002: Geographical Information Systems. Rawat Publication.
9. Skidmore A. 2002: Environmental modeling with GIS and Remote Sensing. Taylor and Francis Tar Bernhardsen. Geographical Information Systems. John Wiley.
10. Thomas M. Lilesand, Ralph W.Kiefer, Jonathan W. Chapman, 2007. Remote sensing and Image interpretation, Wiley India publication, New Delhi.

EES-5018: WATER QUALTIY AND HUMAN HEALTH

UNIT –I Introduction

Understanding the significance of the environment for human health,-Human population pressures and pollution dynamics,Common terms and definitions in water quality, Aquatic resources of the world, Sources of drinking water, Common contaminants of drinking water and linkages to disease. Non-point source pollution, Agricultural runoff, TMDLs, Best management practices (BMPs) and Numeric vs narrative standards.

UNIT –II Water Pollution and the Evolution of Microbial Pathogens and Waterborne diseases

Virulence evolution, Subpopulation selection of Bacterial Pathogens

(Protozoa- Cryptosporidiosis, Giardiasis, *Toxoplasma gondii,* Bacteriology- *Shigella, Vibrio cholearae, Pseudomonas)* Virology - survival and persistence of viruses, (Adenovirus, Norovirus and Rota virus)

UNIT–III Sewage Treatment

Sewage treatment in developed countries, Primary, secondary, and tertiary treatments, Land application of sewage, Sewage treatment in developing Countries

UNIT – IV Influence of Climate Change on Water Quality

What is Climate Change?, How does it Change the Dynamics of Human Pathogens in Water? Water sanitation practices - Biofilms, Antibiotic resistance , Case studies, Vaccines, Water sanitation practices- preventive measures, Education and proper hygiene, Proper waste disposal, Water chlorination, Improving surveillance, Changes in human behaviour, Human population growth , Modern lifestyle affects on the water quality and human health, Predicative models- Modelling infectious diseases

REFERENCES:

1. Edward A. Laws (1993). Aquatic Pollution: An Introductory Text. 3rd Edition, Wiley Publishers.
2. Steven Percival, Rachel Chalmers, Martha Embrey, Paul Hunter, Jane Sellwood and Peter Wyn-Jones (2003). Microbiology of Waterborne Diseases, Academic Press.
3. Guidelines for drinking water quality (1993), 4th Edition by WHO Geneva.
4. Howard G, Bartram J (2003), Domestic water quantity, service level and health. World Health Organization, Geneva.
5. Ainsworth R, ed. (2004) Safe piped water: Managing microbial water quality in piped distribution systems. IWA Publishing, London, for the World Health Organization, Geneva.
6. MN Maulik (2011), Water Supply, Waste Water Treatment & Sewage Disposal, Standard Book House, New Delhi, India.
7. Satinder Ahuja (ED) (2013), Pollution Assessment, Analysis, and Remediation , Elsevier.
8. Barbara Evans , Duncan Mara (2011), Sanitation & Water Supply in Low-income Countries, Ventus Publishing.

DEPARTMENT OF ENVIRONMENTAL SCIENCE
CENTRAL UNIVERSITY OF KERALA

(Established under The Central Universities Act, 2009)

Minutes of BOS Meeting

The First Board of Studies Meeting was held on 12.07.2016 at 10.30 am in the Department of Environmental Science, School of Earth Sciences System, Riverside Transit Campus, Central University of Kerala, Padanakkad to revise the syllabus for M.Sc., Environmental Science curriculum. The following members were present.

Dr. Muthukumar Muthuchamy, Head	Chairperson
Dr. D.S. Jaya, Associate Professor and Head (Subject Expert)	Member
Dr. G. Annadurai, Professor (Subject Expert)	Member
Dr. N. Nandhini, Professor (Subject Expert)	Member (Absent)
Dr. A.G. Devi Prasad Associate Professor (Subject Expert)	Member (Absent)
Dr. Ranjith N Kumavath, Asst. Professor (Other Department)	Member

The Chairperson has welcomed the Members and briefed the existing syllabus of M.Sc Environmental Science course being offered in this University and resolved to make necessary changes in the course subjects as well as the contents.

The Board has approved the core subjects and course content for the two year programme consists of four semesters. The first semester subject and contents were approved and remaining semester subject contents to be taught will be finalized and approved after completion of the revision of all the semesters and to get consent from the BOS members through E-mail.

Cont...

Cont...

The Board recommends two subjects to be compulsorily offered as a elective to the Environmental Science students such as Environmental Statistics and Research Methodology and Environmental Law, Ethics and Policy during the course period in order to acquire necessary knowledge from the above electives.

The Board also recommends to conduct field study and Industrial visit in all semesters. The report has been compiled and submit for the viva voce at the end of 4th semester.

The Board recommends various electives such as Current Environmental issues, Energy and Environment, Environmental Genetics and Biotechnology, Marine environment.

The Board recommends that the revised syllabus should be implemented from this Academic year ie., July 2016 onwards.

The Board also recommends and approved the Ph.D course work subjects such as Research Methodology (Course-I), Principles of Environmental Sciences (Course-II) and Supervisor's Specialized course (Course-III) to be offered to complete the Ph.D course work as per UGC regulations.

Finally the Board Members have thanked Honourable Vice-Chancellor, Central University of Kerala for being offered as the member of the committee to revise the M.Sc., Environmental Science syllabus.

The meeting came to close by 5.00 pm with the vote of thanks by the chair person.

18/07/16
Dr. Muthukumar Muthudhamy
(Chairperson)

12/7/2016
Dr. D.S. Jaya
(Subject Expert and Member)

12/7/16
Prof. Dr. G. Annadurai
(Subject Expert and Member)

18/7/2016
Dr. Ranjith N Kumavath
(Other Department Member)

Revised Syllabus Effective from JULY 2016

M.Sc. ENVIRONMENTAL SCIENCES

Semester-wise Schedule

SEMESTER – I			
Course Code	Title	Credits	
EVS-511	Fundamentals of Environmental Science	4	
EVS-512	Environmental Pollution and Management	4	
EVS-513	Biodiversity and Conservation	4	
EVS-514	Practical – I (Environmental Chemistry and Biology)	3	
Elective-1		3	
Total Credits			18
SEMESTER – II			
EVS-521	Environmental Monitoring and Analysis	4	
EVS-522	Environmental Impact Assessment and Environmental Auditing	4	
EVS-523	Environmental Health and Toxicology	4	
EVS-524	Solid and Hazardous Waste Management	4	
EVS-525	Practical – II (Environmental Tools and Techniques)	3	
Elective -2		3	
Elective -3		3	
Total Credits			25
SEMESTER – III			
EVS-531	Principles of Environmental Engineering and Design	4	
EVS-532	Principles of GIS and Remote Sensing	4	
EVS-533	Environmental Microbiology and Remediation	4	
EVS-535	Practical – III (Env. Engineering, Microbial Analysis and GIS)	4	
Elective - 4		3	
Total Credits			19
SEMESTER – IV			
EVS-541	Project Dissertation and Viva-voce	8	
EVS-542	Industrial and Field Visit Report	2	
Total Credits			10
ELECTIVES			
EVS - 501	Environmental Statistics and Research Methodology	3	
EVS - 502	Current Environmental Issues	3	
EVS - 503	Ecotourism	3	
EVS - 504	Energy and Environment	3	
EVS - 505	Environmental Economics	3	
EVS – 506	Environmental Geosciences	3	
EVS – 507	Environmental Law, Ethics and Policy	3	
EVS – 508	Industrial Ecology	3	
EVS – 509	Environmental Genetics and Biotechnology	3	
EVS - 5010	Natural Hazards and Disaster Management	3	

EVS - 5011	Occupational Health and Industrial Safety	3	
EVS - 5012	Marine Environment	3	

SEMESTER I

EES 511: FUNDAMENTALS OF ENVIRONMENTAL SCIENCE

Unit I: Introduction

Scope and interdisciplinary nature of Environmental Science; Environmental factors; Global environment and its segments; Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere.

Unit II: Environmental Chemistry

Stoichiometry; Chemical Kinetics: control of reactions, first, second and zero order reactions; Chemical equilibrium, Thermodynamics: energy, entropy, enthalpy, Gibb's energy and chemical potential, Acid-Base reactions, Solubility Products, Unsaturated and saturated hydrocarbons, Radio nuclides.

Unit III: Ecosystem

Classification; Biogeographical regions; Biomes; Biogeochemical cycles; Energy flow; Tropic relations; Ecological pyramids; Productivity and ecological efficiencies: primary and secondary producers. Ecological Succession and Climax; Community organization; Interaction between species.

Unit III: Human and environment

Human-environment relationship, General relationship between landscape, biomes and climate. Population growth: Biological growth curves and carrying capacity; Human population growth and environmental constraints; Effects of environment on human culture and livelihood; Human impact on ecosystems. Population Dynamics; Population growth factors; Population regulation; Strategies of species survivability (r-selection and k-selection). Characteristics and trends in human population growth; Human migration and settlement.

Unit V: Social and environmental issues

Concept of sustainable development; Social issues regarding development on environment; Water resources and conservation; Climate change; Economics and Environment; Societal obligations, Environmental justice; Public awareness of environmental issues; Government and Non-government organizations (NGOs); Environmental issues in India and the world.

Reference Books

1. Jackson A. R. W. and Jackson J. M. (2000). Environmental Science – The natural environment and human impact, 2nd Edition, Longman Group, United Kingdom.
2. Santra S. C. (2011). Environmental Science, 3rd Revised Edition, New Central Book Agency.

3. Masters G. M. (2007). Introduction to Environmental Science and Engineering, 3rd Edition, Prentice –Hall of India Pvt Ltd, New Delhi.
4. Dhaliwal G. S., Sangha G. S. and Raina P. K. (2000) Fundamentals of Environmental Science, Kalyani Publication.
5. Arora S. (2003). Fundamentals of Environmental Biology, Kalyani Publications, New Delhi.
6. Cotgreave P. and Forseth I. (2002). Introductory Ecology. Blackwell Science,UK
7. Freedman B. (1995). Environmental Ecology, Academic Press, USA.
8. Odum E.P. (1993). Fundamentals of Ecolgy, W.B.Saunders Co., USA.
9. Townsend C.R., Begon M. and Harper J.L. (2008). Essentials of Ecology, Blackwell Publications, UK.
10. Rana S.V.S. (2005). Essentials of Ecology and Environmental Science. Prentice –Hall of India Pvt. Ltd. New Delhi

EES 512 ENVIRONMETAL POLLUTION AND MANAGEMENT

Unit I: Chemistry of atmosphere and air Pollution

History and evolution of earth's atmosphere; Structure and composition of atmosphere; Classification of elements in the atmosphere, chemical processes for the formation of inorganic and organic particulate matter; Thermo chemical and photo chemical reactions in the atmosphere; Temperature inversion, Atmospheric lapse rate, Adiabatic lapse rate, wet and dry adiabatic lapse rate. Chemistry of atmospheric pollutants: Photochemical smog-origin and occurrence, Ozone chemistry: Ozone layer, Chemistry of Ozone layer, Ozone depletion, Mitigation of ozone depletion, Eco-friendly coolants; Acid rain- chemical reactions and its ecological effects; Green house effect and global warming; Effects of air pollutants on plants and animals; Air quality standards.

Unit II: Chemistry of water and water Pollution

Composition and structure of pure water; Physical and Chemical properties of water. Solubility of solids, liquids and gases in water; Chemical reactions and equilibria in water: carbonate equilibria, metal ion equilibria, redox equilibria; Natural organic components in water - Concepts of DO, BOD and COD; Sources of water pollution; Effects of water pollution on plants and animals; Water quality standards.

Unit III: Chemistry of soil and soil Pollution

Weathering and pedogenesis; Factors affecting soil formation, Development of soil profile; Structure of Soil: gross composition: texture and structure, method of analysis of texture; Organic and inorganic components of soil; Physico-chemical characteristics of soil; Ion-exchange and adsorption processes in the soil; Soil quality parameters and assessment; Classification of soil, Fate of chemicals in the soil; sources of soil pollution: plastics, radioactive leakage, mining activities, pesticides, E-waste; Effects of soil pollution on

microbes, plants and animals.

Unit V: Noise, thermal and radioactive pollution

Sources of noise pollution: indoor and outdoor noise pollution, natural and anthropogenic sources; Effects of noise pollution; Thermal and nuclear power plants as source of thermal pollution. Effects of thermal pollution on aquatic fauna and flora; Controlling measures of thermal pollution; Sources of marine pollution including oil: natural and anthropogenic sources; Control measures of marine pollution; Pollution status of coastal and ocean waters; Radioactive pollution: types and sources, half-life period, natural radiation.

UNIT V: Industrial Disaster- Case Studies

Industrial Disaster and Pollution – Case studies-Chemical Industries – Pesticide Industries, Bhopal Disaster, Nuclear Disaster - Chernobyl accident, Fukushima, Love canal Disaster, Oil Disasters – Exxon, British Petroleum- Gulf of Mexico.

Reference Books

1. Chemistry for Environmental Engineering and Science, Sawyer C.N., Mc Carty P.L., and Parkin,G.F (2003), Tata McGraw-Hill Publishing Company Ltd., New Delhi.
2. A text book of environmental chemistry and pollution control, Dara S S,.(1998), S. Chand & Company Ltd, New Delhi
3. Environmental Engineering, Howard S Peavy (2003), Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
4. Environmental Chemistry, A.K. De (2001), New Age International Publishers, New Delhi.
5. Fundamentals of Environmental Chemistry, S. E. Manahan (2009), CRC Press, USA.
6. Andrew D. Eaton , Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
7. F.W. Fifield (2000). Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
8. Julian E Andrews et al., (2004) An Introduction to Environmental Chemistry, Blackwell Publishing.
9. Stanley E. Manahan (2010). Environmental Chemistry, 9th Edition, CRC Press, London.

EES 513: Biodiversity and Conservation

Unit I: Biodiversity

Scope and concepts: Genetic diversity, Species diversity, Ecosystem diversity, Landscape diversity, Agrobiodiversity, Urban biodiversity. Current centres of biodiversity, Biodiversity hot spots of India and their characteristic flora and

fauna, Economic value of biodiversity. Molecular approaches to assess biodiversity: use of molecular markers, Allozymes, RFLP, AFLP, SSR, SNP, DNA fingerprinting, Barcoding, Introduction to molecular phylogeny.

Unit II: Threats to Biodiversity

Loss of biodiversity, overexploitation, invasive species, habitat destruction and fragmentation, impacts of global climate change, global estimates of species loss, IUCN red list categories, Threatened flora and fauna of India.

Unit III: Natural resources

Land resource, soil conservation, Mineral resources, classification of minerals, non renewable nature of minerals, use and exploitation of mineral resources, environmental impact of mineral extraction, Water resources and utilization, rain water harvesting, forest and wild life: their resources and utilization.

Unit IV: Conservation of Biodiversity: Approaches and Strategies

Historical perspective of conservation, Importance of conservation, Conservation and sustainable development, Role of IUCN and MAB, Ecosystem people and traditional conservation mechanisms, In situ conservation: Biosphere reserves, National parks, Wild life sanctuaries, Protected area management. Ex situ conservation: Botanical gardens, Zoological parks, Herbaria, cryopreservation, seed banks, gene banks.

Unit V: Conservation policies and Law

The Biological Diversity Act, 2002. Biological Diversity rules, 2003. Intellectual Property Rights (IPR), TRIPS, Indigenous Knowledge Systems, The protection of plant varieties and farmer's rights (PVPFR) Act, 2001, 2007. National and International conservation policies and conservation challenges, Laws for protection of forest and wildlife in India.

References Books

1. Chiras D. D and Reganold J. P. 2011. Natural Resource Conservation: Management for a sustainable future, 10/E Prentice Hall.
2. Maiti P.K. and Maiti P. 2011. Biodiversity- Perception, Peril and Preservation. PHI Learning. New Delhi
3. Van Dyke F. 2008. Conservation Biology. Springer, USA
4. Krishnamurthy K.V. 2003. Advanced text book on Biodiversity. Oxford & IBH, New Delhi
5. UNEP 1992. Global Biodiversity. Chapman and Hall , London
6. Singh J.S*. et al*. 2006. Ecology, environment and resource conservation. Anamaya Pub., New Delhi.
7. Promack R.B. 2002. Essentials of Conservation Biology. Sinauer, USA
8. Gaston K.J. and Spicer J. 2004. Biodiversity an introduction. Blackwell

Publications, UK
9. Henry RJ. 1997. Practical Application of Plant Molecular Biology. Chapman and Hall Publication, London

EES 514 PRACTICAL – I Environmental Chemistry and Biology

I. Fundamentals of Environmental Science

1. Quantitative and Qualitative analysis of Phytoplankton and Zooplanktons
2. Primary Productivity - Light and Dark bottle method & Chlorophyll method
3. Study of vegetation & fauna of local area/college campus
4. Study of vegetation density and frequency by quadrate method

II. Biodiversity and conservation

5. Study of community structure and assessing the density and abundance of the species
6. Assessment of beta-diversity to measure the degree of turnover in species composition along a gradient or transect

III. Environmental Pollution

Water Analysis

Determination of pH, conductivity, D.O, total dissolved solids, total suspended solids, chlorides, iron, residual chlorine, Total Hardness, Calcium and Magnesium, Chemical oxygen demand, Biological oxygen demand, fluoride, phosphate, Nitrate, Sodium & Potassium (Flame photometry), sulphate, Acidity and Alkalinity.

Soil Analysis

Determination of soil pH, moisture content, chloride, Total organic carbon (TOC)

Reference Books:

1. Practical field ecology - A project guide. C. Philip Wheater, James R. Bell and Penny A Cook. Wiley - Blackwell.
2. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.

EES-521 ENVIRONMENTAL MONITORING AND ANALYSIS

Unit I: Volumetric and Gravimetric Methods

Sampling of water and waste water, Water and waste water quality analysis – Physical parameters – pH, electrical conductivity, turbidity, total solids, dissolved solids, suspended solids, volatile and fixed solids. Chemical parameters - acidity, alkalinity, hardness, chloride, dissolved oxygen, CO_2, chemical oxygen demand, biological oxygen demand, nitrates, phosphate and sulphate. Soil sampling and estimation - moisture

content, organic and humic matter, extractable ammonium and nitrate, total carbon, nitrogen and sulfur. Air sampling and analysis – H_2S, CO_2, SO_2, SPM, stack monitoring, meteorological analysis.

Unit II: Electrochemical and Microscopic Methods

Potentiometry, Voltammetry – cyclic voltametry, pulse voltametry, square wave voltametry, electrodes and sensors; Conductometry; Polarography; Coulometry; Chronoelectric methods; electrogravimetry. Microscopy - Light microscope, Electron microscopy, Bright field microscopy, Dark field microscopy, Phase contrast microscopy, Fluorescence microscopy; Confocal microscopy, Transmission electron microscopy (TEM) and Scanning electron microscopy (SEM).

Unit III: Spectroscopic Methods

Ultraviolet -Visible spectroscopy; Infrared spectroscopy, Non dispersive infrared (ND-IR)spectroscopy; Fourier transform infrared (FT-IR); Flame emission spectroscopy; Atomic absorption spectroscopy (AAS); Atomic emission spectroscopy; Flourimetry.

Unit IV: Separation Techniques

Extraction and separation of inorganic and organic compounds; Instrumentation and applications of Chromatography: Paper chromatography, Thin layer chromatography, Column chromatography, Gas chromatography and Mass Spectrometry (GC-MS), High Performance Liquid Chromatography (HPLC) and Electrophoresis - Gel electrophoresis, SDS-PAGE.

Unit V: Biochemical Assays and Biomonitoring

Estimation of sugars, amino acids, proteins, carbohydrate, lipids, alkaline phosphatase, acid phosphatase, lysozymes, peroxidase, glutathione derivatives; Ca ATPase, ELISA; Biomonitoring-tolerance levels, multiple level assessment, community level biomonitoring, assessment indices.

Reference Books:

1. Andrew D. Eaton , Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
2. APHA (1998) Standards Methods for the examination of water and Waste water, 20th Edition, Washington DC.
3. B.L. Oser (1965). Hawk's Physiological Chemistry. MacGraw Hill Book Co.
4. Clair N. Sawyer (2003). Chemistry for Environmental Engineering and Science. Tata McGraw Hill.
5. Denise R. Ferrier (2013) Lippincott's Illustrated Reviews Biochemistry; Sixth edition, Iippincott Williams & Wilkins.
6. Douglas A. Skoog, F. James Holler and Timothy A. Niemen.(1998). Principles of Instrumental Analysis. 5th Edition, Saunders College Publishing, Philadelphia.
7. F.W. Fifield (2000). Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
8. Khopkar S M (1985). Basic Concepts of Analytical Chemistry. Wiley Eastern Ltd., New Delhi.
9. Miroslav Radojevic and Vladimir N.Bashkin (1999), Practical Environmental Analysis,The Royal Society of Chemistry, Cambridge

10. Robert K. Murray, David Bender, Kathleen M. Botham, Peter J. Kennelly, Victor W. Rodwell, P. Anthony Weil (2012) Harpers Illustrated Biochemistry 29th Edition, McGraw-Hill.

EES – 522 ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL AUDITING

UNIT – I Importance of EIA

History and objectives – Basis for Environment Impact Assessment, Approach to EIA studies – mandatory requirements, project screening, scoping, environmental baselines, best practices; terms of reference; Phases of EIA – Identification, Prediction, Evaluation, Decision making and Post impact Monitoring.

UNIT – II Methodologies

The Environmental Impact Statement Process. EIA Methodologies – Adhoc Method – Checklist Methods – Matrix Methods – Network Methods – Preparing EIS.

UNIT – III Assessment procedure

Prediction and Assessment of Impacts on natural Resources – Biota, Surface Waters, Ground Water, Air, Noise, Hazards, Historic and Cultural Resources, Transportation, Socio-economic relationships. Interlinking of rivers and River Basin Management.

UNIT – IV Notification and Case studies

Notification 1994 and 2006 – Public Participation, Major limitations of Environmental Impact Assessment. Case studies - Land Clearing Projects – Dam sites – EIA for Aquaculture, Steel, Mines, Hydel, Thermal, Nuclear, Oil and Gas based Power Plants – Highways projects – Industrial Projects.

Unit V: Environmental auditing

Definition of Environment Audit and its importance for industries. Requirements of Rule 14 for Environmental Audit under Environmental protection Act 1986. Definitions of a. Signatory, b. Consumption Audit, c. Pollution audit, d. Hazardous audit, d. Solid waste audit, e. Disposal audit, f. Cost audit, g. Investment audit, h. Voluntary audit. Environmental audit: Pre, Post audit process; International organization for standardization (ISO), ISO 14000 standards and certification, Eco labelling.

REFERENCES

1. Environmental Impact Assessment, Canter, L.W., (1996) Mc Graw Hill, New York.
2. Environmental Impact Statements, Bregman, J. I., (1999) Lewis Publishers, London.
3. Environmental Assessment, Singleton R, Castle, P and Sort, D (1999), Thomas Telford Publishing, London.
4. Effective Environmental Assessment, Eccleston, C. H., (2000) Lewis Publishers, London.
5. Environmental Impact Assessment- A Comprehensive Guide to Project and Strategic Planning, Eccleston, C.H., (2000) John Wiley and Sons.

6. A guide book for Integrated Ecological Assessments, M. E. Jensen and P. S. Bourgeron (2001) Springer-Verlag, New York, Inc.

EES - 523ENVIRONMENTAL TOXICOLOGY AND HEALTH

Unit I: Fundamentals of Toxicology

Toxicology - Definition, history and branches of toxicology, scope and importance of toxicology, principles of toxicology. Toxicants - Classification, routes of entry, transport, storage, metabolism and excretion. Categories of toxic effects - synergistic, antagonistic and additive effects. Mechanism of toxicants – interaction with target, cellular dysfunction and toxicity, repair and disrepair.

Unit II: Environmental Toxicology

Toxic chemicals in the environment - organic and inorganic toxicants. Acute and chronic toxic effects. Dose effect, dose response relationships, lowest observed adverse effect level and no observed adverse effect level. Translocation of xenobiotics. Toxicity of pesticides, insecticides, fertilizers, heavy metals, radioactive substance, fluorides and carbon monoxide. Bioconcentration, bioaccumulation and biomagnification of toxicants. Molecular and cellular concepts in toxicology.

Unit III: Hazardous waste and metabolism of toxicity

Hazardous effect - arsenic, asbestos, cadmium, chromium, mercury, cyanide, lead, PCBs, POPs, radiation and biohazards. Metabolism mediated toxicity, Metabolism and toxicity of drugs. Mode of action of toxicants, bioactivation of toxicants in lung, biotransformation of toxicants. Industrial pollutants - types, characteristics and effects. Factors affecting concentration of toxicants in the environment. Degradable and non-degradable toxic substances.

Unit IV: Toxicity analytical methods

Principles of toxicity testing, methods of toxicity evaluation by *in vitro* and *in vivo* methods. Measurements of LC_{50} and LD_{50} values. Monitoring approaches - indicator populations and indicator species. Model ecosystems - microcosms and mesocosms, Bio-sensors and Bio-markers - Concept and approach, advantages and disadvantages. Molecular marker to toxicants - metabolites as indicators, protein induction, cytochrome P450 enzymes, stress proteins and metallothioneins.

Unit V: Occupational safety and environmental health

Environmental and occupational safety - Definitions, concept and scope, occupational exposure, occupational hazards and diseases. Control of toxic materials and protection measures - air, water and soil. Epidemiology and health ecology, epidemiological diseases due to pollution problems. Health effects of cosmetics and pharmaceuticals products, occupational and industrial health management. Legislative perspective in ecological risk assessment, human health risk assessment.

Reference Books

1. Bryan Ballantyne, Timothy C. Marrs, Tore Syversen. General Applied Toxicology. 6 Volume Set, Third Edition. Queensland, John Wiley & Sons, 2009.

2. Walker C.H., Sibly R.M., Hopkin S.P., Peakall D.B. Principles of Ecotoxicology. Fourth Edition. USA, CRC Press, 2012
3. Edward A. Laws. Environmental Toxicology: Selected entries from the encyclopedia of sustainability science and technology. New York, Springer-Verlag, 2013.
4. Levy B.S., Wegman D.H. Occupational Health recognizing and preventing work related disease. Boston, MA: Little Brown & Co., 1995.
5. Cockerham L.G., Shane B.S. Basic Environmental Toxicology. USA, CRC Press, 1993.
6. Hayes, A. W. Principles and Methods of Toxicology, 5th Edition, Boca Raton, FL, Taylor and Francis, 2008.
7. B.M. Francis. Toxic Substances in the Environment. New York, John Wiley & Sons, 1994.
8. I.C. Shaw and J. Chedwick Principles of Environmental Toxicology, Boca Raton, FL, Taylor and Francis, 2004.

EES - 524 SOLID WASTES AND HAZARDOUS WASTE MANAGEMENT

UNIT - I

Wastes– Classification and Quantification – Solid Waste Management and Disposal: Sources and Generation of Solid Waste – characterization, composition and Classification, Methods of waste collection, collection techniques, waste container compatibility, waste storage requirements, transportation of solid wastes Waste reduction at source – municipal and industrial wastes Material and resource recovery/recycling from solid wastes Treatment and disposal techniques for solid wastes–composting, vermin-composting, autoclaving, microwaving, incineration, nonincineration, thermal techniques, use of refuse derived fuels, landfilling.

UNIT - II

Recycling of Wastes – Types – sources – composition of waste – recycling of waste for Industrial, Agricultural and Domestic Purposes; Recycling of Metals, Reuse, recovery and reduction of paper and plastics; Recycling in Food Manufacturing, Beverages, Apparel, Leather, Paper, Pulp, Chemical and other industries; Fly Ash utilization. Waste Disposal Methods – composting, incineration, pyrolysis, medical waste disposal strategies.

Unit-III

Solid waste management plan, Municipal Solid Waste (Management and Handling) Rules, 2000; Hospital waste management, Biomedical Waste (Management and Handling) Rules, 1988; Fly ash management, Fly ash Management Rules, (1999).

Unit-IV

Hazardous Waste Management: Sources and classification, Hazard communication, Hydrocarbons, Phenols, Chlorophenolic compounds, Polycyclic Aromatic hydrocarbons (PAH), Heterocyclic Compounds, Cyanide, Dioxins. Waste Minimization approaches – Monitoring and Management strategies. Physico-chemical properties of hazardous waste needed in management., Hazardous waste control, treatment and management, Hazardous Waste (Management and Handling) Rules (1989) and (2000) Amendments.

UNIT – V

Radioactive Waste: Sources, half life of radioactive elements, modes of decay. Effects on Plants, Animal and Man. Low and High-level Radioactive Waste Management – Waste Minimization and Treatment, Radiation standards. Biocleaning -Chernobyl radioactive contaminated area - Phytoremediation.

REFERENCES

EES – 525 PRACTICAL II (ENVIRONMENTAL TOOLS AND TECHNIQUES)

1. Air sampling and analysis – H_2S, CO_2, SO_2, SPM
2. Soil analysis by Flame photometer
3. Analysis of water pollutants by Spectrophotometry
4. Microscopy –light, phase contrast and fluorescence microscopes
5. Separation of DNA by Gel Electrophoresis

1. Estimation of residual chlorine by iodometric method
2. Assessment of chlorophyll content of plants exposed to pollutants
3. Effect of pesticide on fish structure and movement
4. Estimation of fluoride in water sample

Reference Books

1. Wight G.D. Fundamentals of Air Sampling. Boca Raton, Lewis Publishers. 1994.
2. Kuo J. Electron Microscopy: Methods and Protocols. New Jersey, Humana Press, 2007.
3. Spencer M. Fundamentals of Light Microscopy, Cambridge, Cambridge University Press, 1982.
4. Rost F.W.D. Fluorescence Microscopy. Cambridge, Cambridge University Press, 1995.
5. Khanpur R.S. Handbook of Analytical Instruments. New York, McGraw Hill Education, 2006.
6. Harp D.L. Current technology of chlorine analysis for water and waste water. Hach Company, 2002.
7. F.A. Smith. Handbook of Experimental Pharmacology: Pharmacology of Fluoride. Vol. XX. Berlin, Springer-Verlag, 1970.
8. Sadasivam S., Manickam A. Biochemical Methods, 2nd Edition, New Delhi, New Age International (P) Ltd. Publishers, 1996.

EES – 531 PRINCIPLES OF ENVIRONMENTAL ENGINEERING AND DESIGN

UNIT - I

Hydraulics – Pressure- Hydrostatic Pressure, Pressure Head, Measurement of Pressure, Flow, Design of Pressure Pipes – Darcy – Weisbach Formula, Manning's Formula, Hazen

– William's Formula – limiting velocities, Minimum and Maximum Test Pressure and Working Pressure in pipes – selection of pipe material – Pump types, Characteristic Curves – selection and determination of capacity.

UNIT - II

General layout of Water Treatment Plant. Flash Mixer – Design – Clariflocculator – parameters for design – Filtration - Rapid sand filter and Pressure filter and Disinfection -calculation of chlorine dosage, chlorine demand, and residual chlorine.

UNIT - III

Physical and Chemical Unit Operations and Applications – Design Parameters and Design of Primary and Secondary Settling Tanks – Activated Sludge Process – types and modifications – Design of Aeration Tanks– Diffusers and Mechanical Aerators. Trickling Filters and Design. Oxidation Ditch and Duncan Mara Systems (Waste Stabilization Ponds).

UNIT - IV

Sludge Processing and Disposal Methods – Design of Anaerobic Digester and Sludge Drying Bed – Reverse Osmosis – Ion Exchange – Incinerators and Multiple Evaporators.

UNIT - V

Air Pollution – Minimum Stack Height – Plume Rise, Ground Level Concentration of Pollutants. Design of Settling Chamber, Cyclones, Fabric filters and Electrostatic Precipitators. Wet Scrubber. Case studies: Distillery, Dyeing, Electroplating, Paper and Pulp, Steel, Tannery - Industrial Effluent Treatments.

REFERENCES

1. Introduction to Environmental Engineering and Science, Gilbert M. Masters (2004), Prentice-Hall of lndia Pvt. Ltd., New Delhi.
2. Water and Wastewater Technology, Hammer M.J. and Hammer Jr M. J. (2001), Prentice Hall of lndia Pvt. Ltd., New Delhi.
3. Wastewater Engineering: Treatment and Reuse, Metcalf and Eddy (2003), Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
4. Handbook of Water and Wastewater Treatment Plant Operations, Frank R. Spellman, (2003), Lewis Publishers, London.
5. Environmental Engineering, Howard S Peavy (2003), Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
6. Environmental Engineering: A Design Approach, Sincero A. P and Sincero G. A. (1999), Prentice-Hall of India Pvt. Ltd., New Delhi.

EES- 532: Principles of Geographic Information System and Remote sensing

Unit 1: Introduction to Remote sensing

Principles of Remote sensing - Electromagnetic Radiation (EMR): interaction of EMR earth's surface-reflection-transmission, Spectral signatures and characteristics, spectral reflectance curves. Process of data acquisition, storage, analysis and visualisation. Interpretation elements.

Unit 2: Remote Sensing System

Remote Sensing observations and platforms: Air borne and space borne platforms. Active, Passive and Optical remote sensing, Concept of Microwave remote sensing and microwave remote sensors. Multi-Spectral Imagery (MSI) - Hyperspectral Imagery (HSI)-Thermal Scanner Imagery. Remote sensing satellites; Land observation satellites, IRS series, LANDSAT series, SPOT series ; High resolution satellites, CARTOSAT series, IKONOS Series, QUICKBIRD series, Weather/Meteorological satellites, INSAT series, NOAA, GOES, NIMBUS Applications, Marine observation satellites OCEANSAT.

Unit 3: Principles of GIS

Introduction to GIS, Components of GIS, Geospatial data architecture, operations, Layers and features, Raster and Vector. Types of data –Spatial, Attribute data-types of attributes-scales/ levels of measurements. Data File Formats, Datum Projection and re projection, Topology. Global positioning System (GPS): types of GPS machines, applications for surveying and mapping, interface of GPS data with GIS. Spatial database Management Product Generation: Types of output products

Unit 4: Applications of remote sensing

Application of Remote sensing; Visual Image Interpretation, Land Use / Land Cover Mapping, Geologic and Soil Mapping, geomorphology, lithology, Agricultural applications, Forestry applications, Rangeland applications, Water Resource applications, Urban and Regional Planning application, Wetland Mapping, Wildlife Ecology applications, Archaeological applications, Environmental and Disaster Assessment.

Unit 5: Applications of GIS

Resources mapping, Inventory and monitoring natural resources, Land cover mapping, Wetland mapping, Applications to Agriculture, Water Management, Ground Water Modelling, Coastal and Marine applications.

REFERENCES

1. Thomas .M.Lillesand,RalpW.Kiefer,JonathanW.Chipman 2012: Remote sensing and Image interpretation John Wiley publications

2. Anji Reddy, M. 2004: Geoinformatics for Environmental Management. B.S. Publications.
3. Chang. T.K. 2002: Geographic Information Systems. Tata McGraw Hill.
4. Clarke, Keith C., Bradley O. Parks, and Michael P. Crane, 2002. Geographic Information Systems and Environmental Modeling, Upper Saddle River, NJ: Prentice Hall.
5. Heywood. I, Cornelius S, CrverSteve. 2003: An Introduction to Geographical Information Systems, Pearson Education.
6. Jensen, J.R., 2000. Remote Sensing of the Environment - An Earth Resources Perspective, Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi.
7. Lillesand, Thomas M. and Kiefer, Ralph, W. 2000. Remote Sensing and Image Interpretation, John Wiley and Sons, New York.

8. Ram Mohan Rao. 2002: Geographical Information Systems. Rawat Publication.
9. Muralikrishna, I.V. 1995. Remote Sensing and GIS for Environmental Planning. Tata- McGraw Hill.
10. Thomas M. Lilesand, Ralph W.Kiefer, Jonathan W. Chapman, 2007. Remote sensing and Image interpretation, Wiley India publication, New Delhi.
11. Skidmore A. 2002: Environmental modeling with GIS and Remote Sensing. Taylor and Francis Tar Bernhardsen. Geographical Information Systems. John Wiley.

EES – 533 ENVIRONMENTAL MICROBIOLOGY AND REMEDIATION

Unit I: Basic Concepts of Microbiology

Introduction to Environmental Microbiology, Scope and importance of microorganisms, Autotrophy and heterotrophy; Different types of media, cultivation of microorganisms. Microbial growth- Growth curve, Batch culture and continuous culture systems. Factors affecting growth of bacteria.

Unit II: Microorganisms in the Environment

Aeromicrobiology – Microflora, sampling techniques, identification, airborne diseases and allergies. Aquatic microbiology – water sampling techniques, MPN technique, eutrophication, water borne pathogens and diseases. Soil microbiology – microbes of rhizosphere, mycorrhizae, role in biogeochemical cycle. Microorganisms of extreme environment – Extremophiles.

UNIT III: Microbial Process for Pollution Abatement

Role of microorganisms in wastewater and sludge treatment- anoxic waste treatment, trickling filter, activated sludge process, important microorganisms in sewage treatment plant-nitrifying bacteria, ammonia oxidizing bacteria, nitrite oxidizing bacteria, indicator microorganisms. Biofilms and microbial mats, biofouling and corrosion. Impact of various environmental pollutants on microbial diversity.

Unit IV: Microbial Remediation

Microbial remediation - composting, biostimulation, bioaugmentation, bioreactor, bioleaching, bioventing. Biodegradation of xenobiotics – herbicides, pesticides, hydrocarbons and phenolic compounds. Bioremediation of heavy metals and radia active wastes. Microbial mediated bioconverstion/transformation. Role of genetically engineered microbes in pollution control.

Unit V: Microbes and Environmental Health

Bioenergy – definition, first generation biofuels - bioethanol, biodiesel, second generation biofules - lignocelulosic biofuels; biohydrometallurgy and biomineralization; Types and role of biofertilizers and biopesticides.

Reference Books

1. Eweis J.B., Ergas S.J., Chang D.P.Y., Schrodwer E.D. Bioremediation Principles. New York, Mc Graw Hill, 1998.
2. Fulekar M.H. Environmental Microbiology. New York, Taylor & Francis, 2010.

3. Koukkou A.I. Microbial Bioremediation of Non-metals: Current Research. Haverhill, UK, Caister Academic Press, 2011.
4. Lederberg J. Encyclopedia of Microbiology, New York: Academic Press, 1992.
5. Maier R.M., Pepper I.L., Gerba C.P. Environmental Microbiology. San Diego, Elsevier Academic Press, 2006.
6. Martin A. Biodegradation and Bioremediation. New York: Academic Press, 1994.
7. Passman F.J. Fuel and Fuel System Microbiology: Fundamentals, Diagnosis and Contamination Control. West Conshohocken, ASTM International, 2003.
8. Prescott L.M., Hareley J.P. Klein D.A. Microbiology (6th Edition). New York, McGraw-Hill Publishing Co. Ltd., 2005.
9. Sangeetha J, Thangadurai D, David M, Abdullah MA. Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of Xenobiotics for Sustainable Development, Boca Raton, Florida, USA, CRC Press, 2016.
10. Sen K., Ashbolt N.J. Environmental Microbiology: Current Technology and Water Applications. Norfolk, UK, Caister Academic Press, 2011.

EES - 535 PRACTICAL III (ENV. ENGINEERING, MICROBIAL ANALYSIS AND GIS)

1. Calculation and designing of Sedimentation Tank, Clariflocculator
2. Calculation and designing of Aeration Tank
3. Calculation and designing of Activated Sludge Processes
4. Calculation and designing of Trickling Filter
5. Calculation and designing of Disinfection Process
6. Calculation and Designing of Cyclones
7. Calculation and Designing of Electrostatic Precipitator

GEOGRAPHICAL INFORMATION SYSTEM

1. Importing Aerial/ Satellite image in ERDAS
2. Georeferencing and Image/Map Projection in ERDAS
3. Supervised and Unsupervised classification

GEOGRAPHICAL INFORMATION SYSTEM

I. Visual Interpretation

1. Map reading (survey of India Topo sheet)
2. Marginal Information and Extra Marginal Information
3. Relief and Cultural Features

II. Digital Interpretation

1. Importing Aerial/Satellite Imagery and Scanned Raster Image
2. Georeferencing and Co-Ordinate System
3. Map Projection (Type of Map Projection)
4. Digitization and Editing
5. Topology Creation
6. Proximity Analysis (Buffer, Distance Measures)
7. Interpolation Analysis (Kriging, Idw Etc)

8. Density Analysis (Point, Line Etc.)

9. Surface analysis: Tin Creation – Aspect – Slope - Hill Shade - View Shed - Cut and Till

MICROBIOLOGIAL ANALYSIS

1. Staining and inoculation techniques
2. Assessment of Water Quality by MPN Technique
3. Sampling and enumeration of airborne microorganisms
4. Dilution and enumeration of microorganisms from soil sample

Reference Books

1. Pepper I.L., Gerba C.P. Environmental Microbiology: A Laboratory Manual, 2nd Edition, 2004, Boston, Elsvier Academic Press, 2005.
2. Hurst C.J., Knudsen G.R., McInerney M.J., Stetzenbach M.V. Manual of Environmental Microbiology. Washington, D.C., ASM Press, 1997.
3. Cappuccino J.G, Sherman N. Microbiology: A Laboratory Manual, 7th Edition, New York, Pearson Education, 2005

EES – 501 ENVIRONMENTAL STATISTICS AND RESEARCH METHODOLOGY

UNIT – I: Descriptive statistics

Fundamentals of Statistics (Basic concept) – Collection of Data – Classification and Tabulation – Diagrammatic Representation – Measures of Central Tendencies and Dispersion – Probability and Monte Carlo Analysis – Moments, Skewness and Kurtosis – Normal, Poisson and Binomial Distributions.

UNIT – II: Standard distributions

Tests of Significance – Mass and alternative hypothesis – error level of significance – Equal and Unequal Sampling - t, z, x2 test, Analysis of variance – One way ANOVA – Two way ANOVA – Regression and correlation - simple and multiple.

UNIT – III: Environmental Models

Modeling – Computer Modeling – Lotka – Volterra Model, Leslie's Matrix Model – Point Source Stream Pollution Model – Air Quality Model. Thermal Plume and Dispersion models. Applications of Computer in Environmental Science and Management – Data Analysis using packages (SPSS): Editing, Data Tabulation, Descriptive statistics – Correlation – Regression – Factor analysis – Cluster analysis – PCA, Graph Plotting

UNIT – IV: Research Applications

Scientific documentation: Methods of literature collection, design, planning and execution of investigation, Statistical methods in biological research, Preparation of scientific documents, general articles, research papers, review articles, editing of research papers, methods of citation, collection of literatures, including web based methods, bibliography and thesis writing. Presentation techniques, effective communication skill, Discussion and critics analysis.

REFERENCES

1. Business Mathematics and Statistics, Vittal, R.R. (1986) Murgham Publications.
2. Programming with C, Byron S Gottfried (1996) Hill Publishing Co, New Delhi.

3. Statistical Methods, Gupta, S.P. (1996) Sultan Chand & Sons Publications, New Delhi.
4. Environmental Science Methods, Haynes, R (1982) Chapman & Hall, London.
5. Fundamentals of Bio-Statistics, Khan, I.A and Kanum, A., (1994) Ukaaz Publication, Hyderabad.
6. Quantitative Techniques, Kothari, C.R (1996) Vikas Publishing Housing Pvt Ltd, Hyderabad.
7. Statistics for Advanced Level, Miller, J., (1989) Cambridge University Press.
8. Statistical Methods, Snedcor, G.W. and Cochran, W.G. (1982) Academic Press.
9. Statistics in Biology. Bliss, G.I. (1970). Mc Graw Hill Book Company, Vol. I and II. New Delhi.
10. Practical Statistics for Experimental Biologists. Wardlaw, A.C. (1985), Wiley Chichester.

EES – 502 Current Environmental Issues

UNIT-I

Population: Population explosion, Malthusian theory, Population distribution, population unsustainability, population growth, population pyramids, pattern of India population, scale of urbanization, migration trends- rural and urban, Population displacement due to developmental projects. International initiatives on population related issues.

UNIT-II

Environment and human health: Hazardous chemicals, pesticides and their impact, polychlorinated biphenyls (PCBs), Lead, mercury, arsenic, cadmium, asbestos, dioxins. Environment and development, poverty and environmental degradation, water requirement, Community participation in water conservation, Water harvesting, role of NGOs in environmental protection. Social consequences of development and environmental changes

UNIT-III

Global Issues : Acid rain and its effects on ecosystems (flora, fauna and human beings). Ozone layer depletion, causes and consequences of Ozone depletion, CFCs, Montreal Protocol. Climate change, global warming- causes and impact of global warming, International initiatives to control global warming, Kyoto Protocol.

UNIT- IV

Natural Resources: Depletion and regeneration of natural resources, Renewable and non-renewable resources, Biotic Resources- Forests, agriculture, fisheries, livestock, biodiversity and its conservation, Abiotic Resources- Surface and ground water, Energy, non-energy mineral resources, land resources, soil erosion, ecosystem services. Sustainable development

Reference Books

1. Botkin, Daniel B. and Keller, Edward A. Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA. 2007.
2. Cunningham, W. P. and Cunningham, M. A. Principles of Environment Science.
3. Enquiry and Applications. 2nd ed. Tata McGraw Hill, New Delhi. 2004.
4. Rajagopalan, R. Environmental Studies: From crisis to cure, Oxford University Press, New Delhi, 2008.
5. Richards, I. S.Principles and Practice of Toxicology in Public Health. Jones and Bartlett Publishers, London. 2008.
6. Singh, J.S., Singh, S.P. and Gupta, S.R. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi, India. 2006.
7. UNEP. Global Environment Outlook 3. Geneva: UNEP, Global Resource Information Division. 2003.
8. World Commission on Environment and Development (WCED): Our Common Future, Oxford University Press, London. 1987

EES-503: Ecotourism

Unit I: Introduction & overview

Ecosystem processes, goods and services with special reference to tourism activities; an overview of Tourism-Environment linkages – the 'Intangibility', 'Heterogeneity', 'Perishability' and 'Inseparability' of Tourism and their Ecological/ Environmental/ social/economic/cultural/ethical implications; impacts of mass tourism and the need for alternative tourism strategies; Adaptive/ Sustainable management of Ecosystems with special reference to Tourism

Unit II: Alternative tourism typology & strategies

Alternative/Appropriate tourism typology- Eco-tourism, Eco-cultural Tourism, Heritage Tourism, Adventure Tourism, Health Tourism, Farm Tourism, Urban Eco-tourism, Eco-development Tourism, Fishing Tourism- definitions, strategies, potentials and constraints; incorporation of pro-poor, community run/based, gender balanced and responsible tourism strategies.

Unit III: Eco-tourism and Sustainable development

Paradigm shifts in Tourism Ecology; Eco-development / Sustainable development-definitions and their relevance for Eco-tourism; common property resources and their management for Eco-tourism; Potentials and constraints for promoting Eco-tourism in our country – authenticity and commodification of ecotourism- case studies; Eco-labels, Ecotels and Tourism certification programmes; codes of conduct for different stake-holders.

Unit IV: Eco-tourism Policy & Planning- a futuristic perspective:

Eco-tourism components and impact monitoring – Ecotourism opportunity spectrum (ECOS), Ecological foot print analysis, Limits of acceptable change (LAC),Visitor activity

management (VAM), Visitor impact management(VIM),Tourism optimization management model (TOMM); suggestions for long term sustainable Eco-tourism initiatives.

References:

1. Buckley, R.C. 2009. Ecotourism: Principles and Practices. CAB International, Oxford, 368pp
2. Fennell, D. A. 2008. Ecotourism: An introduction. New York, NY: Routledge.
3. Weaver, David, 2008. Ecotourism, John Wiley & Sons; 2nd Edition Paper back, pp.360.
4. Brent Ritchie J R & G I Crouch, 2005. The Competitive destination: A sustainable tourism perspective, CABI, UK.
5. Eagles, P.F.J, S.F. McCool, & Haynes, Christopher,D.A. Christopher. 2002. Sustainable tourism, in protected areas: guidelines for planning and management, IUCN, Gland, Switzerland.
6. Honey, M, 2008. Ecotourism and Sustainable Development Who Owns Paradise? Second Edition, Island Press, USA, Paperback pp.558.
7. Wood, M, E, 2003. Eco-tourism: principles, practices and policies for sustainability, UNEP, DTIE/ TIES, 61 pp. accessed at uneptie.org/ tourism/home.html

EES – 504: Energy and Environment

Unit 1: Non renewable Energy resources

Fossil fuels-classification, composition, physico – chemical characteristics and energy content of coal, petroleum and natural gas, nuclear fuel, fission and fusion.

Unit 2: Renewable energy resources

Biomass, bio-fuel, hydroelectric power; Non-conventional energy resources: tidal energy, wind energy, geothermal energy, solar energy, solar radiation and its spectrum, solar collectors, photovoltaics, solar ponds, hydrogen energy.

Unit 3: Energy resource management

Energy crisis; Energy Conservation and Management; Energy audit; Recycling of wastes**:** Types - sources - composition of waste - recycling of waste for Industrial, Agricultural and Domestic Purposes.

Unit 4: Energy use and its Environmental impact

Energy use pattern in different parts of the world; Environmental implication; $C0_2$ emissions, global warming; thermal pollution, air pollution; radioactive waste, radioactivity from nuclear reactors, radioactivity risk assessment and criteria for safe exposure; impacts of large-scale exploitation of Solar, Hydro and Wind energy.

Reference books

1. Chichester, 2010. Renewable Energy and Climate Change. John Wiley & Sons Ltd.
2. Armaroli N, Balzani V, 2011. Energy for a Sustainable World – From the Oil Age to a Sun-Powered Future, Wiley-VCH.
3. Armaroli N, Balzani V, Serpone N, 2013. Powering Planet Earth – Energy Solutions for the Future, Wiley-VCH
4. Sioshansi FP, 2011. Energy, Sustainability and the Environment, Elsevier

EES – 505 Environmental Economics

UNIT-I

Economy and the Environment: World environmental history and economic development, valuation of natural resources, Inter-linkages between the economy and the environment. Economics of Natural Resource Exploitation – Renewable and Non-Renewable Resources – Methods of valuation of Environmental Costs and Benefits. Entropy- Principle and law of entropy. Material flow in economy.

UNIT-II

Environmental Policy: Design of Environmental Policy. Economic Instruments for Environmental Protection: Command & Control versus Incentives and Subsidies. Effectiveness of these instruments. Indian scenario and comparisons with China and developed countries.

UNIT-III

Sustainable Development: Concept and objectives. Strategic Planning for Sustainable Development, Natural resource based economic and social development. Climate Change and India: Vulnerability of regions and populations – Adaptation options.

UNIT-IV

Green Economy: New model for development, Green economy and green economy initiatives, Role of UNEP. Brundtland Commission. ecological economics Economic Growth and the Environment: Environmental Kuznets' curve, Foreign Direct Investment and the Environmental
quality.

Reference Books

1. Allen V. Kneese and James L. Sweeney, eds. Handbook of Natural Resource and Energy Economics, Chapters 2,12,14,17, North Holland,1985
2. Bohm, P. and Russell, C., `Comparative Analysis of Alternative Policy Instruments',Chap. 10 in Handbook of Natural Resource and Energy Economics, Vol.I Ed. A.V.
3. Field, B.C., Environmental Economics: An Introduction, McGraw Hill, 1994
4. Fisher, A.C., Environment and Resource Economics, Selected readings, New Horizon in Environmental Economics, Ed. W.E. Oates, 1995.
5. Hanley, Nick, Jason F. Shogren & Ben White: Environmental Economics in Theory and Practice, New Delhi: Macmillan –India, 1997.
6. James, D.E., Economic Approaches to Environmental Problems: Techniques and Results of Empirical Analysis, Elsevier Scientific Publishing Co., 1978.
7. Kolstad Charles., Environmental Economics,New Delhi: Oxford University Press,2010
8. Mehta, S., S. Mundle and U. Sankar, `Incentives and Regulation for Pollution Control', Sage, 1997..
9. Sankar, U. (ed.) Environmental Economics, New Delhi: Oxford University Press

EES – 506 ENVIRONMENTAL GEOLOGY

Unit I: Basic concepts

Evoluion of earth and it's environment; components of the physical environment, atmosphere, hydrosphere and the lithosphere. Internal structure of earth; Geological maps, Geological time scale, Hydrological cycle, the concept of rock cycle; Agents, types and products of weathering; Rocks and mineral, classification, soil formation, soil profile, soil classification, soils of India.

Unit II: Environmental geology

Environmental factors of deep seated processes of lithosphere-volcanic, seismic and diastrophic tectonic processes with special reference to Indian sub-continent, reservoir induced seismicity, environmental geologic mapping, geological aspects of environmental impact of dredging, mining, river sand mining, quarrying , deforestation, resettlement, farming, and other types of land use, environmental factors of ground water depletion, bore wells, siltation of reservoirs, Geoenvironmental changes associated with highway construction, bridges, tunnels, high rise buildings.

Unit III: Plate tectonics and geological hazards

Concept of plate tectonics; Major and minor lithospheric plates, plate margins and types, causes of plate movement, sea floor spreading and continental drift; geodynamic elements of earth: Mid ocean ridges, trenches, transform faults and Island arcs. Interrelation of toposheet – contour – gradient – dip – strike; Geological structures: Joints, fold-fault-unconformities.

Unit IV: Application of geology in engineering

Geological time scale of rocks; properties of rocks, Geological and environmental investigations for the construction of dams, bridges, highways and tunnels; Impact of major geotechnical projects on the environment.

Reference Books:

1. Bell, F.G., (1999). Geological Hazards, Routledge, London.
2. Brownlow, A.N., (1979). Geochemistry, Prentice Hall.
3. Bryant, E., (1985). Natural Hazards, Cambridge University Press.
4. Keller, E.A., Environmental Geology & Turk and Turk.
5. Krynine, D.S. and Judd, W.R., (1998) Principles of Engineering Geology, CBS, New Delhi.
6. Lahee, (1987) Field Geology. Sixth Edition. Mc Graw Hall Co..
7. Sawkins,J.S.,Chase,C.G., Darby,D.G. and Rapp,G., (1978).The evolving earth, Mac Millan Publishing Co., New York.
8. Smith, K., (1992). Environmental Hazards, Routledge, London.
9. Spencer, Structure of the Earth. Wiley. Brian Mason, 1966, Principles of Geochemistry, Wiley.
10. Valdiya, K.S., (1987). Environmental Geology.

EES - 507 ENVIRONMENTAL LAW, ETHICS AND POLICY

UNIT I

Environmental policy in Ancient India, Medieval India, British India, during post independent era, the seventies, eighties and nineties. International environmental policy – environmental problems and their impact on international system, the instruments of international environmental policy – international law, soft law, scientific cooperation - fund support, sanction, dispute settlement procedures, non state actors and international environmental policy - Transnational environmental policies – the Indus river basin, the Ganga – Brahmaputra river basin system.

UNIT II

Environmental planning, trends in planning, concepts and approaches and strategic environmental planning and management. International Environmental laws - hazardous wastes-Basal convention – Necessity for International Environmental Court. United Nations Environment Programme [UNEP] role on international environment laws. Case studies for International environmental disputes.

UNIT III

Indian legislation to protect the environment: The water act of 1974, the water cess act of 1977, The wildlife Act of 1972, the air act of 1981, The public Liability insurance act of 1991, the natural environmental tribunal act of 1995, the national environment appellate authority act of 1997, the mines and minerals act of 1957. Case studies one each in the protection of forests, rivers and wild life.

UNIT IV

The Indian forest act of 1927, the forest (conservation) act of 1968, The atomic energy act of 1962, The factories act of 1948. The environmental protection act of 1986, The national environment appellate authority act of 1997. The forest conservation act 1980, The wildlife protection act 1972 (2002 amendment), Biodiversity act 2002.

REFERENCES

1. Environmental law in India – Gurudeep Singh (2005) Mc Millan, New Delhi.
2. Environmental law and policy in India, Shyam Diwan and Armin Rosencrany, 2001, Oxford University Press, New Delhi.
3. Pollution Control Legislations, Vol. I and II, 1999, Tamilnadu Pollution Control Board, Chennai.
4. Environmental Management in Practice, Vol I, Nath B., Hens, L., Compton, P and D. Devuyst (1998), Routledge, London and New York.
5. The ISO 14000 Handbook: Joseph Cascio. ISO 14004 – Environmental management systems: General guidelines on principles, systems and supporting techniques (ISO 14004: 1996).
6. ISO 14001: Environmental management systems: Specification with guidance for use (ISO 14001: 1996b (E)). (International organization for standardization – Switzerland).

EES - 508 INDUSTRIAL ECOLOGY

Unit I - The Environment and the Anthrosphere

Definition – Environment and Anthrosphere, Components of the anthrosphere, effects of the anthrosphere on earth, integration of the anthrosphere into the total environment, the anthrosphere and industrial ecology.

Unit II - Industrial ecology and industrial systems

Levels of material utilization, links to other environmental spheres, consideration of environmental impacts in industrial ecology, Key attributes – energy, materials and diversity. Life cycle, consumable, recyclable and service products. Societal factors and environmental ethics.

Unit III – Industrial Metabolism and waste disposal

Networks of Nutrient and Energy transfer. Industrial metabolism, ion exchange, photolytic reactions, thermal treatment methods, biodegradation of wastes, treatment methods for solid and liquid wastes.

Unit IV - Industrial ecosystems

Components of the industrial ecosystem, overview of an integrated industrial ecosystem, examples of symbiotic industrial ecosystems, designing and developing of symbiotic industrial ecosystem. Industrial Ecology and the Legal System.

References

1. Bourg D., Erkman S. Perspectives of Industrial Ecology. Texas, Greenleaf, 2003.
2. Graedel T.E., Allenby B.R. Industrial Ecology and Sustainable Engineering. New Jersey, USA, Prentice Hall, 2010.
3. Graedel T.E., Allenby B.R. Industrial Ecology. New Jersey, USA, Printice Hall, 2003.

4. Manahan S.E. Industrial Ecology: Environmental Chemistry and Hazardous Wastes, Boca Raton, CRC Press, 1999.
5. Socolow R., Andrews C., Berkhout F, Thomas V. Industrial Ecology and Global Change. Cambridge, Cambridge University Press, 2010.
6. Suh S. Handbook of Input-Output Economics in Industrial Ecology. New York, Springer-Verlag, 2009.

EES - 509 ENVIRONMENTAL GENETICS AND BIOTECHNOLOGY

Unit I: Genetic Engineering

Introduction to genetic engineering, Restriction endonucleases, properties of restriction enzymes, introduction of cloned genes into new hosts using plasmid and phage vector systems, isolation of plasmids, DNA – cloning of DNA fragments, Cloning of single stranded DNA, Shuttle vectors and their environmental applications.

Unit II: Biotechnology for environment

Recombinant DNA Technology, development of genetically engineered microorganisms (GEMs), Polymerase Chain Reaction (PCR) and development of gene probes for environmental remediation, Uses of GEMs in bioremediation, Genosensor technology.

UNIT III: Genetically modified microorganisms

Genetically modified microbes & their uses in Environmental, Microbial reactors, management of recycling & up gradation technologies, Bioenergy from waste, Biogas technology – process and biogas from organic waste.

Unit IV: Biotechnology for Management of Resources

Bio-transformation of heavy metals, improved oil recovery, role of environmental biotechnology in management of resources, reclamation of wasteland, biomass production, microorganisms in mineral and energy recovery, nanotechnology for control of pollution.

Reference Books

1. Evano, G.H. and Furlong, J.C. Environmental Biotechnology - Theory and Application. USA, John Wiley and Sons, 2004.
2. Jjemba, P.K. Environmental Microbiology - Theory and Application. USA, Science Pub. Inc., 2004.
3. Kuhad R.C., Singh A. Biotechnology for Environmental Management and Resource Recovery. New York, Springer-Verlag, 2013.
4. Martin C.C. Environmental Genomics. Totowa, NJ, USA, Humana Press, 2008.
5. Olguin, C. J., Sanchez, G., Hernandez. E. Environmental Biotechnology and Cleaner Bioprocesses. Boca Raton, Taylor & Francis, 2000.
6. Pepper, I.L. and Gerba, C.P. Environmental Microbiology - Laboratory Manual. USA, Elsevier, 2005.
7. Ratledge, C. and Kristiansen, B. Basic Biotechnology. 2nd ed. Cambridge, Cambridge University Press, 2002.
8. Rittman, B. and McCarty, P. L. Environmental Biotechnology: Principles and Applications. 2nd edition. USA, Tata McGraw-Hill, 2000.
9. Rittmann, B.E. and McCarty, P.L. Environmental Biotechnology – Theory and Application. USA, McGraw Hill, 2001.

10. Sangeetha J, Thangadurai D, David M, Abdullah MA. Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of Xenobiotics for Sustainable Development, Boca Raton, Florida, USA, CRC Press, 2016.

EES - 5010 NATURAL HAZARDS AND DISASTER MANAGEMENT

UNIT - I

Natural Disasters – Nature and Extent and Educative – trends in climatology, meteorology and hydrology. Seismic activities. Changes in Coastal zone, coastal erosion, beach protection. Coastal erosion due to natural and manmade structures.

UNIT II

Disasters - Cyclone – Tornadoes – Avalanches – Flood –Drought – Valconic – Earthquakes – Fire – Landslides. Forecasting and Warning System: Cyclone Disaster Education - Cyclone Safety – Earthquake – Avalanche – Safety and Flood Safety – Impact on Environment

UNIT - III

Disaster Management. Predisaster Planning-Toning of Disaster – prone areas – prioritization – regulations – protection measures during disaster - Post disaster. Relief Camp Organization – Survey and Assessment. Disaster Management Cycle – Vulnerability Analysis – Warning system – Disaster Training – Legal Aspects – case studies for disasters and management, Safety Measures – a general account, Disaster Management plans

UNIT - IV

Disaster Preparedness and Training. Community Preparedness in Natural Disasters- Role of information, education, communication and training- Roles and responsibilities of different national and international agencies and government - NGO, Armed forces, Paramilitary forces, Community based organizations (CBO) - Army Training for Disaster Reduction –Role of team and co-ordination -Training needs – Target Groups – Local Condition.

REFERENCES

1. Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2. Roy, P.S. (2000): Space Technology for Disaster management: A Remote Sensing & GIS Perspective, Indian Institute of Remote Sensing (NRSA), Dehradun.
3. Sharma, R.K. & Sharma, G. (2005) (ed) Natural Disaster, APH Publishing Corporation, New Delhi
4. Carter, N W. Disaster Management: A disaster Manager's Handbook, Asian Development Bank, Manila. (1992).
5. Gautam Ashutosh. Earthquake: A Natural Disaster. Ashok Publishing House. New Delhi. 1994.
6. Singh T. Disaster Management approaches and strategies, Akansha Publishing House, New Delhi. 2006.
7. Singh D K. Towards Basics of Natural Disaster Reduction, Research book Centre, New Delhi, 2006.
8. Natural Disasters – A Guide for Relief Workers, (1980), JAC Adhyatma Sadhna Kendra-Mehrauli, New Delhi.
9. Disaster Planning: The Preservation of Life and Property, Harold D. Foster

(1980), Springer Verlay, New York.
10. Disaster Management, Shailendra K Singh, Subash C. Kundu and Shobu Singh (1998), Mittal Publications, New Delhi.

EES - 5011 OCCUPATIONAL HEALTH AND INDUSTRIAL SAFETY

UNIT - I

Occupational Health - Hazards and Safety –Physical, Chemical and Biological hazards. Occupational Diseases and Occupationally induced illness - Prevention and Control. Health problems in different types of industries – construction, textile, steel and food processing, pharmaceutical, Occupational Health and Safety considerations in Wastewater Treatment Plants. Measures for Workers. Health Education Medical First-Aid and Management of Medical Emergencies. Epidemiological approaches. Ergonomics – Need, Task Analysis, Preventing Ergonomic Hazards, Ergonomics Programme. Definition and Role of Ergonomics in Designing Work Place - Work Environment - Effects of Light, Ventilation, Vibration, Noise and stress - Performance Evaluation of Man.

UNIT – II

Industrial Safety Management Techniques – Industrial Safety Standards. Industrial Accidents and Disasters - Frequency Rate, Prevention and Control. Dispersion of Radioactive material and release of Toxic and inflammable materials. Work Study - Method of Study and Measurement. Measurement of Skills. Safety - Cost of Expenses. Principles and Functions in Safety Management. Case Study - Preparation of report on safety and remedial measures followed in Industry.

UNIT III

Hazards Exposure evaluation: Sampling techniques, Personal monitoring, Biological monitoring; Threshold Limit Values (TLV), STEL; List of Industries involving Hazardous process Occupational Hazards under the First Schedule of the Factories Act,1948; Permissible Limits of certain Chemical substances in work environment under the Second Schedule of the Factories Act,1948; Hazards Control : Elimination, Control , Substitution, Isolation, Personal Protective Equipment(PPE).

UNIT IV

Hazards Control- Causes of Accident - Accident statistics - Accident Reporting system, Safety Audit, Accident prevention, Disaster Planning, Safety Committee, Case studies on Bhopal, Chernobyl and similar disasters - Control of Hazards Substitutions, Engineering control, Administrative control, Behaviour control, integrated control, Elimination, Control , Substitution, Isolation, Personal Protective Equipment (PPE).

REFERENCES

1. Goetsch D.L., (1999), “Occupational Safety and Health for Technologists”, Engineers and Managers”, Prentice Hall.
2. Della D.E., and Giustina, (1996), “Safety and Environmental Management”, Van Nostrand Reinhold International Thomson Publishing Inc.
3. Environmental Strategies–Hand Book, Kolluru R. V, (1994) Mc Graw Hill Inc., New York.

4. A B C of Industrial Safety, Walsh, W and Russell, L, (1984), Pitma Publishing United kingdom
5. Environmental and Industrial Safety, Hommadi, A. H. (1989), I.B.B Publication, New Delhi.

EES - 5012 MARINE ENVIRONMENT

Unit I: Marine ecosystem

Marine ecosystem – estuaries, rocky and sandy shores, pelagic ecosystems, continental shelf seabed, deep sea, mangroves forests, seagrass meadows, coral reefs, Polar Regions.

Unit II: Marine biodiversity

Distribution of marine biodiversity, relationship between global climate and marine biodiversity, hypoxia and dead zone, significance of marine biodiversity, marine ecosystem functioning. Extinct and endangered marine species, fisheries management and conservation.

UNIT III: Marine Resources and Energy

Fossil records, fishing, mining – minerals and crude oil, tourism, Energy from Marine Environment – Renewable – marine wind power, osmotic power, tidal power, wave power, ocean thermal energy; Non renewable energy.

Unit IV: Marine Pollution

Sources and types of marine pollution, effects of marine pollution – physicochemical and biological effects, impact of climate and environmental factors on marine environment and biodiversity. Mitigation measures for marine pollution.

Reference Books

1. Solan M., Aspden R.J., Paterson D.M. Marine Biodiversity and Ecosystem Functioning: Frameworks, methodologies, and integration. Oxford, Oxford University Press, 2012.
2. Polunin V.C. Aquatic ecosystems: Trends and Global Prospects. Cambridge, Cambridge University Press, 2008.
3. Farmer A. Managing Environmental Pollution. New York, Routledge. 1997.
4. Hofer T.N. Marine Pollution: New Research, New York, Nova Science Publishers, 2008.
5. Kaiser M.J., Attrill M.J. Marine Ecology: Process, Systems and Impacts. Oxford, Oxford University Press. 2011.
6. Iversen E.S. Living Marine Resources: Their Utilization and Management. New York, Chapman Hall, 1996
7. Multon B. Marine Renewable Energy Handbook. Philippines,Wiley-ISTE, 2012.

PHD: **ENVIRONMENTAL MICROBIOLOGY AND ENVIRONMENTAL BIOTECHNOLOGY**

Unit I: Environmental toxicology

Toxic chemicals in the environment - organic and inorganic toxicants. Acute and chronic toxic effects. Dose effect, dose response relationships. Toxicity of pesticides, herbicides, fertilizer, hydrocarbons, phenolic compounds, radioactive wastes. Translocation of xenobiotics.

Unit II: Environmental microbiology

Bioconcentration, bioaccumulation and biomagnification of toxicants. Biodegradation of xenobiotics, bioremediation of heavy metals, first generation and second generation biofuels. Impact of pollutants on microbial diversity in various ecosystems.

Unit III: Environmental biotechnology

Genetically modified organisms (GMO's), role of recombinant DNA technology in environmental sustainability, gene shuffling for remediation of xenobiotics.

Unit IV: Environmental genomics

Shortgun metagenomics, 16S rRNA sequencing, microbial whole genome sequencing - GC fraction, meta proteomics, proteogenomics, metatranscriptomics, partial genome sequencing – Gene finger printing techniques - RFLP, DGGE, RISA, RAPD, clone library method, real time PCR, FISH, DNA Microarrays.

Reference Books

1. Cockerham L.G., Shane B.S. Basic Environmental Toxicology. Boca Raton, CRC Press, 1994.
2. Evano, G.H., Furlong, J.C. Environmental Biotechnology - Theory and Application. USA, John Wiley and Sons, 2004.
3. Kuhad R.C., Singh A. Biotechnology for Environmental Management and Resource Recovery. New York, Springer-Verlag, 2013.
4. Laws E.A. Environmental Toxicology: Selected entries from the encyclopedia of sustainability science and technology. New York, Springer-Verlag, 2013.
5. Madsen E.L. Environmental Microbiology: From Genomes to Biogeochemistry. Denmark, Wiley-Blackwell, 2008.
6. Maier R.M., Pepper I.L., Gerba C.P. Environmental Microbiology. California, Elsevier, 2009.
7. Martin C.C. Environmental Genomics. Totowa, NJ, USA, Humana Press, 2008.
8. Rose J. Environmental Toxicology Current Developments, Boca Raton, CRC Press, 2003.
9. Sangeetha J, Thangadurai D, David M, Abdullah MA. Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of Xenobiotics for Sustainable Development, Canada, Apple Academic Press, 2016.
10. Thangadurai D, Sangeetha J. Biotechnology and Bioinformatics: Advances and Applications for Bioenergy, Bioremediation and Biopharmaceutical Research. Boca Raton, CRC Press, 2014.
11. Thangadurai D, Sangeetha J. Genomics and Proteomics: Principles, Technologies and Applications. Boca Raton, CRC Press, 2015.

PHD - WATER POLLUTION AND MANAGEMENT

UNIT I

Water quality standards – sampling, preservation techniques for water and waste water, Basic Principles and their significance with special reference to colour, turbidity alkalinity, acidity, chemical coagulation, hardness, water softening, BOD, COD,Nitrogen, Phosphate and Sulphate.

UNIT II

Source and classification of water pollution – water pollution: Organic, inorganic, sediments, radionuclieides and heavy metals, biochemical effects of Arsenic, Cadmium, Lead, Chromium, Nickel, Mercury, Selenium, Cyanides and Pesticides.

UNIT III

Pre Primary methods of waste water treatment: Screening and communiting: flow equalization – coagulation – sedimentation – floatation, Granular medium filtration. Basic principles of biological treatment kinetics of biological growth – suspended culture system – sludge characteristics – sludge thickening, sludge digestion and disposal.

UNIT IV

Advance treatment methods - Removal of nitrogen, phosphate, Removal of dissolved inorganic by oxidation and adsorption. Removal of dissolved inorganic and heavy metals by adsorption, chemical precipitation, electro dialysis, and ion exchange and reverse osmosis. Removal of phenols. Flow diagram for sewage and industrial wastewater treatment.

UNIT V

Wastewater reuse and disinfection process: Need for Water reuse- Public health and environmental issues in water reuse – Risk assessment for water reuse – issues involved with storage of reclaimed water – Planning for waste water reclamation. Waste water disinfection – disinfectants – disinfection methods – mechanism – Factors

influencing the action of disinfectants – chlorine – chlorine demand – ozone – other chemical disinfectants – UV radiation – Byproduct formation - Environmental impacts.

PHD - Genetic Modifications

Unit 1: Enzymes

Restriction nucleases: exonucleases and endonucleases. Mechanism of action and application of: DNase, RNase, Phophorylase, Methylase, Phosphatase, Kinase, Ligase.

Unit 2: Gene expression

Mechanism and regulation of gene expression, vectors: cloning and expression vectors, different types and characteristics. Gene cloning, expression and purification of gene product. Recombinant DNA safety guidelines and regulations.

Unit 3: Gene silencing

Introduction to non-coding RNA, RNA interference, mechanism of action of siRNA, mode of action of microRNA, Applications of gene silencing.

Unit 4: Molecular biology techniques and Bioinformatic tools

Polymerase chain reaction, Southern, Northern and Western blotting, DNA sequencing, Transcriptomics, microarray, small RNA sequencing, Bioinformatic tools: BLAST, FASTA, EMBOSS, Clustal W, BioEdit.

Unit 5: Applications of Genetic Engineering

Applications in Agriculture, Bioenergy crops, Bioremediation (microbe and plant based); Transgenic crops- uses and concerns.

References:

1. Nicholl. 2006. Introduction to Genetic Engineering. Cambridge Low Price Edition.
2. Primrose S.B. and Twyman R.M. 2008. Principles of gene manipulation and Genomics, Blackwell Scientific Publications.
3. Lewis B. 2008. Genes IX. Oxford University & Cell Press.
4. Brown T.A. 2001. Gene cloning and DNA analysis: An introduction. Blackwell publishers.
5. Slater A, Scott NW, Fowler MR. 2003. Plant biotechnology: the genetic manipulation of plants. Oxford University Press.

Aquatic Ecology – PhD

Unit I: Water

Nature of Water, Chemical and physical properties, Movement of water, Basic principles of fluid dynamics.Movement of light and heat in water, Diffusion of chemicals.Hydrological cycle, interaction of water with other ecosystems.

Unit II: Hydrology and Physiography

Basics of Hydrology – stage discharge relationships, unit hydrographs, flood estimation. Basics of oceanography. Geography and types of aquatic habitats, intermediate habitats – significance.Global change and its effect on aquatic habitats and vice-versa.Physiography of marine, lentic and lotic ecosystems, formation, characterization, and flow types.Unique and extreme aquatic habitats.Artificial aquatic ecosystems – properties and environmental impact.

Unit III: Aquatic Chemistry

Types of elements and chemicals in water, physical chemistry of chemical transformations, oxygen – photosynthesis and respiration, carbon – forms and transformations. Nutrient cycling – carbon, nitrogen, sulphur, phosphorus, silicon, iron and trace nutrient cycles, and interactions.

Unit IV: Biology of Aquatic Habitats

Types of organisms, major taxonomic groups, classification of organisms by habitat, function and level of interaction. Unicellular and Multicellular organisms in aquatic habitats and their role.Trophic states.Food web, prey and predator interactions.Complex interactions.Species diversity, measures of diversity, and threat perception. Ecosystem services of key aquatic organisms.

Unit V: Aquatic pollution

Types of pollutants – sources and effect, eutrophication, toxins – natural and artificial, anthropogenic chemicals, metals, salt and thermal pollution.Toxicology in aquatic habitats, bioassessment and mitigation measures.Chemical and Biomarkers of pollution.Sewage and wastewater treatment.Sludge disposal. Water quality and effluent discharge standards. Wetland conservation.Watershed management.

Practical study – constructed wetlands for wastewater treatment.

References:

1. American Public Health Association, et al. 1996. Standard Methods for Examination of Waterand Wastewater (19th Edition).American Public Health Assoc., New York.

2. Barnes, R.S.K. and K. H. Mann. 1980. Fundamentals of Aquatic Ecosystems. Blackwell Scientific Publications, Oxford.
3. Brönmark, C. and L.-A. Hansson. 1998. The Biology of Lakes and Ponds. Oxford UniversityPress, Oxford.
4. Cole, G. A. 1983. A Textbook of Limnology.3rd edition.C.V. Mosby, Co., St Louis.
5. Dodds, W. K. and M. R. Whiles (2010). Freshwater Ecology (Second Edition). Academic Press, London.
6. Gopal, B. and R. G. Wetzel. 1995. Limnology of Developing Countries. Vol. 1-4. Int. Assoc.Theor. Appl. Limnology.
7. Lerman, A., D. M. Imboden, and J. R. Gat, Editors. 1995. Physics and Chemistry of Lakes (2nd.Edition). Springer-Verlag, New York.
8. National Research Council. 1992. Restoration of Aquatic Ecosystems. The NationalAcademies Press, Washington, DC.
9. Payne, A. I. 1986. The Ecology of Tropical Lakes and Rivers.John Wiley and Sons.
10. Wetzel, R. G. and G. E. Likens. 2000. Limnological Analyses. 3rd Edition. Springer-Verlag,New York.
11. Wetzel, R. G. 2001. Limnology: Lake and River Ecosystems. 3rd Edition Academic Press, New York.

Paper 1 -Research methodology and Biostatics

Unit I- Fundamentals of Research

Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory.Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process

Unit II- Research Problems

Problem Identification & Formulation; Research Question; Investigation Question; Measurement Issues; Hypothesis; Qualities of a good Hypothesis; Null Hypothesis & Alternative Hypothesis. Hypothesis Testing; Logic & Importance

Unit III- Research Design

Concept and Importance in Research; Features of a good research design; Exploratory Research Design andconcept, types and uses, Descriptive Research Designs and concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

Unit IV- Data Collection and analysis (Bio-statistics)

Introduction to Applied Statistics; identifying the dependent; independent variables; Confidence levels. Descriptive Statistics; Summarizing and describing a collection of data; Univariate and bivariate analysis; Mean, mode and standard deviation; Percentages and Ratios; Histograms; Identifying randomness and uncertainty in data. Inferential Statistics Drawing inference from data; Modeling assumptions; Identifying Patterns; Regression analysis; T-test; Analysis of Variance; Correlations; Chi-square.

Unit V- Research ethics Research Integrity and Research Misconduct

The Ethics of Human Subjects Research; Responsible Conduct of Research with Animals; Intellectual Property and Data Ownership, Responsible Authorship; Conflict of Interest, Mentoring; Data management.

Unit VI- Laboratory Techniques

Biochemical Techniques:- p^H and buffers; centrifugation; colorimetry and spectrophotometry; estimation of protein, amino acid, nucleic acid, RNA.

Separation and Analytical Techniques:- Electrophoresis and type of electrophoresis; western blotting; chromatography and types of chromatography.

Cell Culture Techniques:- Cell/Tissue: Basic Concepts; preparation of medium; preparation of serum; primary cell culture; culturing and sub- culturing of animal cells; vital staining and viable counting. Enzymatic Reactions:- PCR; Real- Time PCR; DNA sequencing Techniques.

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