DEPARTMENT OF ENVIRONMENTAL SCIENCES
CENTRAL UNIVERSITY OF JAMMU
राया-सूचानी(**बागला**), जिला**सांबा -181143**,जम्मू (**जम्मूएवंकश्मीर**)
Rahya-Suchani **(Bagla)**, District **Samba-181143**, Jammu **(J &K)**

Ref. No:- CUJ/ENVS/2019/257 Date: 22-05-2019

Minutes of Meeting

The meeting of Board of studies in Environmental Sciences was held in the committee room of the department on 22nd May 2019. The following were attended:-

1) Prof. Deepak Pathania	Chairman
2) Prof. A.K Kaul	Member
3) Prof. Shakil Ahmad Romshoo	Special Invitee
4) Dr. Piyush Malaviya	Special Invitee
5) Prof. Brijmohan Singh Bhau	Member
6) Dr. Sunil Dhar	Member
7) Dr. Richa Kothari	Special Invitee
8) Dr. Anita Singh	Special Invitee
9) Dr. Shweta Yadav	Special Invitee

The meeting started with brief introduction by the Chairman. He also welcomed the members and introduced the agenda for the meeting which was then taken up for discussion seriatem.

Item I: Confirmation of proceedings of last meeting held on 30th May, 2018.

Resolution: The Board of Studies unanimously confirmed the Proceeding of meeting held on 30th May, 2018.

Item II: Approval of syllabus of M.Sc. Environmental Sciences.

Resolution: The Board of Studies discussed the syllabus of M.Sc. Environmental Sciences at length and suggested that the syllabus be organized under themes specific to a semester. Thereafter the Board approved the course matrix for M.Sc. Environmental Sciences. Semester I and II, attached as Annexure I.

Item III: Approval of syllabus of the pre - Ph.D. (Environmental Sciences)

The Board discussed the course matrix for PhD programme in light of UGC guidelines and approved the course matrix comprising of 16 credit hours. The Board was informed that 8 vacancies are available for PhD programme for academic session (2019-2020). Number of vacancies available under different teachers is as under:

Name of the faculty	Vacancy
1. Prof. Deepak Pathania	2
2. Dr. Sunil Dhar	1
3. Dr. Richa Kothari	1
4. Dr. Anita Singh	1
5. Dr. Pankaj Mehta	1
6. Dr. Shweta Yadav	1
7. Dr. Dinesh Kumar	1

The Course matrix approved for PhD is as under:-

Course-Matrix

SEMESTER-I (2019-20)

Course Title	Credit	ESE	Total Marks
CORE COURSES			
Research Methodology	4	100	100
Advanced tools and techniques in Environmental Sciences	4	100	100
Current Environmental Issues and challenges	4	100	100
Specialized Courses (Any based on the topic of Research)			
Advanced Atmospheric Chemistry	4	100	100
Advances in Microbiology & Bio processes	4	100	100
Advances in Geochemistry	4	100	100
Atmospheric Processes & Climate Change	4	100	100
Bioenergy and Nano-Materials	4	100	100
Total	**16**	**400**	**400**

Item IV: Provision to co-supervise scholars from other University/Institutes as per faculty specialization.

Resolution: Board decided that the item does not concern the Board of studies and it should therefore be dealt administratively.

The meeting ended with vote of thanks to the chair.

Prof. Deepak Pathania

Prof. A.K Kaul

Prof. Shakil Ahmad Romshoo

Dr. Piyush Malaviya

Prof. Brijmohan Singh Bhau

Dr. Sunil Dhar

Dr. Richa Kothari

Dr. Anita Singh

Dr. Shweta Yadav

7.2 The course work shall be treated as prerequisite for M.Phil./Ph.D. preparation. A minimum of four credits shall be assigned to one or more courses on Research Methodology which could cover areas such as quantitative methods, computer applications, research ethics and review of published research in the relevant field, training, field work, etc. Other courses shall be advanced level courses preparing the students for M.Phil./Ph.D. degree.

7.3 All courses prescribed for M.Phil. and Ph.D. course work shall be in conformity with the credit-hour instructional requirement and shall specify content, instructional and assessment methods. They shall be duly approved by the authorized academic bodies.

7.4 The Department where the scholar pursues his/her research shall prescribe the course(s) to him/her based on the recommendations of the Research Advisory Committee, as stipulated under sub-Clause 8.1 below, of the research scholar.

7.5 All candidates admitted to the M.Phil. and Ph.D. programmes shall be required to complete the course work prescribed by the Department during the initial one or two semesters.

7.6 Candidates already holding M. Phil. degree and admitted to the Ph.D. programme, or those who have already completed the course work in M.Phil. and have been permitted to proceed to the Ph.D. in integrated course, may be exempted by the Department from the Ph.D. course work. All other candidates admitted to the Ph.D. programme shall be required to complete the Ph.D. course work prescribed by the Department.

7.7 Grades in the course work, including research methodology courses shall be finalized after a combined assessment by the Research Advisory Committee and the Department and the final grades shall be communicated to the Institution/College.

7.8 A M.Phil./Ph.D. scholar has to obtain a minimum of 55% of marks or its equivalent grade in the UGC 7-point scale (or an equivalent grade/CGPA in a point scale wherever grading system is followed) in the course work in order to be eligible to continue in the programme and submit the dissertation/thesis.

8. Research Advisory Committee and its functions:

8.1 There shall be a Research Advisory Committee, or an equivalent body for similar purpose as defined in the Statutes/Ordinances of the Institution concerned, for each M.Phil. and Ph.D. scholar. The Research Supervisor of the scholar shall be the Convener of this Committee. This Committee shall have the following responsibilities:

8.1.1 To review the research proposal and finalize the topic of research.

8.1.2 To guide the research scholar to develop the study design and methodology of research and identify the course(s) that he/she may have to do.

8.1.3 To periodically review and assist in the progress of the research work of the research scholar.

8.2 A research scholar shall appear before the Research Advisory Committee once in six months to make a presentation of the progress of his/her work for evaluation and further guidance. The six monthly progress reports shall be submitted by the Research Advisory Committee to the Institution/College with a copy to the research scholar.

8.3 In case the progress of the research scholar is unsatisfactory, the Research Advisory Committee shall record the reasons for the same and suggest corrective measures. If the research scholar fails to implement these corrective measures, the Research Advisory Committee may recommend to the Institution/College with specific reasons for cancellation of the registration of the research scholar.

9. Evaluation and Assessment Methods, minimum standards/credits for award of the degree, etc.:

9.1 The overall minimum credit requirement, including credit for the course work, for the award of M.Phil. degree shall not be less than 24 credits.

9.2 Upon satisfactory completion of course work, and obtaining the marks/grade prescribed in sub-clauses 7.8 above, as the case may be, the M.Phil./Ph.D. scholar shall be required to undertake research work

subject specific. The Entrance Test shall be conducted at the Centre(s) notified in advance (changes of Centres, if any, also to be notified well in advance) at the level of the individual HEI as mentioned in clause 1.2; and

5.4.2 An interview/*viva voce* to be organized by the HEI as mentioned in clause 1.2 when the candidates are required to discuss their research interest/area through a presentation before a duly constituted Department Research Committee.

5.5 The interview/*viva voce* shall also consider the following aspects, viz., whether,

5.5.1 the candidate possesses the competence for the proposed research,

5.5.2 the research work can be suitably undertaken at the Institution/College,

5.5.3 the proposed area of research can contribute to new/additional knowledge.

5.6 The University shall maintain the list of all the M.Phil. / Ph.D. registered students on its website on year-wise basis. The list shall include the name of the registered candidate, topic of his/her research, name of his/her supervisor/co-supervisor, date of enrolment/registration.

6. **Allocation of Research Supervisor:** Eligibility criteria to be a Research Supervisor, Co- Supervisor, Number of M.Phil./Ph.D. scholars permissible per Supervisor, etc.

6.1 Any regular Professor of the University/Institution Deemed to be a University/College with at least five research publications in refereed journals and any regular Associate/Assistant Professor of the university/institution deemed to be a university/college with a Ph.D. degree and at least two research publications in refereed journals may be recognized as Research Supervisor.

Provided that in areas/disciplines where there is no or only a limited number of refereed journals, the Institution may relax the above condition for recognition of a person as Research Supervisor with reasons recorded in writing.

6.2 Only a full time regular teacher of the concerned University/Institution Deemed to be a University/College can act as a supervisor. The external supervisors are not allowed. However, Co-Supervisor can be allowed in inter-disciplinary areas from other departments of the same institute or from other related institutions with the approval of the Research Advisory Committee.

6.3 The allocation of Research Supervisor for a selected research scholar shall be decided by the Department concerned depending on the number of scholars per Research Supervisor, the available specialization among the Supervisors and research interests of the scholars as indicated by them at the time of interview/*viva voce*.

6.4 In case of topics which are of inter-disciplinary nature where the Department concerned feels that the expertise in the Department has to be supplemented from outside, the Department may appoint a Research Supervisor from the Department itself, who shall be known as the Research Supervisor, and a Co-Supervisor from outside the Department/ Faculty/College/Institution on such terms and conditions as may be specified and agreed upon by the consenting Institutions/Colleges.

6.5 A Research Supervisor/Co-supervisor who is a Professor, at any given point of time, cannot guide more than three (3)M.Phil. and Eight (8) Ph.D. scholars. An Associate Professor as Research Supervisor can guide up to a maximum of two (2) M.Phil. and six (6) Ph.D. scholars and an Assistant Professor as Research Supervisor can guide up to a maximum of one (1) M.Phil. and four (4) Ph.D. scholars.

6.6 In case of relocation of an M.Phil/Ph.D. woman scholar due to marriage or otherwise, the research data shall be allowed to be transferred to the University to which the scholar intends to relocate provided all the other conditions in these regulations are followed in letter and spirit and the research work does not pertain to the project secured by the parent institution/ supervisor from any funding agency. The scholar will however give due credit to the parent guide and the institution for the part of research already done.

7. **Course Work:** Credit Requirements, number, duration, syllabus, minimum standards for completion, etc.

7.1 The credit assigned to the M.Phil. or Ph.D. course work shall be a minimum of 08 credits and a maximum of 16 credits.

ANNEXURE-I

Matrix for the Master's Degree Programme in Environmental Sciences

SEMESTER I

Course Title	Credit	CIA	MSE	ESE	Total Marks
Core Courses					
Ecosystem Analysis	4	25	25	50	100
Biodiversity and its conservation	4	25	25	50	100
Energy resources and their conservation	4	25	25	50	100
MOOC*	2	12.5	12.5	25	50
Lab Course I	2				50
Lab Course II	2				50
Elective Courses (Students will opt one of the following electives)					
Waste Management	4	25	25	50	100
Environmental Geosciences	4	25	25	50	100
Introduction to Atmospheric Sciences	4	25	25	50	100
Fundamentals of Meteorology	4	25	25	50	100
Palaeoenvironment	4	25	25	50	100
Foundation course					
Fundamentals of Ecology	2	12.5	12.5	25	50
TOTAL	24				600

SEMESTER II

Course Title	Credit	CIA	MSE	ESE	Total Marks
Core Courses					
Environmental Geology	4	25	25	50	100
Climatology	4	25	25	50	100
Environmental Pollution and control	4	25	25	50	100
MOOC*	2	12.5	12.5	25	50
Lab Course I	2	20		30	50
Lab Course II	2	20		30	50
Elective course					
Energy from wastes	4	25	25	50	100
Geochemistry	4	25	25	50	100
Advances in Atmospheric Environment	4	25	25	50	100
Advances in Meteorology and its Applications	4	25	25	50	100
Geomorphology and Himalayan Geology	4	25	25	50	100
Foundation course					
Fundamentals of Earth and ~~Atmospheric~~ Environmental Sciences	2	12.5	12.5	25	50
TOTAL	24				600

*MOOC courses shall be offered depending upon the availability on the SWYAM portal.

जम्मू केंद्रीय विश्वविद्यालय

Central University of Jammu

राया–सूचानी; बागला, जिला सांबा–181143 जम्मू; जम्मू एवं कश्मीर
Rahya- Suchani (Bagla), District Samba – 181143, Jammu (J&K)

No. 4-1/EVS/CUJ/Reg/2019/411

28th November, 2019

NOTIFICATION No. 78 / 2019

Sub: Course Scheme and Syllabus of 1st and 2nd **Semester** of M.Sc. in Environmental Sciences w.e.f. Academic Session **2019-20** – Reg.

Ref: Notification No. 57 dated 29.10.2018

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It is hereby notified for the information of all concerned that on the recommendation of the Board of Studies, Department of Environmental Sciences, School Board, School of Life Sciences, the Academic Council has approved following **Course Scheme** and **Syllabus** of 1st and 2nd **semester** of M.Sc. Environmental Sciences w.e.f. Academic Session **2019-20**.

Semester I

Course Code	Course Title	Credits	CIA	MSE	ESE	Max. Marks
PGEVS1C005T	Biodiversity and its Conservation	4	25	25	50	100
PGEVS1C007T	Ecosystem Analysis	4	25	25	50	100
PGEVS1C008T	Energy Resources and its Conservation	4	25	25	50	100
PGEVS1C007L	Lab Course I	2	-	-	-	50
PGEVS1C008L	Lab Course II	2	-	-	-	50
MOOC available on SWAYAM		-	-	-	-	-
PGEVS1E010T	Environmental Geosciences	4	25	25	50	100
PGEVS1E013T	Palaeoenvironment	4	25	25	50	100
PGEVS1E014T	Waste Management	4	25	25	50	100
PGEVS1E015T	Introduction to Atmospheric Sciences	4	25	25	50	100
PGEVS1E016T	Fundamentals of Meteorology	4	25	25	50	100
PGEVS1F010T	Fundamentals of Ecology	2	12.5	12.5	25	50
Total		22				550

Semester II

Course Code	Course Title	Credits	CIA	MSE	ESE	Max. Marks
PGEVS2C007T	Climatology	4	25	25	50	100
PGEVS2C008T	Environmental Geology	4	25	25	50	100
PGEVS2C009T	Environmental Pollution and Control	4	25	25	50	100
PGEVS2C007L	Lab Course I	2	-	-	-	50
PGEVS2C008L	Lab Course II	2	-	-	-	50
MOOC available on SWAYAM		-	-	-	-	-

PGEVS2E009T	Energy from wastes	4	25	25	50	100
PGEVS2E010T	Geochemistry	4	25	25	50	100
PGEVS2E011T	Advances in Atmospheric Environment	4	25	25	50	100
PGEVS2E012T	Advances in Meteorology and its Applications	4	25	25	50	100
PGEVS2E013T	Geomorphology and Himalayan Geology	4	25	25	50	100
PGEVS2F009T	Fundamentals of Earth and Environmental Sciences	2	12.5	12.5	25	50
	TOTAL	22				550

Deputy Registrar
(Admin – HR)

Encl: Syllabus of I and II Semester

To:

Head, Department of Environmental Sciences

Copy to:

OSD (Exam)

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Semester –I

Subject Course Code: PGEVS1C007T **Credits: 4**

Subject Course Title: Ecosystem Analysis

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit-I: Introduction to Environment

1.1. Definition, scope and importance of Environmental Science; Interaction between man and environment

1.2. Components of environment (atmosphere, hydrosphere, lithosphere and biosphere)

1.3. Biogeochemical cycles: carbon, nitrogen, sulphur, phosphorus

1.4. Concept of biogeography: major biomes of the world: distribution and characteristic features; Floral and faunal peculiarities of Jammu and Kashmir an overview

Unit-II: Ecosystem

2.1 Structure and components of ecosystem

2.2 Ecosystem stability, ecosystem regulation

2.3 Gaia hypothesis, sustainable development; sustainability indicators

2.4 Goods and services of ecosystems: supporting, provisioning, regulatory and cultural

Unit-III: Terrestrial Ecosystem

3.1 Introduction toTundra, forest, Grassland, Desert ecosystem

3.2 Energy flow in ecosystems-Laws of Thermodynamics

3.3 Productivity-Biomass production, primary productivity and net productivity.

3.4 Food Chain – Types of food chain with examples, Food web, Ecological pyramid of biomes

Unit-IV: Aquatic Ecosystem

4.1 Introduction to freshwater, estuarine, and marine ecosystem

4.2 Status of global aquatic resources

4.3 Hydrological cycle

4.4Primary and secondary aquatic productivity

Unit-V: Ecosystem Analysis

5.1. Interspecific interactions, structured population dynamics and demographic effects

5.2. Meta population dynamics, MVP and PVA, small population paradigm,

5.3. Invasive species, habitat destruction and extinction vortex

5.4. Population risk analysis, conservation and ethics

Suggested Readings:

1. E.P. Odum and G.W. Barrett. 2005. Fundamentals of Ecology. Cengage Learning India Pvt. Ltd.

2. J.S. Singh, S.P. Singh and S.R. Gupta. 2008. Ecology, Environment & Resource Conservation. Anamaya Publications.

3. P.D.Sharma.2008. Ecology and Environment.Rastogi Publications

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Semester – I

Course Code: PGEVS1C005T **Credit: 4**

Course Title: Biodiversity and its conservation

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit-I: Introduction to Biodiversity

1.1 Introduction: Definition, History, Components and importance of Biodiversity
1.2 Biodiversity Climatic Zones, resources of India
1.3 Protected areas: biospheres, national parks, Wildlife sanctuaries conservation reserves, marine protected areas, zoological parks and botanical gardens
1.4 Biodiversity hotspots and their characteristic flora and fauna, threatened plants and animals of India

Unit-II: Levels and Types of Biodiversity

2.1 Levels of Biodiversity (alpha, beta and gamma)
2.2.Gradients of biodiversity (latitudinal, altitudinal and insular)
2.3 Species, Genetic and Ecosystem diversity
2.4 Biodiversity use - direct and indirect

Unit-III: Threats to Biodiversity

3.1. Threats to biodiversity: (a) natural process, (b) anthropogenic processes: habitat destruction, fragmentation, (c) exploitation and effect on target species,(d) land use and its impact
3.2. Impact of non-native / invasive species
3.3 Ecosystem degradation influences on biodiversity
3.4 Extinction of local population and its impacts

Unit-IV: Biodiversity and Conservation

4.1. Biodiversity conservation- In-situ and ex-situ conservation
4.2. Red Data Book (IUCN Red list category), Red Data Book of Indian Plants
4.3. Environment conservation organizations: CITES, IUCN, WWF, UNEP, GREEN PEACE, Man and Biosphere Programme
4.4. Bioprospecting

Unit V: Biodiversity Restoration

5.1. Principle, Definition, degradation, tools and methods for biodiversity restoration
5.2. Recreational and Ecotourism
5.3. Public participation, Case studies related to biodiversity conservation
5.4. Biodiversity Conservation Act, 2002.

Suggested Readings:

1. Botkin, Daniel B .and Keller, Edward A . Environmental Science : *Earth as a Living Planet*. 6th ed. John Wiley & Sons, USA. 2007
2. Enger, E.D. and Smith, B.F Environmental Science: *A Study of Interrelationships*. 11thed . McGraw Hill Inc, USA. 2006
3. Frankel, O.H. Brown A.H.D. and Burdon, J.J. *Conservation of Plant Diversity*. Cambridge University Press, UK. 1995.
4. Gadgil, Madhav and Rao, P.R.S. *Nurturing Biodiversity* : An Indian Agenda. Centre for Environment Education, Ahmadabad, India.
5. MeffeG.k. and C.RonalsCorrol(1994) Principles of Conservation Biology, Sinaur Associates, Inc. Sunderland. Massachusetts.

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Semester – I

Course Code: PGEVS1C00BT **Credit: 4**

Course Title: Energy Resources and its conservation

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Introduction to Energy

1.1 Definition, forms and classification of energy
1.2 Measurement of energy
1.3 Indian and global energy resources
1.4 Pattern of energy consumption

Unit II: Renewable Energy Resources-I

2.1 Source of Sun's Energy, solar spectrum, solar radiation, earths energy balance, harnessing of solar energy
2.2 Wind energy: wind power, harnessing of wind energy, hybrid wind energy systems
2.3 Principles of hydroelectric power generation, ocean energy (tides, waves, currents)
2.4 Sources, harnessing methods and potential of geothermal energy

Unit-III: Renewable Energy Resources-II

3.1 Types and composition of biomass
3.2 Conversion processes; biomass gasification and biogas production
3.3 Production of biofuels (ethanol and bio-diesel)
3.4 Energy from landfill gas, distillery waste, Sewage, and paper mill waste
3.5 Biotoilets

Unit IV: Non-Renewable Energy Resources

4.1 Coal; formation, types and reserves of coal; coal mining and utilization
4.2 Petroleum (oil and natural gas); formation and reserve of petroleum; Processing of crude oil
4.3 Nuclear energy; sources, fuels refining and enrichment, fuel cycle. Nuclear reactors for energy generation disposal and safety measures of radioactive wastes

Unit V: Conservation and Management of Energy

5.1 Environmental degradation due to energy production and utilization
5.2 Principles of energy conservation
5.3 Objectives and principles of energy management
5.4 Energy Audit: need, types, and methodology

REFERENCE BOOKS:

1. Craig. J.R., Vaughan. D.J., Skinner. B.J., Resources of the Earth: origin, use, and environmental impact, 2nd Ed. Prentice Hall, New Jersey.
2. Klee. G.A., Conservation of natural resources. Prentice Hall Publ. Co., New Jersey.
3. Owen. O.S. Chiras. D.D, Reganold. J.P. 1998, Natural resource conservation– Management for a sustainable future, 7thEd. Prentice Hall.
4. Anjaneyulu. Y. Introduction to Environmental Science. B. S. Publications.
5. D. Daniel Chiras. Environmental Science. 6th Ed.. Jones and Bartlett Publishers.
6. MukherjiShormila. Fragile environment. Manak Publication Pvt. Ltd.

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Semester – I

Course Code: PGEVS1E014T **Credit: 4**
Course Title: Waste Management
Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Composition of Wastes
1.1.Sources and types of wastes
1.2.Composition of wastes
1.3.Physical, chemical and biological properties of wastes
1.4.Factors affecting waste generation, Environmental and health hazards of waste

Unit II: Collection Techniques
2.1.Collection services: Government and Private sectors
2.2. Types of collection system, transfer and transport
2.3. Handling, separation and storage
2.4. Technical merits and demerits of existing techniques

Unit III: Treatment and Disposal Techniques
3.1. Composting: aerobic, anaerobic, vermin-composting
3.2. Anaerobic digestion: basics, Mechanism, Traditional digesters,
3.3. Thermal processing: Incineration, Pyrolysis, Gasification
3.4. Landfilling: site selection, techniques according to type of waste

Unit IV: Management of Hazardous Waste
4.1.Definition and characteristics,
4.2. Sources, types, treatment technologies,
4.3. Biomedical waste
4.4. E-waste and Radioactive waste

Unit V: Environmental Policies and laws for waste management
5.1: Biomedical Waste (Management and Handling) Rules, 1998; Hazardous Waste (Management and Handling) Rules, 1989; New Plastic Waste (Management and Handling) Rules, 2011; Environmental Protection (Fifth Amendment Rules), 2014.
5.2. Global scenario for waste management; Implementation plans and bottlenecks
5.3. Integrated waste management systems, Merits and demerits of treatment techniques
5.4. Sustainable development-principles and practices in relation to economics and ecology

Suggested Readings:

1. George Tchobanoglouset.al., "Integrated Solid Waste Management", McGraw-Hill Publishers, 1993.
2. Solid Waste Management Manual CPCB, New Delhi
3. Environmental Hazards-Smith, Keith

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Semester – I

Course Code: PGEVS1E010T **Credit: 4**
Course Title: Environmental Geosciences
Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Earth Processes

1.1 Brief geological history of the planet fundamental concepts
1.2 Primary differentiation and formation of core, mantle, crust, magma, generation, eruption and volcanoes
1.3 Formation and classification of rocks
1.4 Plate tectonics-sea floor spreading, mountain formation rock deformation and evolution of continents

Unit-II: Soil

2.1 Weathering and soil formation
2.2 Soil profile, soil classification, soils of India
2.3 Ice sheets and fluctuations of sea levels
2.4 Volcanism: component and types of volcanoes, volcanic materials, processes and effects of volcanism

Unit III: Geo-resources

3.1 Important ferrous and nonferrous metals, non-metallic and industrial minerals in India and in the world; mineral deposits through geologic time
3.2 Geo-indicators, resources and reservoirs
3.3 Mineral resources of J&K
3.4 Ocean as a new area for exploration of natural resources

Unit IV: Geological Agents

4.1 Factors affecting landform development
4.2 Fluvial system: factors affecting stream erosion, deposition, erosional and depositional land form
4.3 Underground water system-water table, land forms formed through ground water action
4.4 Aeolian system, Glacial System: mechanism of erosion, erosional and depositional land forms

Unit -V:Environmental Geochemistry

5.1 Atomic properties of elements, Periodic table and geochemical classification of elements
5.2 Abundance of elements in the bulk earth, crust, hydrosphere, atmosphere and biosphere
5.3 Introduction to mineral structures and compositions; thermodynamic classification of elements into essential, structural, major and trace elements
5.4 Mineral stability diagrams and controls on the chemistry' of natural waters

Suggested Readings:

1. Press &Seiver, The Earth, Frank Press
2. Skinner & Porter, Dynamic Earth, Wiley
3. Krauskopf, Introduction to Geochemistry, Mc-Graw Hill
4. Parbin Singh, Engineering & General Geology, S.K. Kataria& Sons

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Semester – I

Credit: 4

Course Code: PGEVS1E015T

Course Title: Introduction to Atmospheric Sciences

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit -I: Overview

1.1 History and evolution of the earth's atmosphere

1.2 Understanding the atmospheric strata

1.3 Measures of atmospheric composition: absolute concentration, fractional abundance and number density

1.4 Concept of meteorology, meteorological parameters: pressure, temperature, wind direction and wind speed, humidity and solar radiation

Unit-II: Atmospheric Thermodynamics and Radiative transfer

2.1 Understanding the laws of thermodynamics in atmosphere, the concept of air parcel, the dry adiabatic lapse rate

2.2 Moisture parameters: mixing ratio and specific humidity, saturation mixing ratios and vapour pressures, relative humidity; dew point and frost point

2.3 Lifting condensation level and normand's rule.

2.4 The spectrum of radiation and blackbody radiation laws

Unit - III: Atmospheric Cycles

3.1 The atmospheric sulfur cycle: natural and anthropogenic emission of SO_2 major pathways of sulphur compounds, reservoirs and burdens of sulphur, role of sulphate aerosols.

3.2 The atmospheric nitrogen cycle: nitrogen containing compounds, natural and anthropogenic processes for nitrogen fixation. Inter conversion among species, nitrous oxide and its sources, oxides of nitrogen and reactive odd nitrogen in atmospheric chemistry.

3.3 The global carbon cycle: the global mean atmospheric CO_2 level, the flux of carbon between various reservoirs, the six compartment model of carbon cycle.

3.4 The atmospheric oxygen cycle: odd oxygen chemistry, formation and destruction of ozone and OH radical.

Unit - IV: Particles in the lower atmosphere

4.1 Basic terminologies and properties of atmospheric particles

4.2 Spatial and temporal variations in aerosols

4.3 Reactions involved in particle formation and growth: nucleation, condensation and coagulation

4.4 Cloud processing of aerosols, concept of cloud condensation nuclei and ice particle nuclei

Unit-V: Behaviour of particles and gases in atmosphere

5.1 Atmospheric transport and diffusion of pollutants

5.2 Gas laws governing the behaviour of pollutants in the atmosphere.

5.3 The behaviour and categories of plume and effect of plume rise on ground level concentrations of atmospheric constituents.

5.4 The gaussian plume model and the derivation of the gaussian plume equation

Semester – I

Course Code: PGEVS1E016T Credit: 4

Course Title: ~~Metrology~~ Fundamentals of Meteorology

Duration of Examination: 3 Hours Maximum Marks: 100

Unit 1: Basic Concepts

1.1. Importance of meteorology, various branches of meteorology and their applications,
1.2. Meteorological elements; Atmospheric Pressure, Dry Bulb, Wet Bulb,
1.3. Atmospheric Moisture and its representation, DPT,
1.4. Virtual Temperature, Potential Temperature, equivalent Potential Temperature, Winddescription and measurement

Unit II: Atmospheric stability

2.1. Concept of lapse rates, Laws of thermodynamics, Concept of Geopotential height
2.2. Geostrophic wind, pressure-height curve,
2.3. Thermodynamic diagram ,Fog,
2.4. Clouds and precipitation, basic knowledge of their formation

Unit III: Weather Processes

3.1. Scales of weather systems, Indian summer monsoon,
3.2. Monsoon depressions, Easterly wave structure and associated weather,
3.3. Waves in mid-latitude westerlies, Western disturbance,
3.4. Jet streams around the globe and weather

Unit IV: Weather products analysis

4.1. Surface and upper air observations,
4.2. Analysis of fields of meteorological elements on synoptic charts,
4.3. Wind and pressure analysis: slope of pressure system,
4.4. Analysis of surface charts, Tephigram

Unit V: Climate change and Impacts

5.1. Basics of Climate Change,
5.2. Observed climate change over India and globe,
5.3. Global warming and its factors,
5.4. Possible causes and its impact on environment

Suggested Readings:

1. Monsoon Meteorology by C.P. Chang & T.N. Krishnmoorthy
2. Mesoscale Meteorological Modelling by Roger A. Pielke
3. Mesoscale Atmospheric Circulation by B.W. Atkinson
4. Atmospheric Turbulenceby Panofsky and J.A. Dutton.
5. Introduction to Boundary Layer Meteorology" Stull
6. The Atmospheric Boundary Layerby R.M. Stewart, WMO-523
7. Climate Change: The Science of Global Warming and Our Energy Future by Edmond Mathez
8. Tropical Meteorology Volume I & II by G.C. Asnani
9. Synoptic Meteorology by M.Kurz

Semester – I

Course Code: PGEVS1F010T **Credit: 2**

Course Title: Fundamentals of Ecology

Duration of Examination: 2 Hours **Maximum Marks: 50**

Unit-I: Introduction to Ecology

1.1 Four levels of ecological organization: Population, Community,Ecosystem and Biosphere.
1.2 Concept of food chain, food web, ecological pyramids, trophic structure,
1.3 Energy flow pathways; Concept of primary and secondary productivity
1.4 Shelford's law of tolerance, Liebig's law of minimum

Unit-II: Population Ecology

2.1 Characteristicsand attributes of population
2.2 Population growth vis-a-vis the concept of carrying capacity, s''& 'j' shaped growth curve, minimum viable population (MVP), metapopulation and model, extinction vortex, Population viable analysis (PVA).
2.3 Population interactions: positive and negative; Predator-prey relationship, Lotka –voltera equation. Concept of 'r' and 'k' species. Keystone species.
2.4 Population behaviour: Basic, regulatory, social and compensatory

Unit-III: Community Ecology

3.1 Concept of communities, concept of niche, edge effect, ecotypes, ecotone
3.2 Intra-community classification and the phenomenon of ecologicaldominance
3.3 Types of interactions – Commensalism, Mutualism, predation, parasitism and allelopathy.
3.4 Succession causes, trends and type of succession, climax community and types of climax.

Suggested Readings:

1. E.P. Odum and G.W. Barrett. 2005. Fundamentals of Ecology. Cengage Learning India Pvt. Ltd.
2. J.S. Singh, S.P. Singh and S.R. Gupta. 2008. Ecology, Environment & Resource Conservation. Anamaya Publications.
3. P.D.Sharma.2008. Ecology and Environment. Rastogi Publications

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Semester –II

Subject Course Code: PGEVS2C008T **Credits: 4**

Subject Course Title: Environmental Geology

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Basics of Environmental Geology

1.1 Definition; History of Environmental Geology;
1.2 Environmental Geology and Commercial reality;
1.3 The Tools of the Environmental geologist;
1.4 Critical thinking about the environment; internal structure of earth

Unit II: Geological Resources and Natural Hazards

2.1 Water resources;, Exogenic hazards;
2.2 Endogenic hazards; Engineering geology in extreme events.
2.3 hazard zonation of India, anthropogenic hazards;
2.4 impact assessment and role of geologists in disaster management plan.
2.5 Urban planning and geology

Unit III: Waste Management & Medical Geology

3.1 Waste management and geological environment;
3.2 Chronic diseases and geologic environment;
3.3 Landfilling wastes; Effluent treatment and disposal;
3.4 Waste gases and the atmosphere; elements related health diseases.

Unit IV: Global Warming

4.1 Concept of global warming, climate change and palaeo-climate;
4.2 increase of green house gases (due to industrialization, urbanization, volcanic activity and deforestation);
4.3 ozone layer depletion and its impact, suggestive measures,

Unit V: Mass Movements, Glaciers and Deserts

5.1 Mass movements: definition, causes, types (falls, slumps, slides, flows and avalanches)
5.2 and consequences; slope control and stabilization.
5.3 change of glaciers due to global warming and its consequences, Desertification,

Suggested Readings :

1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Valdiya, K.S., 1987. Environmental Geology - Indian Context. Tata McGraw Hill.
4. Keller, E.A., 1978. Environmental Geology, Bell and Howell, USA.
5. Patwardhan, A.M., 1999. The Dynamic Earth System. Prentice Hall.
6. Smith, K., 1992. Environmental Hazards. Routledge, London.
7. Subramaniam, v., 2001. Textbook in Environmental Science, Narosa International.

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Semester –II

Subject Course Code: PGEVS2C0D7T **Credits: 4**

Subject Course Title: Climatology

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit-I: Introduction

1.1 Introduction and subfields of climatology
1.2 A brief history of climate and the earth system
1.3 Link between climatology and meteorology,
1.4 spatial and temporal scales, normals, extremes and frequencies in climatology.

Unit-II: Governing Factors

2.1 Physical factors of climate and their inter-relationship,
2.2 Earth-sun relationship, ecliptic and equatorial plane
2.3 Rotation of the earth, seasons, climatic controls
2.4 Long term changes (Climate of Past century, past millennium, past glacial period).

Unit-III: Variability and Forcing

3.1 Climate variability and forcings;
3.2 Concept and types of feedback processes
3.3 Global seasonal variations in wind and pressure belts and its association with other spheres
3.4 General idea of internal dynamical processes of the atmosphere, oceanic processes, cryospheric processes and land processes

Unit-IV: Classification and circulations

4.1 Climatic variables and classification
4.2 Secondary circulations, upper and mid-level flow
4.3 Divergence and convergence, global warming and dimming
4.4 Methods of determining past climate.

Unit-V: Modelling

5.1 Climate monitoring and prediction
5.2 Future climate and potential consequences,
5.3 Definition and concept of climate models,
5.4 Simple climate model- 0D, 1D and 2D climate models.

Suggested Readings

1. Frederick K. Lutgens, Edward J. Tarbuck (2010): The Atmosphere: An Introduction To Meteorology, Phi (Prentice-hall New Arrivals), ISBN: 978-8120344150
2. Wallace John M. Jr., Peter V. Hobbs (2006): Atmospheric Science: An Introductory Survey, 2nd Edition, Academic Press, ISBN: 978-0127329512
3. John H. Seinfeld, Spyros N. Pandis (2006): Atmospheric Chemistry and Physics, John Wiley & Sons Inc., ISBN: 978-0-471-72018-8.

Semester –II

Subject Course Code: PGEVS2C009T **Credits: 4**

Subject Course Title: Environmental Pollution and Control

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Introduction

1.1 Air Pollution: Types, sources and classification of air pollutants
1.2 Effect of air pollution on plants, animals and human health.
1.3 General methods of control of air pollutants from mobile and stationary sources.
1.4 Air quality standards

Unit II: Water Pollution

2.1 Water Pollution: Types, sources and classification
2.2 Industrial effluents characteristics of effluents from different industries (pulp and paper mills, oil exploration and refinery) water quality standards proposed by national and international agencies
2.3 Estuarine pollution, marine pollution, Eutrophication – causes, effects and control measures
2.4 Waste water, characteristics-Domestic waste water, Sewage treatment: preliminary, primary, secondary and tertiary treatment; process description of aerobic and anaerobic processes: aerobic fixed film bed reactor, anaerobic fluidized bed reactor, Upflow Anaerobic Sludge Bed reactor (UASB)

Unit III: Noise and Radioactive Pollution

3.1 Noise Pollution: types, sources, consequences; measurement of noise pollution, threshold hearing level and abatement measures
3.2 Radio-active Pollution: types, sources and consequences
3.3 Biological effects of ionizing radiation's: the interactions of radiation's with cells – various stages, somatic and genetic effect; maximum permissible dose
3.4 Parameters affecting the radiation monitoring - personal monitoring equipment's; Disposal and management of radioactive waste

Unit IV: Soil Pollution

4.1 Sources of soil pollution: industrial effluents, fertilizers, pesticides, heavy metals and waste disposal
4.2 Effects of soil pollutants on flora , fauna and ground water
4.3 Solid-waste Pollution: types, sources and consequences
4.4 Waste management practices

Unit-V: Thermal, Oil and E-waste Pollution

5.1 Thermal pollution : sources, impact and control
5.2 Oil pollution ;sources of oil spillage and impact, factors effecting fate of oil spillage
5.3 E-waste : generation, sources, types and constituents; environmental consequences and management of E-waste
5.4 Bio indicators of Pollution

Semester –II

Subject Course Code: PGEVS2E009T **Credits: 4**

Subject Course Title: Energy From Wastes

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Energy From Waste

1.1 Introduction to waste to energy conversion: Waste to energy (WTE): An introduction
1.2 Environmental and social impacts of waste to energy (WTE) conversion plants
1.3 Recovery of energy from municipal solid waste and industrial waste,
1.4 Energy generation from waste: Refuse Derived Fuel (RDF)

Unit II: Conversion of Biomass to Energy

2.1 Biochemical conversions of industrial waste and agro residues for energy generation
2.2 Anaerobic digestion- biogas production; types of biogas plant
2.3 Thermochemical conversions: sources of energy generation,
2.4 Environmental impacts of biochemical and thermochemical conversion

Unit III: Biomass Energy

3.1 Sources of biomass energy, Petroleum plants, Energy plantation
3.2 Classification and generations of biofuel
3.3 Policy issues in biofuels, Indian Biofuel Programme
3.4 Advantages and disadvantages of biofuels, Recent Trends in biofuel production

Unit IV: Liquid Biofuels

4.1 Ethanol production from starch, sugar materials and lignocellulosic biomass
4.2 Ethanol and Biodiesel production from algae
4.3 Biodiesel fuel, origin, chemical and physical properties
4.4 Biodiesel production from Jatropha, cooking oil

Unit V: Gaseous and Solid Biofuels

5.1 Biogas and methane production from organic waste
5.2 Hydrogen production from organic waste and algae
5.3 Synthetic natural gas
5.4 Wood, charcoal, Briquetting; utilization and advantages of briquetting

Reference Books:

1.Martin Alexander. Biodegradation and Bioremediation. Academic press: 2nd edition, 1999
2.Kothari, D.P., Singal, K.C. and Ranjan, R. 2008. Renewable Energy Sources and Emerging Technologies, Prentice hall, New Delhi.
3. Armstrong, F. and Blundell, B. K. 2007. Energy beyond oil, Oxford, New York.
4. Bhojvaid, P.P. 2007. Biofuels Towards a Greener and Secure Energy Future Teri Press, New Delhi.
5. Klinghoffer, N. and Castaldi, M. 2013.Waste to Energy Conversion Technology. WoodheadPublishig

Semester –II

Credits: 4

Subject Course Code: PGEVS260107

Subject Course Title: Geochemistry

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Introduction to Geochemistry

1.1 The history of Geochemistry, The periodic table, chemical bonding.
1.2 States of matter, and atomic environments of elements,
1.3 Geochemical classification and Mobility of elements.

Unit II: Geochemical Cycles

2.1 The formation of solar system, the Earth in the solar system
2.2 Composition of-the bulk Silicates, meteorites. Geochemical behaviour of selected elements like Fe, Ni, Si, Al etc.
2.3 Basic concept of biogeochemical cycling,concept of reservoirs and fluxes.

Unit III: Soil Geochemistry

3.1 Thermodynamic classification of elements into essential, structural, major and trace elements
3.2 Partitioning of element during mineral formation; chemical reactions involving proton and electron transfers.
3.3 Factors controlling Soil formation, Soil major nutrients and Trace elements,
3.4 Effects of modern agriculture on soil geochemistry.

Unit IV: Geological Processes and Geochemical Sampling

4.1 Sampling and Geochemical sample preparation.
4.2 Geological processes and their geochemical signatures,
4.3 Abundance of elements in the bulk earth, crust, hydrosphere, atmosphere and biosphere.

Unit V: Chemical Weathering and Isotope Geochemistry

5.1 Chemical weathering of rock-forming minerals,
5.2 Paleosols and past climate.
5.3 Health aspects of geochemistry in modern environment,
5.4 Radioactivity, decay of parent and growth of daughter nuclides and methods of radiometric dating,
5.5 Stable isotopes, their fractionation and application to paleoclimates.

Book References:

1. Faure, G (1998) Principles and Applications of Geochemistry. 2nd Edition Prentice- Hall, New Jersey
2. Hoefs, J (1986) Stable isotope geochemistry 3rd edition. Spriger- Verlag, Berlin.
3. Mason, B (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
4. Holme (1992). Principles of Physical Geology. Chapman & Hall.

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Semester –II

Subject Course Code: PGEVS2E011T **Credits: 4**

Subject Course Title: Advances in Atmospheric ~~Sciences~~ Environment

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit-I: Emerging field of bio-aerosols

1.1 Definition, nature, sources and types of bio-aerosols
1.2 Traditional methods of characterization: cultivation and microscopy
1.3 Modern methods of analysis: molecular techniques, optical and non-optical methods
1.4 Atmospheric transport of bio-aerosols

Unit-II: Carbonaceous aerosols

2.1 Carbonaceous aerosols and their composition
2.2 Major compound classes and atmospheric tracers used in source apportionment
2.3 Methods for determination of carbonaceous aerosol components: TC, OC and EC
2.4 Recent advances in carbonaceous aerosol research

Unit-III: Application of chemical transport and statistical models

3.1 Air quality parameters and the concept of Air Quality Index (AQI)
3.2 Source apportionment methods and their importance
3.3 Types of Atmospheric Chemical Transport Models
3.4 Box Models: The Eulerian and Lagrangian Box Model

Unit-IV: Understanding the aerosol - climate change connection

4.1 Optical properties of aerosols
4.2 Aerosol scattering and colors in the atmosphere
4.3 Hygroscopic properties of aerosols, homogeneous and heterogeneous nucleation
4.4 Influence of aerosols on the climate system

Unit-V: Aerosols and climate in the Himalayan region

5.1 Concept of atmospheric brown clouds
5.2 Black Carbon and its impact on Himalayan glaciers
5.3 Biomass burning: causes of biomass burning and its impacts on climate.
5.4 Effect of Climate Change on the Himalayan Ecosystem

References:

4. Gelencsér, A, (2004) Carbonaceous Aerosol, Springer, The Netherlands.
5. Seinfeld, J.H., Pandis, S.N., (2006): Atmospheric Chemistry and Physics: From Air Pollution to Climate Change.Awileyinterscience publication.
6. Gilbert, M. Masters &Ela, W. P. (2007): Introduction to Environmental Engineering and Science. PHI learning Pvt Ltd
7. Andrews, D. G. (2010): An introduction to atmospheric physics, 2nd Edition, Cambridge university press.

Semester –II

Subject Course Code: PGEVS2E012T **Credits: 4**

Subject Course Title: Advances in Meteorology and its Applications

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit-I: Introduction

1.1. Meso-scale meteorology,
1.2. sea and land breezes,
1.3. Mountain/valley winds, mountain wave,
1.4. satellite, radar observations,

Unit-II: Satellite Meteorology

2.1. Meteorological satellites, Current and future meteorological satellites of the world,
2.2. Characteristics of various channels,
2.3. Identification of typical clouds and weather systems from cloud imageries,
2.4. Use of various satellite-derived products.

Unit-III : Weather Radars

3.1. Introduction to Weather radars,
3.2. Different frequency bands used in the weather radars and their applications,
3.3. Principle of Doppler Weather radar,
3.4. Derived DWR products, DWR and its application in prediction.

Unit-IV: Weather Monitoring tools

4.1. Principle of Radiosonde,
4.2. RS/RW observation, Meteorological Balloons, AWS,
4.3. Introduction to Windprofiler,
4.4. Global climatological observing System (GCOS System)

Unit-V: Numerical Weather Prediction

5.1.NWP, Global Forecast System,
5.2. Regional and mesoscale forecast system,
5.3. Nowcast model, Different NWP products; Direct and Derived,
5.4. Post processing of model output, NWP Application in severe and depression systems.

Reference Books:

1. Monsoon Meteorology by C.P. Chang & T.N. Krishnmoorthy
2. Mesoscale Meteorological Modelling by Roger A. Pielke
3. Mesoscale Atmospheric Circulation by B.W. Atkinson
4. Tropical Meteorology" by T.N. Krishnamurthy, WMO Publication.
5. Introduction to Boundary Layer Meteorology" Stull
6. The Atmospheric Boundary Layerby R.M. Stewart, WMO-523
7. Climate Change: The Science of Global Warming and Our Energy Future by Edmond Mathez
8. Tropical Meteorology Volume I & II by G.C. Asnani
9. Synoptic Meteorology by M.Kurz

Semester –II

Subject Course Code: PGEVS2E013T **Credits: 4**

Subject Course Title: Geomorphology and Himalayan Geology

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit-I : Evolution of landforms

1.1 Fundamental concepts of geomorphology; drainage patterns
1.2 Earth surface features, Landforms and their evolution: structural and lithological control
1.3 Detailed study of geological processes involved in the building of land forms
1.4 General degradational processes, processes of rock weathering and their effects on landform

Unit-II : Geological Processes

2.1 Mountain building processes
2.2 Geosynclines, evolution, classification and significance
2.3 Fluvial processes and landforms, morphology of ocean floor
2.4 Glacial and Aeolian processes and landforms

Unit-III : Soils, Karst topography, slope instability

3.1 Soils, their development and types
3.2 Processes and features of karst geomorphic cycle
3.3 Mass movements - causes
3.4 Hill slope instability, controls and mitigation

Unit-IV : Evolution of Himalayas

4.1 Geological and Geographical sub-divisions of Himalayas
4.2 Origin of Himalayas, different phases in evolution of Himalayas
4.3 Study of major groups and formations of Himalayas
4.4 HFF (Himalayan frontal fault), MBT (main boundary thrust), MCT (main central thrust)

Unit-V : Seismology

5.1 Seismology: seismic waves
5.2 Intensity and isoseismic lines, earthquake belts
5.3 Earthquake zones of India, Seismograph
5.4 Neo-tectonics and causes of earthquakes

Suggested Readings

1. Duff. D. (1993). Homes' Principles of Physical Geology, 4 th Ed. Chapman & Hall. London.
2. Leet, L.D. and Judson, S. (1969). Physical Geology, 3rd Ed. Prentice Hall of India, New Delhi.
3. K.S. Valdiya (1998). *Dynamic Himalaya* Orient Blackswan.
4. K.S. Valdiya (1998). Aspects of Tectonics Tata-McGraw Hill, New Delhi.
5. E.W.Spencer (1972) Dynamic of earth, 5th Ed. John Wiley & Sons: London.

Semester –II Credits: 2

ourse Code: PGEUS2F0D9T

Course Title: Fundamentals of Earth and Environmental Sciences

on of Examination: 2 Hours Maximum Marks: 50

t-I: Introduction to Origin of Earth

1.1 General characteristics and origin of the Universe, Solar System and its planets, Plate tectonics, Mountain building, Detailed Classification of igneous, sedimentary and metamorphic rocks.

1.2 Primary differentiations of the earth and Interior of earth

1.3 Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arc, geological time scale

1.4 Earthquake and Distribution of earthquake belts

Unit-II: Geomorphology and Oceanography

3.1 Basic concepts of geomorphology

3.2 Introduction to global geomorphology and overview of Indian geomorphology

3.3 Minerals: definition and classification, physical and chemical composition of common rock forming minerals.

3.4 Basics of crystal symmetry,basics of hydrosphere and its component, Elementary Oceanography, chemical composition of ocean

Unit-III: Geological Hazards and Engineering Geology

4.1 Geology vs. Engineering

4.2 Environmental considerations related to civil engineering projects

4.3 Construction materials

4.4 Geological hazards (landslides and earthquakes) their significance, causes and preventive/remedial measures,

4.5 Scope of hydrogeology and its societal relevance, Geological formations as aquifers, types of aquifers, geological classification of aquifers, springs

Reference Books

1 Singh, S. 1998. Geomorphology. Prayag PustakBhavan, Allahabad.

2 Todd, D.K. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.

3 Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

4 Press and Siever, The Earth; W.H. Freeman

5 Skinner & Porter, The Dynamic Earth; Wiley

6 Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.

7 C.M.R. Fowler, The solid earth: An introduction to Global Geophysics, Cambridge University Press, 2005.

Semester –II

Subject Course Code: **Credits: 4**

Subject Course Title: Environmental Geology

Duration of Examination: 3 Hours **Maximum Marks: 100**

Unit I: Basics of Environmental Geology

Definition; History of Environmental Geology; Environmental Geology and Commercial reality; The Tools of the Environmental geologist; Critical thinking about the environment; internal structure of earth

Unit II: Geological Resources and Natural Hazards

Water resources;, Exogenic hazards; Endogenic hazards; Engineering geology in extreme events. hazard zonation of India, anthropogenic hazards; impact assessment and role of geologists in disaster management plan. Urban planning and geology

Unit III: Waste Management & Medical Geology

Waste management and geological environment; Chronic diseases and geologic environment; Landfilling wastes; Effluent treatment and disposal; Waste gases and the atmosphere; elements related health diseases.

Unit IV: Global Warming

Concept of global warming, climate change and palaeo-climate; increase of green house gases (due to industrialization, urbanization, volcanic activity and deforestation); ozone layer depletion and its impact, suggestive measures,

Unit V: Mass Movements, Glaciers and Deserts

Mass movements: definition, causes, types (falls, slumps, slides, flows and avalanches) and consequences; slope control and stabilization. change of glaciers due to global warming and its consequences, Desertification,

Suggested Readings :

1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Valdiya, K.S., 1987. Environmental Geology - Indian Context. Tata McGraw Hill.
4. Keller, E.A., 1978. Environmental Geology, Bell and Howell, USA.
5. Patwardhan, A.M., 1999. The Dynamic Earth System. Prentice Hall.
6. Smith, K., 1992. Environmental Hazards. Routledge, London.
7. Subramaniam, v., 2001. Textbook in Environmental Science, Narosa International.

जम्मू केंद्रीय विश्वविद्यालय
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Rahya- Suchani (Bagla), District Samba – 181143, Jammu (J&K)

No. 4-1/EVS/CUJ/Reg/2020/

January, 2020

NOTIFICATION No. / 2020

Sub: Course Matrix and Syllabus Notification of **Ph.D.** in **Environmental Sciences** w.e.f. Academic Session 2019-20 – Reg.

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It is hereby notified for the information of all concerned that on the recommendation of the Board of Studies, Department of Environmental Sciences and School Board, School of Life Sciences, the Academic Council has approved following **Course Scheme** and **Syllabus** of Ph.D. in Environmental Sciences w.e.f. Academic Session **2019-20**.

Course Code	Course Title	Credit	ESE	Max. Marks
	Compulsory Course			
PHEVS1C001T	Research Methodology	4	100	100
PHEVS1C002T	Advanced tools and techniques in Environmental Sciences	4	100	100
PHEVS1C003T	Current Environmental Issues and Challenges	4	100	100
	Specialized Courses (Any One)			
PHEVS1E001T	Advanced Atmospheric Chemistry	4	100	100
PHEVS1E002T	Advances in Microbiology & Bioprocesses			
PHEVS1E003T	Advances in Geochemistry			
PHEVS1E004T	Atmospheric Processes & Climate Change			
PHEVS1E005T	Bioenergy and Nanomaterials			
	Total	**16**	-	**400**

Deputy Registrar
(Admin – HR)

Encl: Syllabus of Ph.D

To:
Head, Department of Environmental Sciences

Copy to:
OSD (Exam)

Ok
30/01/2020

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CENTRAL UNIVERSITY OF JAMMU
Syllabus for PhD in Environmental Sciences

Semester-I
Academic Year 2019-20
Subject course Code: PHEVS1C001T
Subject Course Title: Research Methodology
Duration of examination: 3 Hours **Maximum Marks: 100**
Credits:4 **Contact Hours/Week: 4**

UNIT-I
Meaning, objectives, types and significance of Research; Research approaches, Research methods; Overview of Moral and Ethical questions in Scientific writing; Introduction to Intellectual Property Rights (IPR); Defining uncertainty of measurements, validation of method, calibration of method; QA/QC parameters in environmental sciences, use of CRMs, Inter-laboratory comparison exercise, participation in National and International round Robin tests; Citation analysis.

UNIT-II
Probability distribution and their properties, Normal, Poisson and Binomial distribution, sampling and test of significance, parametric and non-parametric test, correlation and regression, Error analysis.

UNIT-III
Introduction to philosophy: definition, nature and scope, concept; branches; Ethics: definition, moral philosophy, nature of moral judgements and reactions.

UNIT-IV
Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP); Redundant publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data.

UNIT-V
Publication ethics: definition, introduction and importance; Best practices/ standards setting initiatives and guidelines: COPE, WAME etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributorship; Identification of publication misconduct, complaints and appeals; Predatory publishers and journals.

Suggested **Readings**

1. Principles of biometry by Charles M. Wolf
2. An Introduction to Geographical Information Systems, by Ian Heywood
3. Text book of quantitative chemical analysis by Vogel, I & Mendham, J. Vogel's
4. Practical Handbook of spectroscopy by James W. Robinson
5. Introduction to computers by P.K.Sinha
6. Quantifying Uncertainity in Analytical Measurement by Ellison and William
7. The Fitness for purpose of Analytical methods by Eurachem Guid

CENTRAL UNIVERSITY OF JAMMU
Syllabus for PhD in Environmental Sciences

Semester-I
Academic Year 2019-20
Subject course Code: PHEVS1C00...T
Subject Course Title: Current Environmental Issues and Challenges
Duration of examination: 3 Hours **Maximum Marks: 100**
Credits:4 **Contact Hours/Week: 4**

UNIT I

Global Environmental Issues: Biodiversity loss, Climate change, Ozone layer depletion, Sea level rise, International efforts for environmental protection, Carbon sequestration and carbon credits.

UNIT II

National Action Plan on Climate Change: Eight National missions – National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a 'Green India', National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change; Waste Management – Swachha Bharat Abhiyan; Green Building, GRIHA Rating Norms.

UNIT III

Environmental Conventions and Agreements: Stockholm Conference on Human Environment 1972, Montreal Protocol, 1987, Conference of Parties (COPs), Basel Convention (1989, 1992), Ramsar Convention on Wetlands (1971), Earth Summit at Rio de Janeiro, 1992, Agenda-21, Global Environmental Facility (GEF), Convention on Biodiversity (1992), UNFCCC, Kyoto Protocol, 1997, Clean Development Mechanism (CDM), Earth Summit at Johannesburg, 2002, RIO+20, UN Summit on Millennium Development Goals, 2000, Copenhagen Summit, 2009. IPCC, UNEP, IGBP.

UNIT IV

Environmental Disasters: Minamata Disaster, Love Canal Disaster, Bhopal Gas Disaster, 1984, Chernobyl Disaster, 1986, Fukushima Daiichi nuclear disaster, 2011; Australian Bush fire (2019)

UNIT V

Environmental policies and Laws (Indian): National Environment Policy, 2006; National Action Plan on Climate Change, 2008; National Green Tribunal Act, 2010; Environment Protection Act, 1986; The Water (Prevention and Control of Pollution) Act, 1974; The Air (Prevention and Control of Pollution) Act, 1981; Hazardous Wastes (Management , Handling and Transboundary Movement) Rules, 2008; Vehicular emission norms in India.

Suggested Readings:

1. Sharma, P. D., and P. D. Sharma. Ecology and environment. Rastogi Publications, 2012.
2. De, A. K. "Environmental chemistry 7th edn." New Age International Publications, New Delhi (2010)
3. Garg, V.K., Bishnoi, M.S., and Malik, C.P. Environmental Policies and Laws. Kalyani Publishers, 2002
4. Leelakrishnan, P. Environmental law in India. LexisNexis, 2016.
5. Sharma, B. K., and H. Kaur. "Environmental Chemistry, Meerut." India, Krishna Prakashan (1994).
6. Singh, S., Allen, T., Tyagi, R.K. Basic Environmental Sciences for Under Graduates. Vayu Education

CENTRAL UNIVERSITY OF JAMMU

Syllabus for PhD in Environmental Sciences

Semester-I
Academic Year 2019-20
Subject course Code: PHEVS1C00...T
Subject Course Title: Advanced tools and techniques in Environmental Sciences
Duration of examination: 3 Hours **Maximum Marks: 100**
Credits:4 **Contact Hours/Week: 4**

UNIT I:
Standard protocol for sampling of air, water and soil for chemical analysis; Gravimetric analysis and Volumetric analysis; Principle, structure and working of pH meter; Conductivity meter; Nephelometer; Bomb calorimeter; Sound level meter; thermal gravimetric analysis (TGA)

UNIT II:
Basics of chromatography; Paper chromatography, thin layer chromatography and column chromatography; Gas chromatography (GC), Gas chromatography–mass spectrometry (GC-MS); High Pressure Liquid Chromatography (HPLC); Ion chromatography

UNIT III:
Basics of spectrometry; UV-Visible spectrophotometer, Flame photometer, Atomic absorption spectroscopy (AAS); Inductively coupled plasma atomic emission spectroscopy (ICP-AES); Inductively coupled plasma mass spectrometry (ICP-MS)

UNIT IV:
Basics of microscopy; Phase contrast, Fluorescent and Electron microscopy; Scanning electron microscope (SEM); Transmission electron microscope (TEM); X-ray florescence (XRF); X-ray diffraction (XRD); Nuclear magnetic resonance spectroscopy (NMR); Fourier transform infrared (FTIR); Eletrophoresis

UNIT V:
Earth approximation and coordinate system, data types and management in geospatial techniques, GPS functioning to estimate the position, Digitization, editing and map preparation in GIS platform, Sensor and data processing in remote sensing, Spectral signature, Image enhancement, Vegetation type and hazard zone mapping using remote sensing technique

CENTRAL UNIVERSITY OF JAMMU

Syllabus for PhD in Environmental Sciences

Semester-I

Academic Year- 2019-20

Subject course Code: PHEVS1E001T

Subject Course Title: Advanced Atmospheric Chemistry

Duration of examination: 3 Hours **Maximum Marks: 100**

Credits: 4 **Contact Hours/Week: 4**

UNIT-I:

The Layers of the Atmosphere and their chemical composition, Expressing the amount of a Substance in the Atmosphere, Variation of Pressure and Temperature with Height in the Atmosphere, Energy Balance for Earth and Atmosphere, Beer-Lambert Law and the concept of Optical Depth.

UNIT-II:

Chemistry of Nitrogen in troposphere: Sources and chemistry of NO_x and NO_y, Chemistry of Sulphur in troposphere: Sources and chemistry of SO_x, Chemistry of Carbon in troposphere: Sources and chemistry of CO, CO_2, CH_4 and Non-methane Hydro Carbons Chemistry of Oxygen in troposphere: ODD oxygen chemistry, formation of Ozone and OH^* radicals, Influence of Meteorology on the concentration of Atmospheric constituents

UNIT-III:

Physical Properties and Chemical Composition of Atmospheric Aerosols, Interaction of Light with Particles, Role of Atmospheric Aerosols in Global Climate Change

UNIT - IV:

Techniques for Sampling of Atmospheric Gases, Sampling of Atmospheric Aerosols, Real-Time Monitoring Techniques for Atmospheric Gases, Real-Time Monitoring Techniques for Atmospheric Aerosols

UNIT - V:

Analytical techniques in atmospheric chemistry: Elemental (CHNSO) Analyzer, Thermo-Optical (TOR/TOT) Carbon Analyzer, Atomic Absorption Spectrophotometer (AAS), Inductively Coupled Plasma - Atomic Emission Spectrophotometer (ICP-AES), and Inductively Coupled Plasma – Mass Spectrometer (ICP-MS), Ion Chromatography System (ICS), Gas Chromatography System (GCS) and Gas Chromatography – Mass Spectrometer (GC-MS), X-Ray Diffractometer (XRD) and X-Ray Florescence Spectrometer (XRF)

Text Books:

1. Finlayson-Pitts, B.J., Pitts J.N., J., (2000): Chemistry of the upper and lower atmosphere-Theory experiments and applications. Academic Press, US.
2. Seinfeld, J.H., Pandis, S.N., (2006): Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, Atmospheric Chemistry and Physics.
3. Wallace John M. Jr., Peter V. Hobbs (2006): Atmospheric Science: An Introductory Survey, 2nd Edition, Academic Press, ISBN: 978-0127329512
4. Frederick K. Lutgens, Edward J. Tarbuck (2010): The Atmosphere: An Introduction To Meteorology, Phi (Prentice-hall New Arrivals), ISBN: 978-8120344150
5. Gilbert, M. Masters & Ela, W. P. (2007): Introduction to Environmental Engineering and Science. PHI learning Pvt Ltd.
6. Standard Methods for Examination of Water and Waste Water. APHA, AWWA, WEF, 21 Ed, 2005
7. Vogel, I & Mendham, J. (2000): Vogel's Text book of quantitative chemical analysis. Prentice Hall Publication.

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CENTRAL UNIVERSITY OF JAMMU

Syllabus for PhD in Environmental Sciences

Semester-I

Academic Year 2019-20

Subject course Code: PHEVS.....

Subject Course Title: Advances in Microbiology and Bioprocesses

Duration of examination: 3 Hours **Maximum Marks: 100**

Credits: 4 **Contact Hours/Week: 4**

Unit- 1

Historical overview of microbiology, Industrially important microorganisms, Isolation, purification and preservation of microbes techniques; Cell culture techniques- aseptic transfer; Methods of determining microbial growth; factors affecting microbial growth; types of microbial growth.

Unit-II

Fermentation equipment's and its uses, Fermenter designs, Aerobic and anaerobic fermentation, Types of fermentation: batch, continuous, submerged, solid state, Consolidated bioprocessing.

Unit-III

Landfill classification, design and operation of sanitary landfills, Landfill bioreactors, Methane mitigation: biofilteration and biotarp, Biosorption; microbial biosoprtion; mechanism of biosorption and bioaccumulation, Case studies related to bioremediation.

Unit-IV

Environmental clean-up technologies, Biodegradation: Factors affecting on process of biodegradation, Microbial degradation of naturally occurring compounds- cellulose, lignin,

hydrocarbons, Biodegradation of oil and petroleum products, Biodegradation of agricult chemicals.

Unit-V

Microbes in ethanol production from biomass, Microbes in biogas production, Microbes i reclamation of polluted sites, Microbes in human welfare, Vermi-composting.

Reference Books:

1. Prescott, L. M., Harley, 3. P., and Klein, D. A., Microbiology, 2nd Edition, Wm. C. Brown Publishers, Dubuque, Iowa, 1993
2. Purohit, S.S., Microbiology- Fundamentals and Applications, 7th Edition, Agrobios (Inida) Publisher, 2017
3. Stanbury,P.F., Whitaker, A., Hall, S.J. Principles of Fermentation Technology, 3rd Edition, 2016
4. Martin Alexander. Biodegradation and Bioremediation. Academic Press; 2nd edition (April 15, 1999)
5. Das, S., Microbial Biodegradation and Bioremediation. Elsevier press, 1st edition, 2014

CENTRAL UNIVERSITY OF JAMMU
Syllabus for PhD in Environmental Sciences

Semester-I
Academic Year 2019-20
Subject course Code: PHEVS1E003T
Subject Course Title: Advances in Geochemistry
Duration of examination: 3 Hours **Maximum Marks: 100**
Credits: 4 **Contact Hours/Week: 4**

Unit I:
Primary differentiation of the earth and the formation of crust, mantle and core. Weathering and soil formation, Sea water; Components of marine sediments, Isotope Geochemistry: stable Isotopes, Radioactive isotopes; Physical properties of sediments, Oxygen and Redox chemistry, Distribution of element as provenance Indicator.

Unit II:
Porewater alkalinity Titration, Chemistry of natural waters, physical chemistry of dissolved materials in water, Eh, pH and stability diagram, Transport processes; sediment diagenesis, sediment organic geochemistry, processes at the sediment water interface, Grain size Analysis, Organic matter as provenance indicator.

Unit III:
Geochemical classification of elements; abundance of elements in the bulk earth, crust, hydrosphere, atmosphere and biosphere; Biogeochemical processes in sediments, Carbon and nutrient remineralization, Geochemical indicators of Environment change, Global cycles of Carbon and Sulfur, sedimentation, effects of modern agriculture on sediment and soil geochemistry

Unit IV:
Modern Analytical Methods in Geoscience; Bulk (Non-Position Sensitive) methods: Classical Wet Chemical Methods, AAS, AES, XRFA, MS. Beam(Position-Sensitive) Methods; SIMS, LA-ICP-AES, LA-ICP-MS, EPMA.

Unit V:
Sampling and Geochemical sample preparation. ACNK and ACNKFM Diagrams, Interpretation of XRD,XRF,ICP-OES, ICP-MS and IC data for Environmental components (Rock, Sediment and Water); Health aspects of sediment geochemistry in modern environment,

Suggested Readings:

1. Potts, P.J. A Handbook of Silicate Rock Analysis, Blackie, London, 1987.
2. Thompson, M. and Walsh, J.N. A Handbook of Inductively Coupled Plasma Spectrometry, Blackie, London, 1983.
3. Van Loon, J.C. Analytical Atomic Absorption Spectroscopy, Academic Press, London, 1980.

4. Jeffery, P.G. and Hutchinson, D. Chemical Methods of Rock Analysis, 'Pergamon Press, Oxford, 1981.

5. Rollinson, H.R. Using Geochemical Data, Longman, New York, 1993

6. William M. White, Geochemistry; Wiley-Blackwell

7. Press and Siever, The Earth; W.H. Freeman

8. Skinner & Porter, The Dynamic Earth; Wiley

9. Mcsween,Richardson,Uhle, Geochemistry Pathways and Process; Columbia University Press.

10. Ray C. Lindholm: A Practical Approach to Sedimentological Analysis

CENTRAL UNIVERSITY OF JAMMU
Syllabus for PhD in Environmental Sciences

Semester-I
Academic Year 2019-20
Subject course Code: PHEVS1E004T
Subject Course Title: Atmospheric Processes and Climate Change
Duration of examination: 3 Hours **Maximum Marks: 100**
Credits: 4 **Contact Hours/Week: 4**

Unit-I

Structure and composition of the atmosphere, Humidity Parameters, Virtual Temperature, Stable and Instable atmosphere, Entropy, Potential Temperature, Equivalent Potential Temperature, Thermodynamic Diagrams. Precipitation process.

Unit-II

Tropical Meteorology: Hadley cell, trade winds, trade wind inversion, tropical convection, equatorial trough, ITCZ, easterly waves, tropical weather events, quasi-biennial oscillation (QBO). Monsoon, Rossby Waves, Madden-Julian oscillation(MJO), Elnino and Southern Oscillation (ENSO).

Unit-III

Boundary layer evolution and properties, Taylor's hypothesis, Eddy transport of momentum, Heat and moisture, TKE Budget; Stability concepts-Richardson number, Obhukhov length, Ekman layer, Boundary-layer profiling.

Unit-IV

Atmospheric Radiation and scattering (Raleigh and Mie scattering), Absorption spectra of atmospheric gases, Aerosols: Sources and Sinks, Characterisation of Aerosols, Reynold's number, Direct and Indirect Radiative Effects of Aerosols, Aerosol Measurement Techniques, Satellite Remote Sensing of Aerosols, Aerosols and Regional Climate

Unit-V

Climate system, factors for climate change, factors across different time scales and their interaction, climate modelling, Global circulation Models (GCM), Basic concepts of numerical weather prediction, Global Dimming versus Global Warming, Potential social, economic and environmental consequences of climate change.

Suggested Readings:

1. Monsoon Meteorology by C.P. Chang & T.N. Krishnmoorthy
2. Mesoscale Meteorological Modelling by Roger A. Pielke
3. Mesoscale Atmospheric Circulation by B.W. Atkinson
4. Atmospheric Turbulenceby Panofsky and J.A. Dutton
5. Introduction to Boundary Layer Meteorology" Stull
6. The Atmospheric Boundary Layerby R.M. Stewart, WMO-523
7. Climate Change: The Science of Global Warming and Our Energy Future by Edmond Mathez
8. Tropical Meteorology Volume I & II by G.C. Asnani
9. Synoptic Meteorology by M.Kurz

Ph.D Course work: Specialized subject (Newly Introduced)

Syllabus for the Ph.D. Programme in Environmental Sciences

Applicable for the Academic year 2019-2020

Subject Course Code No. .....

Subject Course Title: Bioenergy and Nanomaterials **Duration of Examination: 3 Hours**

Maximum Marks: 100 **Credits: 4** **Contact Hours / Week: 4**

UNIT-1 : Basics of Biomass and bioenergy

1.1. Biomass– types and potential; Energy crops.

1.2. Bioconversion processes: Biomass characterization; Biomass pyrolysis and gasification; Composting. Fermentation

1.3. Biofuels: Type of feedstocks for biofuels; Pellets and bricks of biomass: Biomass based thermal power plants; Biomass as boiler fuel;

1.4. Social, economic and ecological implications of biomass energy.

UNIT-2 : Waste and their treatment options

2.1. Waste treatment and disposal: Aerobic composting, incineration, different type of incineration: Advantages and disadvantages

2.2. Land-fill classification, types, methods, layout and preliminary design of landfills: movement and control of landfill leachate and gases, Advantages and disadvantages

2.3. Agricultural residues and wastes including animal wastes; industrial wastes; municipal solid wastes: waste processing-size reduction (Incinerators, gasifiers and digestors) and separation;

2.4. Waste management hierarchy: waste minimization and recycling processes of solid waste.

UNIT-3: Hydrogen: Future energy source

3.1. Introduction of hydrogen energy systems: Properties of hydrogen as fuel.

3.2.Hydrogen Production methods-current uses, general introduction to infrastructure requirement. optimized process parameters and hydrogen production plants.

3.3.Fuel cells: applications and types. Relative merits and demerits.

3.4. Hydrogen energy storage: materials; merits and demerits

UNIT-4 : Bioenergy options

4.1. Biogas: availability of raw materials; Production methods, and different type of digesters, operational parameters

4.2. Bio-diesel: availability of raw materials; Production methods, and different type of digesters. operational parameters; Fuel quality standards and properties.

4.3. Applications of Bioenergy, Potential in India: Policies and Challenges

4.4. Environmental impacts: advantages and disadvantages

UNIT-5 : Nanomaterials: Fundamentals and Applications

5.1. Screening of nanomaterials for understanding potential effects to human health and the environment. Mapping of the environmental fate of nanomaterials. Relationships between key properties of nanomaterials and their environmental fate, bio-distribution, toxicity.

5.2. Environmental Pollution by Nanoparticles: Health impact, safety and toxicological effects transport of nanomaterials in soil/sediments. Physical and chemical properties of nanomaterials influencing their behavior in the environment and in biological systems.

5.3. Application to Environment: Nanotechnology for waste reduction and improved energy efficiency.

5.4. Nanotechnology based water treatment strategies: Nanoporous polymers and their applications in water purification

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References:

[1] Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, by Gary C. Young. ISBN:9780470539675. Publisher: John Wiley & Sons. Publication Date: June 2010.

[2] Recovering Energy from Waste Various Aspects Editors: Velma I. Grover and Vaneeta Grover. ISBN 978-1- 57808-200-1; 2002

[3] Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall 2000.

[4] Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987

[5] Waste-to-Energy by Marc J. Rogoff, DEC-1987, Elsiever. ISBN-13: 978-0-8155-1132-8. ISBN-10: 0-8155- 1132-9.

[6] Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies. Elsevier Applied Science, London, 1985.

[7] Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997

[8] Bhide A. D., Sundaresan B. B., Solid Waste Management in Developing Countries. INSDOC, New Delhi, 1983.

[9] Robert Green, From Waste to Energy, Cherry Lake Pub. ISBN: 1602795096, 2009.

[10] G. Evans, Biowaste and Biological Waste Treatment, 2005 [11]. Biogas from waste and renewable resources, by Dieter D. And Angelika S. Wiley-Vch Publication 2010.

[11]. Environmental Chemistry for a Sustainable World, Volume 1: Nanotechnology and Health Risk Editors: Lichtfouse, Schwarzbauer, Robert

[12]. Advances in Nanotechnology and the Environment, Juyoung Kim, CRC Press, Taylor and Francis Group