Curriculum Framework

for

Ph.D. Degree Program

in

ENVIRONMENTAL SCIENCES

(As per National Education Policy- 2020)

DEPARTMENT OF ENVIRONMENTAL SCIENCES
SCHOOL OF BIOLOGICAL SCIENCES

DR. HARISINGH GOUR VISHAWAVIDYALYA (A CENTRAL UNIVERSITY) SAGAR, MADHYA PRADESH

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Background

Environmental Science examines the role of humans in shaping their surroundings and seeks sustainable solutions to environmental challenges. The 1972 Stockholm Conference highlighted the need for environmental protection, prompting India to amend its Constitution to include Articles 48A and 51A(g) emphasizing environmental responsibilities and duties. Over the years, increasing pollution, deforestation, and land degradation have underscored the necessity of understanding the environmental impacts of human activities, including pollution, biodiversity loss, and climate change, following their effects on agriculture, livelihoods, and the economy.

Vision

Our vision is to create environmental leaders through quality education with innovative and interdisciplinary approaches to address current and emerging sustainability challenges.

Mission

- **Scientific Expertise:** Provide high-quality scientific expertise in environmental science to tackle ongoing challenges related to climate change, resource depletion, biodiversity loss, and energy-water crises.
- **Skill Development:** Build necessary skills for future environmental leaders to find sustainable solutions for pressing environmental, societal, and climatic issues through bioengineering, renewable energy technologies, novel waste management methods, and conservation strategies.
- **Education and Communication:** Create environmental educators and researchers who can effectively communicate scientific knowledge on current and future environmental changes and crises to both specialists and the general public.

Program Educational Objectives (PEOs)

- **Awareness and Knowledge:** To create awareness and impart knowledge about sustainability.
- **Skill Development:** To produce confident, technical, creative, and employable graduates.
- **Innovation and Solutions:** To foster innovation in addressing environmental issues.

The Ph.D. in Environmental Sciences

Our Ph.D. program in Environmental Sciences is designed to address the need for scientifically informed experts to engage with complex environmental issues. The program emphasizes multidisciplinary research, innovative approaches, and the development of sustainable solutions. Through rigorous coursework and research activities, we aim to create environmental professionals who can contribute towards sustainability and environmental protection at all levels.

Course Structure

Ph.D. Course Work

Department of Environmental Sciences

Course Code	Paper Title	Credits
Compulsory Courses		**L-T-P-C**
ENV-CC-141	Research Methodology	2-2-0-4
ENV-CC-142	Essentials of Environmental Sciences	2-2-0-4
ENV-CPE-RPE	Research and Publication Ethics	0-2-0-2
ENV-CC-143	Reviewing of Literature/ Scientific Writing/ Presentations	0-2-0-2
Elective Courses (Select any one)		
ENV-EC-141	Ecosystem Management	3-1-0-4
ENV-EC-142	Air Pollution and Meteorology	3-1-0-4
ENV-EC-143	Environmental Monitoring and Assessment	3-1-0-4

Total Credits = 16

Examination Scheme will be as follows:

Semester Examination	Distributions of Marks
Mid-I	20
Mid-II (Continuous internal assessment)	20
End Semester	60
Total	100 (Each Paper)

Examination Scheme of Reviewing of Literature/ Scientific Writing/ Presentations will be as follows:

Semester Examination	Distributions of Marks
Presentation	40
Review of literature	60
Total	100

Department of Environmental Sciences				
Class	**Subject**	**Course Code**	**Course Title**	**Credits**
Ph.D.	Environmental Sciences	ENV-CC-141	Research Methodology	4

Course Objectives:

- To familiarize the doctoral students to the principles of scientific methodology and analytical skills in performing environmental research.
- To introduce the fundamental concept of statistics, measurement techniques and applications of statistical methods.

Unit 1 12 hours

Fundamentals of Research: Definition, Objectives, Motivation, Types, Significance; Research approaches, Research process, Criteria of good research; Research Problem: formulation, necessity, selection; Techniques involved in drafting research problem.

Unit2 12 hours

Research and Sampling Design: Concept, Types and Importance of research design, Features of research design, Principles of experimental design, Meaning and types of sampling, Sampling theory, Sampling procedure, Characteristics of sample design.

Unit 3 12 hours

Measurement Techniques and Data Collection: Measurement: Concept, Importance, Scales; Measurement of uncertainty: Precision and accuracy, Reproducibility/Repeatability; Errors; Tests of validity, Quality assurance and quality control; Data: sources and types, Methods of Data Collection.

Unit 4 12 hours

Descriptive Statistics: Data processing: Entry, Editing, Coding; Data cleaning, Missing data, Tabulation of data, Graphical representation, Measures of Central Tendency, Dispersion: Range, Standard Deviation, Co-efficient of Variation; Skewness and Kurtosis.

Unit 5 12 hours

Analytical Statistics

Hypotheses testing, t-test, z-test, F-test, ANOVA test, Confidence interval, Regression, Correlation, Time series analysis, Parametric and non-parametric tests, Multivariate statistical analysis, Statistical software.

Course Outcomes:

- Ability to formulate research problem, designing research, experiments and sampling protocols.
- Acquiring the knowledge and understanding of measurement techniques, data processing along with statistical methods.

Essential Readings

1. Kothari C. R. (1985) Research Methodology: Methods and Techniques, New Age Publications
2. Creswell, J. W. (2014) Research Design. Qualitative, Quantitative and Mixed Methods, Approaches. Fourth ed. Sage Publication
3. Krishnaswamy, K. N. (2006) Management Research Methodology: Integration of Principles, Methods and Techniques. Pearson Education India
4. Gupta S. C. (2019) Fundamentals of Statistics, Himalayan publication.
5. Wayne, R.O. (2018) Environmental Statistics and Data Analysis, CRC Press.

Suggested Readings

1. Garg B. L, Karadia, R, Agarwal, F, Agarwal, U.K. (2002) An introduction to Research Methodology, RBSA Publishers.
2. Geoffrey M, David D, Festinger D., (2005) Essentials of Research Design and Methodology, John Wiley & Sons
3. Bailey N. T. J. (1995) Statistical Methods in Biology, Cambridge University Press.
4. Mohanty P. K. and Patel S. K. (2015) Basic statistics, Scientific Publishers, New Delhi.

Department of Environmental Sciences				
Class	**Subject**	**Course Code**	**Course Title**	**Credits**
Ph.D.	Environmental Sciences	ENV-CC-142	Essentials of Environmental Sciences	4

Course Objectives

- To introduce the fundamental principles and components of environmental science
- To analyze environmental data to assess pollution levels, habitat degradation, and ecosystem health
- To develop ability to synthesize information from multiple sources to propose solutions for environmental issues

Unit 1 12 hours

Introduction to Ecology and Environmental Sciences: Definition, Principles, and Scope of Environmental Science; Components of the Environment; Ecology: Definition, scope, and types, levels of organization, Regulating factors, Concept of species and speciation.

Unit 2 12 hours

Ecosystems and Biodiversity: Structure and functions of ecosystems, Ecological niche, Homeostasis, and ecosystem regulation; Biogeochemical Cycles, Ecological Succession, Types and examples of aquatic and terrestrial ecosystems; Biodiversity: Definition, types, importance and threats; Measures of biodiversity; Strategies for biodiversity conservation.

Unit 3 12 hours

Natural Resources: Introduction and their consumption patterns; Classification; Renewable and Non-renewable Resources; Factors influencing resource availability; Reserve-to-production ratio; Degradation of natural resources; Concept of conservation; Approaches to natural resource management and their implications; Integrated resource management strategies.

Unit 4 12 hours

Environmental Pollution: Air Pollution: Sources, types and effects, Air Quality Parameters; Water Pollution: Sources, types and effects, Water quality parameters; Soil Pollution: Sources, types and effects; Noise and Light Pollution; Radioactive Pollution.

Unit 5 12 hours

Global environmental challenges and impacts: Deforestation; Biodiversity Loss; Land Degradation; Acid Rain, Ozone Layer depletion, Global warming and climate change: drivers of climate change, Sources and impacts of greenhouse gases, Implications for climate, oceans, agriculture, natural vegetation, wildlife, and humans, International efforts on climate change issues.

Course Outcome

At the end of the course the learner will be able to

- Demonstrate a comprehensive understanding of environmental science principles, ecological concepts, and the interrelationships within environmental systems.
- Apply knowledge of environmental science to analyze environmental problems, interpret data, and propose evidence-based solutions.
- Critically evaluate environmental issues and their implications for ecosystems, biodiversity, and human societies.

Essential readings:

1. Singh J.S., Singh S.P. and Gupta S.R. (2017) Ecology, environmental Science & Conservation, S. Chand Publications.
2. Smith T.M. and Smith R.L. (2006) Element of Ecology, Pearson Education Inc., San Francisco, USA.
3. De A.K. (2006) Environment Chemistry, New Age International Pvt Ltd Publishers.
4. Santra S.C. (2011) Environmental Science, New Central Book Agencies, Pvt., Ltd. Kolkata.
5. John G., Thomas H. J, Press F, and Siever R. (2006). Understanding Earth, 5th Ed. W. H. Freeman.

Suggested readings:

1. Singh J. and Pandey G. (2005) Natural Resource Management and Conservation, Kalyani Publishers.
2. Peavy H.S., Rowe D.R. and Tchobanoglous G. (1985) Environmental Engineering. McGraw-Hill Book Company, Singapore.
3. Sharma B.K. and Kaur H. (2016). Environmental Chemistry, Pragati Prakashan Meerut.
4. Singh S. (2017) Physical Geography, Allahabad, Prayag Pustak Bhavan.

Department of Environmental Sciences				
Class	**Subject**	**Course Code**	**Course Title**	**Credits**
Ph.D.	Environmental Sciences	ENV-CPE-RPE	Research and Publication Ethics	2

Course Objectives

1. To educate students on ethical principles related to scientific research, emphasizing intellectual honesty, research integrity, and awareness of scientific misconduct.
2. To familiarize students with open access publishing, ethical research practices, and the use of tools and metrics for evaluating scientific impact.

Theory

RPE 01

Philosophy and Ethics:

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

RPE 02

Scientific Conduct:

1.Ethics with respect to science and research
2.Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

RPE 03

Publication Ethics:

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Practice

RPE 04

Open Access Publishing:

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

RPE 05

Publication Misconduct:

A. Group Discussion

1.Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools

1. Use of plagiarism software like Turnitin, Urkund and other open source software tools

RPE 06

Databases And Research Metrics

A. Databases

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i-lO index, altmetrics

Course Outcome

1. Students will be able to identify and apply best practices in publication ethics, recognize conflicts of interest, and address publication misconduct effectively.
2. Students will demonstrate practical knowledge of open access publishing, critically analyze ethical issues using detection tools, and effectively use databases and metrics to evaluate scientific impact.

References

1. Bird, A. (2006). Philosophy of Science. Routledge.MacIntyre,
2. MacIntyre, A. (1967). A Short History of Ethics. United Kingdom: Collier Books.
3. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978- 9387480865
4. National Academy of Sciences (2009). On Being a Scientist: A Guide to Responsible Conduct in Research. United States: National Academies Press.
5. Resnik, D. B. (2011). What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 1-10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis /index.cfrn
6. Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179-179. https://doi.org/10.1038/489 l79 a
7. Indian National Science Academy (INSA), Ethics in Science Education, Research and Govemance (2019) , ISBN:978-81-939482-l-7. http://www.insaindia.res.in/pdf/Ethics Book.pdf

Department of Environmental Sciences				
Class	**Subject**	**Course Code**	**Course Title**	**Credits**
Ph.D.	Environmental Sciences	ENV-CC-143	Reviewing of Literature/ Scientific Writing/ Presentations	2
In this paper, students are encouraged to write a review on a specific topic to develop their expertise in reading and writing in the scientific field. They will also need to present their work.				

Department of Environmental Sciences				
Class	**Subject**	**Course Code**	**Course Title**	**Credits**
Ph.D.	Environmental Sciences	ENV-EC-141	Ecosystem Management	4

Course Objectives

- Evaluate the role of biodiversity and ecosystem services in ecological systems.
- Apply Geographic Information Systems (GIS) and remote sensing for mapping land use changes and ecosystem health.
- Apply field techniques for vegetation sampling, wildlife surveys, and habitat assessments in ecosystem management.

Unit 1 12 hours

Principles of Ecosystem Management: Definitions and objectives, History and evolution of ecosystem management, Structure and Function of Ecosystems, Sustainability, resilience, and adaptive management, Ecosystem services and their valuation, Techniques for measuring ecosystem structure and function.

Unit2 12 hours

Geospatial Technology and Ecological Modeling: Basics of Geographic Information Systems (GIS) and remote sensing, Mapping and monitoring land use and land cover changes, Habitat suitability modeling and conservation planning, Assessing ecosystem health and detecting disturbances, Monitoring climate change impacts on ecosystems, Population and community modeling, Ecosystem and landscape models.

Unit 3 12 hours

Management of Forest and Grassland Ecosystems: Forest Ecosystem Management: Sustainable forestry practices and principles, Biodiversity conservation in forest landscapes, Forest restoration and rehabilitation techniques; Grassland Ecosystem Management: Grazing management and fire regimes, Restoration of degraded grasslands, Conservation of grassland biodiversity; Field Techniques for Forest and Grassland Management: Vegetation sampling and monitoring, Wildlife surveys and habitat assessments.

Unit 4 12 hours

Water and Soil Resource Management in Forest Ecosystems: Integrated watershed management, Role of forests in watershed protection, Riparian zone and wetland management, Field methods for assessing riparian health and function, Riparian Quality Index, Riperian Vegetation Index, Soil conservation, Soil health and fertility management, Techniques for soil restoration and remediation, Soil mapping and land degradation assessment.

Unit 5 12 hours

Landscape Level Management: Introduction to Landscape Ecology: Principles and concepts, Scale and hierarchy in landscape ecology, Spatial patterns and their ecological implications, Landscape connectivity and fragmentation, Disturbance regimes and landscape resilience, Human impacts on landscape dynamics, Applications of Landscape Ecology in Ecosystem Management: Landscape planning and conservation, Use of GIS and remote sensing in landscape ecology, Case studies in landscape ecology and ecosystem management.

Course Outcome:

At the end of the course the learner will be able to

- Understand the application of geospatial technology, GIS, remote sensing, and ecological modeling in ecosystem analysis and management.
- Analyze ecological data and apply modeling techniques to assess habitat suitability and ecosystem responses to climate change.
- Evaluate the effectiveness of ecosystem management practices and policies in enhancing biodiversity conservation and ecosystem resilience.

Essential readings:

1. Singh, J. S., Singh, S. P., & Gupta, S. R. (2014). Ecology, environmental science & conservation. S. Chand Publishing.
2. Odum, E. P. (2017). Fundamentals of Ecology, Cengage India Private Limited; 5th edition (15

November 2017).
3. Jensen, J. R. (2015). Remote Sensing of the Environment: An Earth Resource Perspective (2nd ed.). Pearson.

Suggested readings:

1. Levin, S. A. (1999). Fragile Dominion: Complexity and the Commons. Perseus Books.
2. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic Information Science & Systems (4th ed.). Wiley.
3. Wang G., & Weng Q. (2020) Remote Sensing of Natural Resources. United Kingdom: CRC Press.

Department of Environmental Sciences				
Class	**Subject**	**Course Code**	**Course Title**	**Credits**
Ph.D.	Environmental Sciences	ENV-EC-142	Air Pollution and Meteorology	4

Course Objectives:

- To impart basic scientific knowledge of air pollution formation, pollutant types, release, and transformations in the atmosphere.
- To provide deeper understanding of meteorological parameter's role in transport and diffusion of air pollutants.

Unit 1 12 hours

Air Pollution Science: Atmospheric structure and composition; Air pollution system: sources, sinks, transport; Effects on environment and human health, Criteria air pollutants, Air quality standards and regulations.

Unit2 12 hours

Atmospheric Pollutants: Aerosols: Introduction, Size distribution and Chemical composition; Dynamics of aerosols, Impacts of aerosol on climate and health; Reactive trace gases: CO, SO_2, NO*x*, VOCs, Photochemical oxidants.

Unit 3 12 hours

Meteorological Basis of Atmosphere: Sun, Atmosphere system and Heat balance; Vertical Structure of the Temperature, Temperature Inversion, Atmospheric stability; Atmospheric moisture, Law of motion, Ventilation, Stagnation, Removal mechanism, Atmospheric turbidity.

Unit 4 12 hours

Air Pollution Dispersion and Modeling

Wind velocity, Turbulence, The Gaussian Equations: Dispersion parameters, Dispersion instrumentation; Effective stack height, Plume behavior; Atmospheric tracers; Meteorological models for air quality forecasting.

Unit 5 12 hours

Inter-Linkage of Air Pollution with Climate Change

Air pollution and Climate change: The global linkages, Grand challenges to the sustainability, Common roots of air pollution and climate change, Impacts of climate change on air quality; Role of atmospheric aerosol, Ozone, CH_4 on climate change; Climate extreme events and air pollution; Air quality considerations of Net Zero, Joint strategy to control air pollution and climate change.

Course Outcome:

- Ability to understand the air pollution system, type and nature of air pollutants and their impacts on the atmosphere.
- Acquire knowledge of meteorological importance in the air quality, forecasting air pollution through modeling and inter-linkage of air pollution & climate change.

Essential Readings

1. Seinfeld J. H. and Pandis, S.N. (2006) Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley & Sons, INC.
2. Masters G.M. (2004). Introduction to environmental engineering and science. Prentice-Hall.
3. Lutgens F.K., Tarbuck E.J. (1996) The Atmosphere an Introduction to Meteorology, Printice HallPublisher, New Jersey.
4. Holton J. R. and Hakim G. J. (2013) An Introduction to DynamicMeteorology, Academic Pess, Elsevier
5. De A.K. (2006) Environment Chemistry, New Age International Pvt Ltd Publishers; 6th ed.

Suggested Readings

1. Peavy H.S. Rowe D.R. and Tchobanoglous (1985) Environmental Engineering. McGraw Hill series
2. Vesilind A. and Morgan S.M. (2004) Introduction to Environmental Engineering, Eds. 2nd,

Thomson Brooks/Cole.
3. Manahan S.E. (1993) Fundamentals of Environmental Chemistry. Publisher: Lewis.
4. Santra, S. C. (2001) Environmental Science. New Central Book Agencies, Pvt., Ltd. Kolkata

Department of Environmental Sciences				
Class	**Subject**	**Course Code**	**Course Title**	**Credits**
Ph.D.	Environmental Sciences	ENV-EC-143	Environmental Monitoring and Assessment	4

Course Objectives:

- To learn various aspects of environmental monitoring and assesment
- To develop sampling skills required in environmental monitoring
- To provide scientific understanding of instruments, their operation and applications
- To understand the recent trends of environmental monitoring

Unit 1 12 hours

Introduction to Environmental Monitoring: Definition, Principles and objectives of monitoring and sampling; Environmental Parameters: Air (gaseous and particulate matter), Water (Physico-chemical parameters, biological indicators), Soil (Contaminants).

Unit2 12 hours

Environmental sampling: Types of environmental samples, Sampling objectives and strategies, Sampling Techniques: Grab sampling, Composite sampling, Passive sampling etc., Sample preservation and handling, Field Sampling Protocol, Sample preparation techniques.

Unit 3 12 hours

Analytical instrumentation I: Principle and applications of Microscopy: Optical microscopy: Bright field and dark field, Phase contrast, Fluorescence, Confocal; Scanning electron microscopy, Transmission electron microscopy and Atomic force microscopy.
Principle and applications of Chromatography: Thin layer chromatography, Gas chromatography, High performance liquid chromatography, Ion-exchange chromatography.

Unit 4 12 hours

Analytical instrumentation II: Principle and applications of Spectroscopy: Ultraviolet-Visible spectroscopy, Atomic absorption spectroscopy, Inductively coupled plasma mass spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, Laser induced fluorescence, X-ray Fluorescence, X-ray diffraction, Photoluminescence, Nuclear magnetic resonance.

Unit 5 12 hours

Emerging Trends in Environmental Monitoring: Nanosensing, Real-time monitoring, IoT connectivity, AI and big data analytics, Remote sensing, Wearable environmental monitors, Low-Cost Sensors: Bioindicators, Biomarkers, Biosensors, Biomonitoring in polluted environment.

Course Outcome: On completion of the course, the students will be able to:

- Understand basics of environmental monitoring and assessment
- Know about the concept and techniques of environmental sampling
- Learn different analytical methodologies for studying environmental samples

Essential readings:

1. Reeve R. N. (2002) Introduction to Environmental Analysis. John Wiley & Sons, LTD, West Sussex, England.
2. Burden F. R., Donnert D., Godish T. and McKelvie I (2002) Environmental Monitoring Handbook. McGraw-Hill, New York, USA.
3. Keith L.H. (1988) Principles of Environmental Sampling. American Chemical Society.
4. Ewing G.W. (1985) Instrumental Methods of Chemical Analysis, 5th Edition, Mc-Graw Hill.
5. Wilson K. and Walker J. (2010) Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition, Cambridge University Press.
6. Chatwal G.R. and Anand S.K. (2007) Instrumental Methods of Chemical Analysis. Himalaya Publishing House, Delhi.

Suggested readings:

1. Reeve R. (2002) Introduction to Environmental Analysis. John Willey and Sons.
2. Khopkar S.M. (2015) Basic Concepts of Analytical Chemistry. Wiley Eastern Ltd., New Delhi.

3. Mitra S. and Kebbekus B.B. (2018) Environmental Chemical Analysis. CRC Press.
4. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2019). Textbook" principles of instrumental analysis.". *Cengage learning. core. ac. uk. https://core. ac. uk/download/pdf/232277508. pdf*.
5. Willard H.H., Merritt L.L, Deen, J.A. and Settle, F.A. (2015) Instrumental Methods of Analysis. CBS Publishers and Distributers, New Delhi.