Course title: Environmental Statistics			
Course code: NRE 115	**No. of credits:** 4	**L-T-P:** 42-18-0	**Learning hours:** 60
Pre-requisite course code and title (if any): No pre-requisite required			
Department: Energy and Environment			
Course coordinator(s):		**Course instructor(s):** Prof. Prateek Sharma	
Contact details: prateeks@terisas.ac.in			
Course type: Core		**Course offered in:** Semester 1	

Course description

As the world gets more crowded and technology continues to develop, environmental problems multiply. There are many aspects of these problems–economic, political, psychological, medical, scientific and technological. Addressing such problems often involves quantitative aspects; in particular, the acquisition and analysis of environmental data. Treating these quantitative problems effectively involves the use of statistics. When one is confronted with a new problem that involves the collection and analysis of data, two crucial questions exist: "How will using statistics help this problem?" and "Which techniques should be used?"

The course has been designed and intended to help budding environmental scientists/managers to answer these questions in order better to understand and design systems for environmental protection. The course is about how to extract information from data and how informative data are generated in the first place. Analysing data is part science, part craft and part art. An effort has been made through this course to provide some useful tools 'to get to the grips' of environmental problems and to encourage the students to develop the necessary craft and art.

Course objectives

- Need for studying environmental statistics
- Introduce basic concepts useful for environmental data analysis
- Become aware of a wide range of applications of statistics in environmental management & decision making
- Develop technical skills to use statistical tools and software in environmental data analysis

Course content

Module	Topic	L	T	P
1.	**Introduction** Environmental models-deterministic and stochastic; generation of environmental data; types and objectives of environmental studies, stochastic processes in environment; the nature environmental data; concept of random variable and its relevance with respect to the environmental data; relevance of statistics in environmental management; populations and samples – parameters and statistic.	1		
2.	**Describing environmental data** Measurement scales; statistical descriptors of environmental data – numerical and graphical; measurement uncertainty – accuracy, precision and bias estimation of environmental data; variability and errors in environmental pollution data.	4	1	
3.	**Probability models and their use** Probability concepts; probability distribution functions and their applications-discrete and continuous distributions. Probability distribution applications-interpreting environmental standards, flood frequency analysis and air quality data.	4	2	
4.	**Environmental data sampling** Need and purpose of sampling; methods for selecting sampling locations and times for different environmental matrices – monitoring of water bodies for hydrological and water quality data; air quality monitoring; soil	10	5	

	sampling-statistical considerations; types of sampling designs-probability and non-probability sampling designs for environmental monitoring and sampling; Sampling theory, sampling distributions; environmental parameter estimation-point and interval estimates; confidence interval estimation; sample size determination.			
5.	**Tests of hypothesis** Hypothesis testing-parametric and non-parametric tests: assessment of violation of environmental standards, comparing environmental parameters (differences of means, proportions, difference of proportions, multiple proportions, variances, ratio of variances and analysis of variance).	12	6	
6.	**Environmental data analysis** Measuring association between two variables-Correlation analysis: graphical analysis, covariance, correlation coefficient, distribution of correlation coefficient and its statistical significance. Empirical model building-Regression analysis: assumptions and definitions, principle of least squares, regression parameters their distribution and statistical significance; applications in environmental process description and prediction; non-linear processes in environment; use of transformation for linearising non-linear relations; introduction to multiple linear regression. Case studies: Climate change and volume-discharge curve Applications: Stage-discharge curve and volume-discharge curves, water quality parameters and agriculture. Analysis of trend in the environmental data Introduction to time-series analysis; characteristics of hydrological, water and air quality time series; Trend and seasonality; detecting and estimating trends-applications to hydrological, meteorological, water and air quality data.	7 4	2 2	
	Total	**42**	**18**	

Evaluation criteria

- Test 1: 20% [Module 1 & 2, after 5-6 weeks of teaching]
- Test 2: 20% [Module 3 & 4, after 12-13 weeks of teaching]
- Test 3: 40% [Module 1 to 6, end of semester]
- Tutorials: 20% [10 tutorial assignments spread over entire semester]

Learning outcomes

After completing this course the students will be able to

- develop an intuitive statistical sense for inferring meaning out of data collected from different environmental matrices
- implement statistics for environmental monitoring and sampling
- able to critically analyse environmental evidence
- analyse, model and quantify uncertainty and variability in environmental data
- extract information and draw scientific inference from large amount of data collected to solve environmental problems
- analyse trend and seasonality in environmental data
- apply statistical tools and software to analyse environmental data

[Assessment mechanism for learning outcomes: The three tests and tutorial assignments spread over the entire semester]

Pedagogical approach

Classroom lectures, tutorial assignment along with relevant case studies.

Materials

Textbooks

The following textbooks independently cover all the 6 modules.

Ayyub, B.M. and McCuen, R.H. (2011) *Probability, Statistics and Reliability for Engineers and Scientists,* CRC Press, Boca Raton, FL.

Gilbert R.O. (1987) *Statistical Methods for Environmental Pollution Monitoring,* New York, Van Nostrand Reinhold.

Helsel D.R. and Hirsch R.M. (1997) *Statistical Methods in Water Resources,* Elsevier Science Ltd., UK.

Kottegoda N.T. and Rosso R. (2008) *Applied Statistics for Civil and Environmental Engineers,* McGraw-Hill, International Edition.

Suggested readings

Suggested readings may be referred to for getting more insights and additional relevant examples for the more interested student.

Berthouex P.M. and Brown L.C. (1994) *Statistics for Environmental Engineers,* Lewis Publishers, CRC Press, Boca Raton, FL.

Cothern C.R. and Ross N.P. (1994) *Environmental Statistics, Assessment and Forecasting,* Lewis Publishers, Boca Raton, FL.

Hoshmand A.R. (1997) *Statistical Methods for Environmental and Agricultural Sciences*, CRC Press, Boca Raton, FL.

Gibbons R.D. (1994) *Statistical Methods for Groundwater Monitoring,* John Wiley & Sons, New York.

Ginevan M.E., Splistone D.E. (2004) *Statistical Tools for Environmental Quality Measurement.* John Wiley & Sons Hoboken, NJ.

Gregoire T.M. and Valentine H.T. (2008) *Sampling Strategies for Natural Resources and the Environment,* Chapman & Hall/CRC, Boca Raton.

Keith L.H. (1991) *Environmental Sampling and Analysis: A Practical Guide,* Lewis Publishers, Boca Raton, FL.

Keith L.H. (ed) (1996) *Principles of Environmental Sampling,* Second Edition, American Chemical Society, Washington, D.C., Distributed by Oxford University Press, New York.

Manly B.F.J. (2001) *Statistics for Environmental Science and Management*. Chapman & Hall/CRC, Boca Raton, FL.

McBride G.B. (2005) *Using Statistical Methods for Water Quality Management: Issues, Problems and Solutions,* John Wiley & Sons, Hoboken, NJ, USA.

Ott W.R. (1995) *Environmental Statistics and Data Analysis,* Lewis Publishers, Boca Raton, FL.

Shaefer S.J. and Theodore L. (2007) *Probability and Statistics Applications for Environmental Science,* CRC Press, Boca Raton, FL.

USEPA (2002). *Guidance on Choosing a Sampling Design for Environmental Data Collection,* United States Environmental Protection Agency, Office of the Environmental Information, Washington DC, 20460, EPA/240/R-02/005

Walford N. (2011) *Practical Statistics for Geographers and Earth Scientists,* John Wiley & Sons, New Jersey, USA.

Zhang C. (2007) *Fundamentals of Environmental Sampling and Data Analysis*, John Wiley & Sons, NJ, USA.

Journals

1. Applied Statistics
2. Biometrika
3. Environmental and Ecological Statistics
4. Environmetrics
5. International Statistical Review
6. Journal of Statistical Computing and Simulation
7. Journal of the American Statistical Association
8. Risk Analysis
9. Statistical Science
10. Technometrics
11. The American Statistician

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course reviewers:

- Prof V.K. Minocha, Department of Civil Engineering, Delhi Technological University, Delhi
- Prof. S. Shiva Nagendra, Department of Civil Engineering, Indian Institute of Technology Madras, Chennai
- Dr Anil Haritash, Associate Professor, Department of Environmental Engineering, Delhi Technological University, Delhi