Course title: Environmental statistics

Course code: NRE 111	**No. of credits:** 3	**L-T-P:** 28-14-0	**Learning hours:** 42

Pre-requisite course code and title (if any): No pre-requisite required

Department: Department of Energy and Environment

Course coordinator(s):	**Course instructor(s):** Prof. Prateek Sharma
Contact details:	
Course type: Elective	**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 statistics
- Become aware of a wide range of applications of statistics in environmental management, life sciences & decision making
- Define statistics
- Understand the relation between probability and statistics
- Differentiate between descriptive and inferential statistics

Course content

Module	Topic	L	T	P
1.	**Introduction** Mathematical models–deterministic and stochastic; generation of environmental data; stochastic processes in environment; the nature of random variables; populations and samples; parameters and statistics.	1		
2.	**Review of basic concepts** Measurement theory, levels of measurement; statistical descriptors of environmental data–numerical and graphical; Chebyshev's theorem; measurement uncertainty–accuracy, precision and bias. Probability theory: probability concepts; probability distribution functions and their applications–discrete and continuous distributions.	3 3	2 2	
3.	**Data sampling** Methods for selecting sampling locations and times; types of sampling designs–probability and non-probability sampling; sampling theory, sampling distributions; parameter estimation, point and interval estimates; confidence interval estimation of–means, differences of means, proportions, difference of proportions, variances, ratio of variances sample size determination for different sampling designs	10	5	
4.	**Tests of hypothesis** Hypothesis testing–parametric and non-parametric tests (concerning means, differences of means, proportions, difference of proportions, variances, ratio of variances)	8	4	
5.	**Correlation and simple regression analysis** Correlation analysis: graphical analysis, bivariate correlation, covariance, correlation coefficient, distribution of correlation coefficient and its statistical significance. Simple regression analysis: assumptions and definitions, principle of least	3	1	

	squares, regression parameters their distribution and statistical significance, applications in process description and prediction			
		28	**14**	

Evaluation criteria

- 2 minor test: 20% each
- Tutorials: 20%
- Major test: 40%

Learning outcomes

After completing this course the students will be able to

- develop an intuitive statistical sense
- analyse, model and quantify uncertainty
- extract information and draw scientific inference from large amount of data collected to solve environmental problems
- take informed decisions under uncertainty

Pedagogical approach

Materials

Textbooks

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

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

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

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

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

Suggested Readings

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

Caulcutt R. and Boddy R. (1983) *Statistics for Analytical Chemists*, Chapman & Hall, London.

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

Csuros M. (1997) *Environmental Sampling and Analysis, Lab Manual*, Lewis Publishers, Boca Raton, FL.

Ebdon D. (1984) *Statistics in Geography*, 2nd edn., Blackwell, Oxford.

Everitt B.S. (1999) *Chance Rules: An Informal Guide to Probability*, Risk and Statistics, Springer-Verlag, New York.

Fisher L.D. and Van Belle G. (1993) *Biostatistics: A Methodology for the Health Sciences*, John Wiley & Sons, New York.

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

Gibbons R.D. and Coleman D.E. (2001) *Statistical Methods for Detection and Quantification of Environmental Contamination*, John Wiley & Sons, Inc., New York.

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

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

Graham R.C. (1993) *Data Analysis for the Chemical Sciences: A Guide to Statistical Techniques*, VCH Publishers, New York.

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.

McBean E.A. and Rovers R.A. (1998) *Statistical Procedures for Analysis of Environmental Monitoring Data & Risk Assessment*, Prentice-Hall PTR, Upper Saddle River, NJ.

McBride G.B. (2005) *Using Statistical Methods for Water Quality Management: Issues, Problems and Solutions,* John Wiley & Sons, Hoboken, NJ, USA.
Meier P.C. and Zund R.E. (1993) *Statistical Methods in Analytical Chemistry,* John Wiley & Sons, New York.
Moore D.S., McCabe G.P. and Craig B.A. (2009) *Introduction to the Practice of Statistics,* W.H. Freeman and Co., New York.
Ott W.R. (1995) *Environmental Statistics and Data Analysis,* Lewis Publishers, Boca Raton, FL.
Piegorsch W.W. and Bailer A.J. (1997) *Statistics for Environmental Biology and Toxicology,* Chapman & Hall, New York.
Reichman W.J. ((1961) *Use and Abuse of Statistics,* Penguin, Harmondsworth.
Rogerson P.A. (2006) *Statistical Methods for Geographers: A Student's Guide,* Los Angeles, CA.
Taylor J.K. (1987) *Quality Assurance of Chemical Measures,* Lewis Publishers, CRC Press, Boca Raton, FL.
Walford N. (2011) *Practical Statistics for Geographers and Earth Scientists,* John Wiley & Sons, New Jersey, USA.
Williams R.B.G. (1984) *Introduction to Statistics for Geographers and Earth Scientists,* Macmillan, London.
Wrigley N. (1985) *Categorical Data Analysis for Geographers and Environmental Scientists,* Longman, Harlow.
Zhang C. (2007) *Fundamentals of Environmental Sampling and Data Analysis,* John Wiley & Sons, NJ, USA.

Journals

Applied Statistics
Biometrika
Environmental and Ecological Statistics
Environmetrics
International Statistical Review
Journal of Statistical Computing and Simulation
Journal of the American Statistical Association
Risk Analysis
Statistical Science
Technometrics
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

1. Prof. Bilal M. Ayyub, University of Maryland, College Park, USA.
2. Prof. Richard H. McCuen, Department of University of Maryland, College Park, USA.