Course title: Groundwater quality modelling

Course code: WSW 171	**No. of credits:** 4	**L-T-P: 42-14-0**

Pre-requisite course code and title (if any): NIL

Department: Department of Regional Water Studies

Course coordinator(s): Prof Prateek Sharma	**Course Instructor(s):** Dr Brijesh Yadav

Contact details

Course type: Elective	**Course Offered in: Semester 3**

Course Description

The goal of this course is to impart a general understanding of fate and transport processes of contaminants in groundwater. In the first part, the natural and anthropogenic sources of nutrients, heavy metals, organic pollutants, and radionuclides are treated, along with their physicochemical characteristics and toxicity in subsurface. The second part provides an introduction to the mathematical modelling of processes of transport, exchange, and transformation, such as advection, dispersion, diffusion and kinetics of adsorption and decay. The spatial and temporal patterns of pollutants in groundwater and their treatment techniques are explained subsequently. During the lectures, the basic theory will be presented and illustrated with examples from practical and simulation studies. The theory will be applied in problems to be solved during tutorials. After the course the student will have the required knowledge to qualitatively assess soil and groundwater contamination problems and will have the skills to tackle simple problems in a quantitative manner.

Course objective: This course aims at exposing the student to basic concepts and principles related to the fate and transport of pollutants in soil and groundwater systems under various environmental conditions. The specific objectives of this course are to understand: 1) Physical and chemical behaviour of pollutants, 2) Modelling of transport and transformation processes and 3) Pollutant patterns in soil, groundwater and their remediation techniques.

Course content

Module	Topic	L	T	P
1.	Sources and causes of groundwater pollution; Various ways of classification of pollutants; groundwater quality parameters; Site specific groundwater quality problems in Indian context	4	1	
2.	Concepts and principles related to the movement of solutes in aquifer systems; continuity equation and Ficks' law, mass transfer; mass transport, Solute transport in double-porosity media	8	3	
3	Description of adsorption: linear and nonlinear isotherms, kinetic adsorption, Determination of adsorption coefficients, Determination of flow velocity and dispersivity coefficients, Hydrodynamics dispersion, longitudinal and lateral dispersivity	6	2	
3.	Degradation processes, Biodegradation, Factors affecting biodegradation, Radioactive decay, Reactive processes, Multiphase contamination, NAPLs, VOCs; density driven flow, Ghyben-Herzberg principle, concepts of fresh saline interface	5	2	
4.	Direct and inverse problems, Analytical solution of classical advection-dispersion equation, Finite difference methods, Numerical modeling of steady and transient flows in variably saturated domain, Contaminant transport modeling, Numerical dispersion, Discussion of initial and boundary conditions, Regional aquifer quality simulation, matrix solution techniques and iteration methods	10	3	
5.	Concepts of pollution control and remediation measures; pump-and treat; Permeable reactive barriers and their design, Soil vapor extraction, Air sparing, bioremediation and phytoremediation processes	6	2	
6.	Development and optimization based management of aquifer systems, Stochastic models, Random field concepts in groundwater models; planning of groundwater development in coastal aquifers	3	1	
		42	**14**	

Evaluation criteria

- **Minor test 1: 15%**
- **Minor test 2: 15%**
- **Tutorials: 20%**
- **Major test: 50%**

Learning outcomes

- Characterization of groundwater quality
- Develop models based on the continuity and Fick's law approaches
- Predict the movement of pollutants in subsurface under varying environmental conditions
- Quantity spatial and temporal loads of pollutants in subsurface
- Forecasting future conditions under various loading scenarios or management/intervention action alternatives
- Remediation strategies for polluted groundwater systems

Pedagogical approach

The course will be delivered through class room lectures, discussion of case studies from original relevant research articles and hands on simulation experiments.

Materials

Textbooks

Fetter, C.W., Contaminant hydrogeology, Macmillan, New York, (2nd ed.).

Domenico, P.A. and Schwartz, F.W. Physical and chemical hydrogeology (2nd ed.). John Wiley & Sons, New York. ISBN 0-471-59762-7

Schwartz, F.W. and Zang, H., "Fundamentals of Ground Water", John Wiley & Sons

Freeze, R.A., Cherry, J.A., 1979. Groundwater. Prentice-Hall, Englewood Cliffs: 604 pp

Suggested Readings

Bear, J., 1972. Dynamics of Fluids in Porous Media. Am. Elsevier Publishing Co., New York: 764 pp

Todd D.K. (1980) Groundwater Hydrology, John Wiley and Sons.

Dunnivant F.M. and Anders E. (2006) *A Basic Introduction to Pollutant Fate and Transport*, John Wiley & Sons, Inc., New Jersey.

Rastogi A.K. (2008) Numerical Groundwater Hydrology, Penram International Publishing Pvt. Ltd., Bombay.

Schnoor, J.L. (1996). *Environmental Modeling*. John Wiley & Sons, Inc., New York.

Journals

Journal of contaminant Hydrology

Water Resources Research

Journal of Irrigation and Drainage Engineering

Water Air and Soil Pollution

Advances in Water Resources

CLEAN - Soil, Air, Water

Additional information (if any)

Course reviewers

1. Dr Arun Kansal, Head and Professor, Department of Regional Water Studies, TERI University
2. Dr Brijesh Yadav, Department of Hydrology, IIT Roorkee