WATER INSTITUTE

ADDITIONAL SUBJECTS

Code	Subject Name	Credit
09CE396	Probability and Statistics	4:0:0
09CE397	Introduction to Integrated Water Resources Management	4:0:0
09CE398	Hydrologic Processes	4:0:0
09CE399	Water Quality Analysis and Modeling	3:1:0
09CE3100	Water Quality Testing Laboratory	0:0:2
09CE3101	Hydrogeology	3:1:0
09CE3102	Systems Analysis for Management of Water Resources	3:1:0
09CE3103	Computational Methods in Water Resources Management	3:1:0
09CE3104	Participatory Water Management	4:0:0
09CE3105	Irrigation Water Management	4:0:0
09CE3106	Experimental and Computational Laboratory	0:0:2
09CE3107	Watershed and River Basin Management	4:0:0
09CE3108	Water Resources Management Tools: Remote Sensing and -- Environmental Isotopes	4:0:0
09CE3109	Aquatic Ecology and Environmental Impact Assessment of Water Resources Projects	4:0:0
09CE3110	GIS and Database Management in Water Resources Management	3:1:0
09CE3111	Water and Wastewater Treatment and Management	3:1:0
09CE3112	IWRM Implementation: Gender Issues, Economics, Policies and Institutional Mechanisms	4:0:0

09CE396 PROBABILITY AND STATISTICS

Credit 4:0:0

Objectives

To provide the student with the concepts and an understanding of statistics and probability and random processes, needed for analysis and modeling in hydrology and water resources management.

Unit 1: Basic Statistics

Measures of central tendency, dispersion, skewness and kurtosis – Correlation and regression- Introduction to multivariate statistics.

Unit 2: Probability and Distributions

Axioms of probability – Bayes' Theorem – Random variables – Binomial, Poisson, Exponential and Normal distributions – Expectation and variance.

Unit 3: Sampling Distributions and Estimation

Sampling distributions – Estimation of parameters – Method of moments – Principle of least squares – Method of maximum likelihood-L Moments

Unit 4: Testing of Hypothesis
Tests based on Normal, t, Chi-square and F distributions for mean and variance – Analysis of variance – One way and two way classifications.

Unit 5: Random Processes
Classification – Stationary random process – Markov process – Markov chain – Time series analysis– Auto regressive processes.

Text Books

1. Johnson, R.J., Miller and Freunds, Probability and Statistical Methods for Engineers. 6th Edition, Prentice – Hall of India, Private Ltd., New Delhi, 2002.
2. Gupta,S.C and Kapoor, V.K., Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi, 2001.

References

1. Jay L. Devore, Probability and Statistics for Engineers and the Scientists. Thomson and Duxbury, Singapore, 2002.
2. Murry R.Spiegel and Larry J.Stephens, Schaum's Outline Series- Statistics, 3rd Edition, Tata McGraw Hill, 1999.
3. Medhi, J., Stochastic Processes. New Age International (P) Ltd., New Delhi, 2000.
4. Maidment, D. R(editor), Handbook of Hydrology for Engineers, McGraw Hill, 1975.

09CE397 INTRODUCTION TO INTEGRATED WATER RESOURCES

Credit 4:0:0
Objectives:

1. Concepts of IWRM will be introduced and its inter-disciplinary nature highlighted.
2. Students will be exposed to sustainable water resources management, water security and public-private participation issues.
3. They will be briefed about integrated multi-sectoral and multi-dimensional issues in developing water resource management plans.

Unit 1: Concepts, Principles and Tools
IWRM principles-Modern principles of water management and planning-Definition, components, and critique of IWRM-IWRM implementation*:* socio-scientific, economic, political and ecological factors affecting the implementation-Global and national perspectives of water crisis, water scarcity, water availability and requirements of human beings and nature- Concepts of 'blue water', 'green water' and 'grey water' and their role in water management-Global climate change and its effects on natural water resources.

Unit 2: Sustainable Water Resources Management
Concept of sustainable development-Sustainability principles for water management -Goals for guiding sustainable water resource management-Important preconditioning in water policy

approaches-Framework for planning a sustainable water future- Renewable water potential-Integration of natural water resources in national water supply systems-Sustainable use of natural water resources in arid and semi-arid regions- Water demand forecasting and management-Water use efficiency- Water conservation, treatment and reuse-Concept of sustainable groundwater development and management- Water balance: matching water sources with demands-Minimum water table and minimum discharges.

Unit 3: Resources and End Users

Population-water resources equation-Water stress, strain and water modulus -Resource classification-Resource assessment (water quantity and quality)- Environmental flows-Water for basic human needs -Role of water in serving national interests: agriculture, nature, peace agreements, others -Strategic importance of agriculture and its role in the national water demand picture -Competition between water consumers on water resources-Role of "shadow water" (partly virtual water) in balancing population-Water resources equation-Instruments for demand management (economic, regulatory, institutional, etc.) – Water efficiency in irrigated agriculture-Overall picture of irrigation schemes.

Unit 4: Conventional and Non-conventional Techniques for Water Security

Rainwater harvesting-Groundwater mining and artificial recharge-Conjunctive use of surface water and groundwater resources-Long-distance water conveyance and transport- Inter-basin water transport-Conservation of 'green water'-Desalination-Treatment of poor quality waters-Health protection and promotion in the context of IWM- Health impact assessment of water resources development- Virtual water trade for achieving global water security.

Unit 5: Public-Private Partnership in Water Management

Private sector involvement in water resources management: PPP objectives, PPP options, PPP processes, PPP experiences through case studies – Links between PPP and IWM-Private water markets

Text Books

1) S.S. Negi. Integrated Watershed Management, Oriental Enterprises, 2001
2) Cech Thomas V., Principles of Water Resources: History, Development, Management and Policy, John Wiley and Sons Inc., New York, 2003.

References

1) Vinita Bhati. India's Water Resources: Planning and Management, Universal Scientific, 2003
2) Technical Advisory Committee, Integrated Water Resources Management, Technical Advisory Committee Background Paper 4. Global Water Partnership, Stockholm, Sweden. 2002.
3) Technical Advisory Committee, Poverty Reduction and IWRM Technical Advisory Committee, Background paper 8. Global Water Partnership, Stockholm, Sweden, 2003

09CE398 HYDROLOGIC PROCESSES

Credit 4:0:0
Objectives

1. To provide a basic knowledge of different components of hydrologic cycle (precipitation, evapotranspiration, runoff, infiltration, and stream flow and groundwater regime).
2. To impart practical experience in hydrological data acquisition, analysis and interpretation on temporal and spatial scales.

Unit 1: Hydraulics and Hydrology
Definition and introduction to hydraulics and hydrological science-Structure and properties of water-Conservation of mass-Conservation of energy-Hydrological cycle: global to local scales-Radiation balance –Evaporation and condensation.

Unit 2: Precipitation
Precipitation- Types of precipitation- Temporal and spatial distribution of precipitation-Precipitation measurement: precipitation gauges, satellite estimates of precipitation, radar measurement of precipitation- Interpretation of precipitation data: estimating missing precipitation data, double-mass analysis-Average precipitation over area: isohyets and Thiessan polygon-Depth-area-duration analysis.

Unit 3: Runoff and Stream flow
Phenomena of runoff: surface retention, infiltration-Runoff cycle- Estimating the volume of storm runoff: storm analysis- Basin characteristics-Streamflow measurements and rating curves-Storm hydrograph analysis-Unit hydrograph-Flood estimation.

Unit 4: Evaporation and Transpiration
Factors affecting evaporation process- Water-budget determination of reservoir evaporation-Energy-budget determination of reservoir operation-Estimation of evaporation from Pan evaporation,Thornthwaite and Penman-Monteith methods-Water-budget, Lysimeter determination of evapotranspiration-Infiltration loss estimation (phi-index).

Unit 5: Subsurface Hydrology
Vadozone-Soil moisture-Moisture movement-Water retention characteristics of soil-Characteristics of saturated zones.

Text books

1) Ojha, Berndtsson, Bhunya. Engineering Hydrology, Oxford Press, 2008
2) Ward and Robinson, Principles of Hydrology, Tata McGraw Hill, 1998.

References

1) Maidment, D.R. (editor), Handbook of Hydrology. McGraw-Hill, New York,1993
2) Linsley, R., M. Kohler, and J. Paulhus, Hydrology for Engineers, McGraw Hill, 1975.

3) Subramanya, K., Engineering Hydrology, Tata Mc Graw Hill, New Delhi, 1984.
4) Singh V.P., Elementary Hydrology, Prentice Hall of India, New Delhi, 1994.
5) Todd, D.K., Groundwater Hydrology, 2nd Edition, Wiley Eastero Limited, 1985.
6) Dingman, S.L., Physical Hydrology (2nd ed.), Prentice Hall, 2002.

09CE399 WATER QUALITY ANALYSIS AND MODELING

Credit 3:1:0

Objectives

1. This course examines the physical, chemical and biological processes influencing water quality
2. It imparts knowledge on the potential role of models in water quality management

Unit 1: Introduction to Water Chemistry

Chemistry of natural water-Principles and applications of aqueous chemistry -Unique properties of water-Chemical activity of natural waters-Water as nature's solvent and its properties-Natural waters: hardness index, oxidation and reduction-Redox reactions in natural waters-pE-pH diagrams-Acid-base chemistry: CO2 in water, CO2 dissolution in water, pH of rain water-Acid-base reactions of CO2 (aq), calcium carbonate-Oxygen dissolution-Henry's Law

Unit 2: Water Quality Standards

Drinking water quality characteristics-Significance of various parameters -Various drinking water quality standards-Aesthetic and health effects beyond permissible limits-Water quality problems associated with excess iron, fluoride, arsenic, hardness, nitrate, heavy metals, and pesticides -Genesis of fluoride and arsenic in groundwater sources- Indian Standards for water quality in industrial and agricultural sector- Distribution of microorganisms, indicator organisms, coliforms - Fecal coliforms - E.coli, streptococcus - Significance - MPN index, M.F. technique-Standards.

Unit 3: Water Pollution

Introduction and definitions of water pollution -Types of water pollution-Types, sources and consequences of water pollution-Ecological and biochemical aspects of water pollution-Types and characteristics of domestic, industrial, agricultural wastes and their effects on water bodies-Chemical and bacteriological sampling and analysis-Water quality parameters: criteria and standards -Classification of water pollutants: inorganic pollutants and toxic metals, organic pollutants-DO-BOD-COD-Radio active pollutants, Eutrophication effects and control; Pesticide pollution; Oil pollution-Abiotic and biotic interactions in aqueous system: exchange process - speciation - transformation and degradation-Effects of pollution on marine environment.

Unit 4: Water Quality Modeling

A. Surface Water

Effluent and stream standards- Historical development of water quality models- Principles of water quality modeling of rivers, estuaries.

B.Groundwater

Applied geochemistry: application of geochemical principles and techniques to environmental problem solving.

Unit 5: Experimental Methods of Analysis

Analytical instruments –Working principle and analytical methods in water analysis-pH meter-Electrical conductivity meter-UV visible spectrophotometer-Flame photometer-Atomic absorption spectrophotometer-Gas chromatograph-Electro analytical techniques.

Text Books

1. Steven C.Chapra, Surface Water Quality Modeling, McGraw-Hill-Companies, Inc., New York, 1997.
2. Manahan S.E, Environmental Chemistry (7^{th} Ed), Lewis Publications, Florida, U.S.A, 2000.

References

1. Stumm, Werner and James J. M, Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters, John Wiley and Sons, Inc., 1st Edition 1970, 3rd Edition, 1996
2. B.K. Sharma and H. Kaur, Environmental Chemistry:, Goel Publishers,Meerut,1994
3. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F., Chemistry for Environmental Engineers, 4th Edn. McGraw Hill, New Delhi, 1994
4. De.A.K., Environmental Chemistry, New Age International Ltd., New Delhi, 1995
5. S.M.Khopkar, Basic Concepts of Analytical Chemistry 2^{nd} edition New Age International Publishers, 1998
6. Qasim, Motley, Guang. Water Works Engineering, Prentice-Hall India, 2006.

09CE3100 WATER QUALITY TESTING LABORATORY

Credit 0:0:2

List of Experiments

Water sampling

1. Preservation-insitu analysis

Mineral analysis

2. PH and conductivity
3. turbidity, colour, suspended and dissolved solids,
4. chloride, sulphate, hardness,

5. fluoride (spectrophotometry)

Demand analysis

6. BOD
7. COD

Nutrient analysis

8. Nitrate, nitrogen (ammonia)

Metal analysis

9. Iron (spectrophotometry),
10. sodium and potassium (flame photometry)

Bacteriological analysis

11. Analysis of total coliforms
12. fecal coliforms and e-coli by MPN technique

References

1. APHA. 1996. Standard Methods for the Examination of Water and Wastewater, 14th ed, American Public Health Association, Washington, DC.
2. Inorganic Quantitative Analysis, - A.I. Vogel, 6th edition, Prentice Hall Inc., (1998)
3. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F., Chemistry for Environmental Engineers, 4th Edn. McGraw Hill, New Delhi, 1994

09CE3101 HYDROGEOLOGY

Credit 3:1:0

Objectives

1. To provide the student an introduction to the occurrence, distribution and movement of ground water.
2. To equip the student with analytical techniques to solve groundwater problems.

Unit 1: Introduction

Hydrologic cycle-Groundwater budget- Groundwater issues and problems in India.

Unit 2: Physical Hydrogeology

Aquifers and aquitards - Properties of aquifers: Darcy's law, hydraulic conductivity, intrinsic permeability, hydraulic head, water table, , transmissivity, storativity, homogeneity, isotropy - Groundwater flow patterns-specific discharge, average linear flow velocity, laminar and turbulent flow.

Unit 3: Groundwater Flow Theory and Its Applications

Groundwater velocity-Steady state equations of flow (confined and unconfined aquifers)-Theis equation-Dupuit equation- Unsteady-state flow in confined and unconfined aquifers-Thiem method for estimating drawdown using observation wells–Pumping test and estimation of parameters.

Unit 4: Groundwater Resources
Types of wells-Measurement and interpretation of groundwater level data -Surface water-ground water interactions -Land subsidence -Salt water intrusion.

Unit 5: Groundwater Quality and Contaminant Hydrogeology
Water chemistry: geochemistry of naturally occurring water-Contaminant transport- Point source and non-point source pollution- Advection, dispersion and degradation.

Text Books

1. Fetter, C. W., Applied Hydrogeology, Merril Publishing Co., Columbus, OH, 592 pp., 4th ed., 2001.
2. Hiscock, Kevin, Hydrogeology, Principles and Practice, Blackwell Publishing, Oxford, UK, 2005.

References

1. Bear, J., Hydraulics of Groundwater, McGraw Hill, New York, 567 pp., 1979.
2. M. Thangarajan, Groundwater: Resource Evaluation, Augmentation, Contamination, Restoration, Modeling and Management, Capital Pub., 2006.
3. A R Freeze and J A Cherry, Groundwater, John Willey Publishers, 1979.

09CE3102 SYSTEMS ANALYSIS FOR MANAGEMENT OF WATER RESOURCES

Credit 3:1:0

Objectives

1) Students will be introduced to application of systems concept to water resources planning and management.
2) Optimization techniques for modeling water resources systems will be introduced.

Unit 1: Introduction to Systems Analysis
Concepts of systems analysis: definition, systems approach to water resources planning and management-Role of optimization models-Objective function and constraints-Types of optimization techniques.

Unit 2: Linear Programming
Formulation of linear programming models-Graphical method-Simplex method-Application of linear programming in water resources- Sensitivity analysis-Application to design and operation of reservoir.

Unit 3: Dynamic Programming
Belman's principles of optimality forward and backward recursive dynamic programming-Curse of dimensionality-Application of dynamic programming for resource allocation.

Unit 4: Simulation
Basic principles and concepts – Random variate and random process – Monte Carlo techniques.

Unit 5: Water Resources Management
Reservoir operation policy-Optimal operation of single reservoir system-Allocation of water resources-Optimal cropping pattern-Conjunctive use of surface and groundwater.

Text Books

1. Vedula & Mujumdar. Water Resources Systems: Modelling Techniques and Analysis, Tata-McGraw Hill, 2005
2. Gupta P.K and Man Mohan, Problems in Operations Research (Methods and Solutions). Sultan Chand and sons, New Delhi (Seventh Edition). 1995.

References

1. Water Resources Economics - James & Lee. Oxford Publishers, 2005.
2. Optimal Design of Water Distribution Networks P.R.Bhave, Narosa Publishing house 2003
3. Hiller F.S and Liebermann G.J., Operations Research. CBS Publications and Distributions. New Delhi (2nd edition). 1992.
4. Chaturvedi. M.C., Water Resources Systems Planning and Management. Tata McGraw Hill Inc., New Delhi. 1997.
5. S. S. Rao, Optimization: Theory and Applications, Wiley Eastern, 1978

09CE3103 COMPUTATIONAL METHODS IN WATER RESOURCES MANAGEMENT

Credit 3:1:0

Objectives

1) To develop skills in computational techniques and programming for developing and validating simple models in hydrology.
2) To improve computing knowledge for applications in water resources management.

Unit 1: Modeling Principles
Principles of models-Physical, mathematical and numerical models – Verification and validation-Parameter estimation -Sensitivity analysis – Error in modeling

Unit 2: Computing Methods
Computer methods in water resources – Algorithms – Computing techniques – Solution to ordinary and partial differential equation -Numerical methods - Interpolation - Finite difference schemes –Finite element methods - Initial and boundary conditions.

Unit 3: Digital Database Management

Data base structure – Data acquisition, warehousing, and retrieval – Data format – Attribute – RDBMS – Data analysis – Network data sharing – Statistical Package for Social Science (SPSS)- Regression - Factor analysis – Histogram – Scatter diagram – Goodness of fit.

Unit 4: Soft Computing Techniques

Artificial Neural Network analysis - Application of genetic algorithm in optimization of reservoir operation.

Unit 5: Application of Software in Water Management

Application to water resources using Hydrological Modeling System – SWAT (Soil and Water Assessment Tool)–Water quality model (QUAL 2E)-Ground water flow and transport model (Visual MODFLOW) - WEAP (Water Evaluation and Planning system)

Text Books

1. A K Rastogi, Numerical Groundwater Hydrology, Penram International Publishing (India), 2006
2. S. S. Rao, Applied Numerical Methods for Engineers and Scientists, Prentice-Hall, 2002.

References

1. John E. G, Introduction to Hydraulics and Hydrology with Applications for Stormwater Management, DELMAR, Thomson Learning, USA, 2002.
2. Remson I, Hornberger G.M. and Moiz F.J., Numerical Methods in Sub-Surface Hydrology, Wiley Inter Science, 1985.
3. Stephen A, Thompson, Hydrology for Water Management,A.A.Balkema Rotten Publications,1999.
4. Vijay P. Singh, Kinematic Wave Modelling in Water Resources-Surface Water Hydrology, John Wiley and Sons Inc, 1996.

09CE3104 PARTICIPATORY WATER MANAGEMENT

Credit 4:0:0

Objectives

1. To introduce the student to the concept of farmer involvement in water management.
2. To highlight the value of participatory approach for better performance of the irrigation systems, and for providing other facilities to the water users through organized associations.

Unit 1: Fundamentals of Sociology

Sociology as a science: basic concept – Perspectives of sociology – Social system – Early sociological thought.

Unit 2: Concept of Participation

Introduction – Dublin statement – Irrigation as a socio-technical process – System management by agencies and users – Farmers organization and participation: need, and contribution to irrigation management (greater productivity, improved water distribution, conflict management, greater resources mobilization and sustained system performance).

Unit 3: Water User Association

Kinds of participation – Activities in irrigation management – Water users Association – Types and levels of operation and organization in irrigation systems – User roles in irrigation management – Role of community organizers – The context of participation: factors in the environment-Organizational structure for watershed management-Role of SHGs and NGOs-Participatory planning and implementation of watershed projects.

Unit 4: Supporting Farmers Organization and Participation

Policy consideration – Support – Experimentation, phasing and flexibility – Bottom-up approach – Existing organizations – Ownership – Non-political associations – Bureaucratic reorientation – Compatibility of objectives – Choices in organizational design – Scope of activity – Size and structure – Membership and decision making – Leadership and responsibilities – Legal basis – Development strategy – Channels for implementation.

Unit 5: Improving Agency Relation with Farmers

Agency incentives – Technical cooperation – Special roles and style of agency –Agency organization – Irrigation management transfer.

Text Books

1. Uphoff N. Improving International Irrigation Management with Farmer Participation – Getting the Process Right – Studies in Water Policy and Management. New Westview Press, 1986.
2. Geijar J.C. M.A., Irrigation Management Transfer in Asia. FAO/RAP, Thailand. 1995.

References

1. Abraham Mark, Social Research Methods. Prentice. Hall Inc. Eaglewood Cliffs, N.J. 1993.
2. Chambers R., Managing Canal Irrigation. Oxford IBM Publishing Co., New Delhi. 1988.
3. Desai A.R., Rural Sociology in India. Popular Prakashan, Bombay. 1969..
4. Johnson S.H., Vermillon D.L. and Sagardoy J.A., Irrigation Management Transfer – Selected Papers from the International Conference Management Transfer. Wuhan, China, IIMI, FAO, Rome. 1994.
5. Korten F.F, and Robert Y.Siy, Jr., Transforming a Bureaucracy – the Experience of the Phillipine National Irrigation Administration. Ateneo De Manila University Press, Quezon City, P.O. Box 154, Manila. 1989.
6. Michal C.M. Putting People First. Sociological Variables in Rural Development, Oxford University Press, London. 1985.

09CE3105 IRRIGATION WATER MANAGEMENT

Credit 4:0:0

Objectives:

1. To introduce soil-water-plant relationships in the context of irrigation.
2. To introduce the concepts of scheduling, water distribution, design and methods of irrigation.

Unit 1: Development of Irrigation

Importance of irrigation – Impact of irrigation on development of humanity – Need for irrigation– Development of irrigation in India – National Water Policy – Irrigation using canal, tank and ground water.

Unit 2: Crop Water Requirement

Infiltration and movement of water in soil – Soil-water-plant relationships-Role of climate – Water requirement of crops – Evapotranspiration (ET) and consumptive use - Methods of estimating ET – Effective rainfall-Soil and water quality-Leaching requirements – Irrigation requirements-FAO procedure - Duty of water – Irrigation of lowland and upland crops.

Unit 3: Water Distribution

Canal network and canal regulation – Methods of distribution: supply based and demand based – Delivery of water to farms – Measurement of water – Scheduling of irrigation – Criteria for scheduling – Frequency and interval of irrigation-Turn system

Unit 4: Surface Irrigation Methods

Classification of irrigation methods – Border irrigation: design parameters, evaluation and ideal wetting pattern – Furrow irrigation: design parameters, types of furrows, evaluation, ideal wetting pattern and planting techniques – Basin irrigation: types of basins, suitable crops, soils and slopes, ideal wetting pattern, shapes and size – Efficiency of surface irrigation methods-Drainage systems.

Unit 5: Drip and Sprinkler Irrigation Methods

Drip irrigation: components, suitable crops and land types – Sprinkler irrigation: types, components, and suitable crops, slope, soils and climate.

Text Books

1. Majumdar D. P., Irrigation Water management Principles and Practices, Prentice Hall of India, New Delhi, 2005.
2. Dewasish Choudhary, Irrigation Theory and Practice, Anmol Pub., 2008

References

1. Michal A.M., Irrigation Theory and Practice, Vikas Publishing House, New Delhi, 1999.

2. Van den Bosch B.E., Hoevenaars J. and Broumer C., Irrigation Water Management Training Manual No.1 to 7, FAO, Rome, 1999.
3. Asawa G.L., Irrigation Engineering, New Age International Private Limited, New Delhi, 1996

09CE3106 EXPERIMENTAL AND COMPUTATIONAL LABORATORY

Credit 0:0:2

List of Experiments

1. Probable maximum precipitation estimates for one of the river basins
2. Computation of flow duration curve based on field data
3. Testing and validation of simple monthly rainfall-runoff model
4. Estimation of sheet erosion using USLE
5. Developing a DSS integrating USLE with a GIS package
6. Estimation of evapotranspiration using Penman-Monteith Method
7. DO fluctuation model in streams and rivers
8. Simulation of transport processes in ground water using numerical schemes such as finite difference and finite element methods
9. Experiments in open channel flow (Calibration of notches, flumes etc.)
10. Experiments on pipe flow (friction in pipes, orifice meter, venturi flow rate meter)

References

1. A K Rastogi, Numerical Groundwater Hydrology, Penram International Publishing (India), 2006
2. John E. G, Introduction to Hydraulics and Hydrology with Applications for Stormwater Management, DELMAR, Thomson Learning, USA, 2002.

09CE3107 WATERSHED AND RIVER BASIN MANAGEMENT

Credit 4:0:0

Objectives:

1. To make the student understand the processes leading to degradation of soil and water resources and implementation of conservation measures.
2. To impart the principles of managing water from watershed to river basin scale.

Unit 1: Introduction to Watershed

Watershed delineation-Watershed development: Definition and concepts, objectives and need-Integrated and multidisciplinary approach for watershed management- Characteristics of watershed: size, shape, physiography, slope, climate, drainage, land use, vegetation, geology and soils, hydrology and hydrogeology- Socio-economic characteristics.

Unit 2: Watershed Management

Definition of watershed management – Factors affecting watershed management- Preparation of land drainage schemes-Types and design of surface drainage -Controlling of soil erosion and soil salinity- Estimation of soil loss due to erosion: Universal soil loss equation.

Unit 3: Water Conservation and Harvesting

Types and design of water conservation and water harvesting structures for different types of catchments-Rainwater harvesting-Catchment and roof top harvesting-Harvesting structures- Soil moisture conservation-Check dams-Artificial recharge-Farm ponds-Percolation tanks.

Unit 4: Introduction to River Basins

River systems-Water and river basin management in India-Upstream-downstream demands-Quality problems downstream-Environmental flows-Shared rivers-Water conflict resolution-Requirements for integrated river basin management.

Unit 5: River Basin Management

River basin management - Principles of planning processes-Water availability assessment – Surface water and groundwater-Water demand assessment: municipal, industrial, agricultural and environmental-Water allocation - Principles and policies-Case studies- Impacts of anthropogenic activities and climate change on water resources.

Text Books

1) J V S Murthy, Watershed Management - New Age International Publishers, 1998
2) N C Thanh, A K Biswas, Environmentally sound water management UNEP, International Training Centre for Water Resources Management (ITCWRM), International Water Resources Association (IWRA) , Oxford University Press, Delhi 1990 s

References

1) Ghanshyam Das, Hydrology and Soil Conservation Engineering. Prentice-Hall of India Pvt. Ltd., New Delhi. 2000.
2) Suresh R., Soil and Water Conservation Engineering. Standard Publishing Distributors, New Delhi. 2000.
3) Tideman E. M., Watershed Management. Omega Scientific Publishers, New Delhi. 1996.
4) M Newson, Land, Water and Development: River Basin Systems and Their Sustainable Management, Routledge, London, 1992
5) G J Young, J C I Dooge and J C Rodda, Global Water Resources Issues, Cambridge University Press, Cambridge, UK, 1994.

09CE3108 WATER RESOURCES MANAGEMENT TOOLS: REMOTE SENSING AND ENIVROMENTAL ISOTOPES

Credit 4:0:0

Objectives:

1. To introduce the student to emerging tools used in water resources investigations such as remote sensing and isotope hydrology
2. To demonstrate the application of these tools to solve some simple practical problems in hydrology and water resources engineering

Unit 1: Introduction to Remote Sensing

Remote Sensing – Basic concepts and foundation of remote sensing – Satellite and sensors- Elements involved in remote sensing- Electromagnetic Radiation-Electromagnetic spectrum: visible, infra red (IR), near IR, middle IR, thermal IR and Microwave – Black body radiation - Remote sensing terminology and units

Unit 2: EMR Interactions with Atmosphere and Earth Materials

Atmospheric characteristics – Scattering of EMR – Raleigh, Mie, Non-selective and Raman scattering – EMR interaction with water vapour and ozone – Atmospheric windows – Significance of atmospheric windows – EMR interaction with earth surface materials :radiance, irradiance, incident, reflected, absorbed and transmitted energy – Reflectance – Specular and diffuse reflection surfaces- Spectral signature – Spectral signature curves

Unit 3: Application of Remote Sensing in Water Resources

Land use/land cover mapping-Watershed characteristics- Surface water mapping- Groundwater mapping-Runoff potential indices of watersheds.

Unit 4: Introduction to Isotopes

Isotopes and their characteristics-Radioactive and environment isotopes-Mass spectrometric sampling and analysis of stable isotopes.

Unit 5: Isotope Applications in Surface Water and Groundwater Hydrology

Water balance: groundwater inflow and outflow estimates- dating of groundwater-Percolation tank hydrology-Determination of groundwater velocity in saturated zone-Identification of recharge/discharge processes-Pollution migration studies.

Text Books

1. Floyd F. Sabins, Remote Sensing-Principles and Interpretation, W H Freeman and Company 1996.
2. S. M. Rao, Practical Isotope Hydrology, New India Publishing Agency, 2006.

References

1. M. Anji Reddy, Remote Sensing and Geographical Information Systems, B.S. Publications, 2001.

2. J. R. Jensen, Remote Sensing of the Environment, Prentice Hall, 2000.
3. Environmental Isotopes in Hydrological Cycle, Principles and Applications (Ed. WG Mook), IHP-V, Technical Documents in Hydrology, No 39, Vol 1, UNESCO, Paris, 2000
4. Use of Artificial Tracers in Hydrology, Proc. Adv. Group Meeting, Vienna, IAEA, 1990.
5. C. Kendall and J J McDonnell, Isotopes in Catchment Hydrology, Elsevier, 1998.
6. M.G. Srinivas (Edited by), Remote Sensing Applications, Narosa Publishing House, 2001.

09CE3109 AQUATIC ECOLOGY AND ENVIRONMENTAL IMPACT ASSESSMENT OF WATER RESOURCES PROJECTS

Credit 4:0:0

Objectives

1. To introduce the concepts of ecology and biological aspects of environment in the context of water resources management
2. To enable the student to acquire necessary skills to assess the impact of water resources projects, development on the environment and to take necessary steps to bring down the adverse impacts.

Unit 1: The Ecosystems

The scope of ecology-Basic kind of ecosystem- Component parts of ecosystem-Toxinomic components of an ecosystem-Diversity and stability in the ecosystem.

Unit 2: Systems Ecology

Energy flow within the ecosystem- Solar radiation environment– Food chain and tropic levels– Production and utilization rates-Concepts of community and carrying capacity – Biodiversity - Characteristics of inland and coastal aquatic ecosystems.

Unit 3: Important Aquatic Ecosystems of the World

Wetlands: definition, classification, wetland science, wetland values and functions, hydrologic modifications, water balance, integrated management concept-Rivers: values and functions, sources of pollution, water quality standards, river basin management-Tanks and lakes: ecologic relevance, water balance, ecosystem management concept.

Unit 4: Environmental Impacts

Hydrological and water quality impacts – Ecological and biological impacts – Social and cultural impacts – Soil and landscape changes – Agro-economic issues – Human health impacts – Ecosystem changes.

Unit 5: Methods of Environmental Impact Assessment (EIA)

EIA team formation – Development of scope, mandate and study design – Baseline survey – Check lists – Adhoc procedures – Network and matrix methods – Simulation methods-Environmental Impact Statement (EIS) preparation with special reference to water resources development.

Text Books

1) Barathwal, R.R., Environmental Impact Assessment. New Age International Publishers, New Delhi. 2002
2) Odum, E.P., Basic Ecology, Saunders & Co., Philadelphia. 1984.

References

1) Canter, L.W., Environmental Impact Assessment. McGraw Hill International Edition, New York. 1995.
2) Arnel, N., Hydrology and Global Environmental Change. Prentice Hall, Harlow. 2002
3) K.B. Chari, Richa Sharma and S.A. Abbasi. Comprehensive Environmental Impact Assessment of Water Resources Projects : With Special Reference to Sathanur Reservoir Project (Tamil Nadu), Discovery Pub., 2005
4) Petts, J. Handbook of Environmental Impact Assessment, Vol. 1. Blackwell Science Publication, 1999

09CE3110 GIS AND DATA BASE MANAGEMENT IN WATER RESOURCES MANAGEMENT

Credit 3:1:0

Objectives

1) To introduce database and spatial attributes.
2) To teach GIS analysis and its simple applications to hydrological modelling and water resources management using GIS packages.

Unit 1: Spatial Information Technology for Water Resources

Spatial variation in water resources – Water resources database –Introducing GIS and spatial data: definition - Maps and spatial information -Computer assisted mapping and map analysis - Components of GIS - Maps and spatial data - Thematic characteristics of spatial data.

Unit 2: Spatial and Attributes Data Modeling and Management

Concepts - Definitions - Components and assessment of data quality: spatial entities - Generalization - Raster and vector spatial data structures - Comparison of vector and raster methods - Acquisition of spatial data for terrain modeling – Satellite imageries-Raster and vector approach to digital terrain modeling - Problem of data management - Database management system - Relational database model - Linking spatial and attribute data.

Unit 3: Data Input and Editing Operation in GIS

Manual digitizing, scanning and automatic digitizing methods-Electronic data transfer – Geo-referencing-Data editing-Methods of developing and correcting errors in attributes and spatial data: reproduction, transformation and generalization - Edge matching and rubber sheeting.

Unit 4: Spatial Analysis

Thematic mapping – Measurement in GIS: length, perimeter and areas – Query analysis – Reclassification – Buffering - Neighbourhood functions - Integrated data - Raster and vector overlay method: point-in-polygon, line-in-polygon and polygon-on-polygon-Spatial interpolation- Network analysis: shortest path problem, travelling salesman problem, location allocation of resources - Route tracing-Introduction to GPS.

Unit 5: Water Resources Applications

Base map preparation – Catchment survey – Regional rainfall mapping – Landuse/landcover mapping-Surface water resources -Ground water potential mapping - Site selection for artificial recharge-Water quality mapping – GIS as a tool for water resources planning.

Text Books

1) Ian Heywood Sarah, Cornelius and Steve Carver, An Introduction to Geographic Information Systems,Pearson Education,New Delhi. 2002.
2) Maidment. Arc Hydro:GIS for Water Resources, ESRI Press, 2002

References

1) Burrough P.A., McDonnell, Principles of Geographic Information Systems, London: Oxford University Press, 2000
2) Haywood.L, Comelius.S and S. Carver,An Introduction to Geographic Information Systems, Addison Wiley Longmont, New York,1988
3) Lynn E. Johnson, Geographic Information Systems in Water Resources Engineering, IWA Publications, 2009
4) Burgh P.A., Principles of Geographic Information System for Land Resources Assessment, Clarendon Press, Oxford,1986
5) Lo.C.P., Yeung. K.W. Albert, Concepts And Techniques of Geographic Information Systems, Prentice-Hall of India Pvt ltd, New Delhi,2002
6) Biswas, A.K. and Agarwal, S. B. C., Geographic Information System: An Introduction, John Wiley & Sons, Inc., 1992.
7) Arctur & Zeiler. Designing Geodatabases, ESRI Press, 2004

09CE3111 WATER AND WASTEWATER TREATMENT AND MANAGEMENT

Credit 3:1:0

Objectives

1. To make the student learn about the issues involved in water and wastewater quality aspects
2. To make the student learn about physical, chemical and biological techniques available for managing water quality.

Unit 1: Water and Wastewater Quantity Estimation
Population forecast-Water demand for various purposes- Estimation of wastewater quantity-Temporal and spatial variation in quantity of water and wastewater -Water supply/distribution systems -Wastewater collection systems-Underground drainage systems.

Unit 2: Water/Wastewater Quality Enhancement
Philosophy of treatment-Unit operations and processes-Physical, chemical and biological methods-Wastewater characteristics-Primary, secondary and tertiary treatment-Physical unit processes: screening, commutation, grit removal, equalization, sedimentation.

Unit 3: Chemical Unit Processes for Water and Wastewater Treatment
Coagulation-Flocculation-Filtration- Disinfection- Aeration and gas transfer-Precipitation-Softening- Adsorption and ion exchange-Membrane technology.

Unit 4: Biological Treatment of Wastewater
Types of microorganisms-Aerobic *vs*. anaerobic processes-Aerobic treatment: suspended growth aerobic treatment processes-Activated sludge process and its modifications-Attached growth aerobic processes: Trickling filters and rotating biological contactors-Anaerobic treatment: fluidized bed and sludge blanket systems-Nitrification-Denitrification.

Unit 5: Natural Wastewater Treatment Systems
Ponds and lagoons-Wetlands and root-zone systems-Surface and ground water treatment for potable water supply- rural water supply-Low cost sanitation-Septic tanks, soak-pits-Bioremediation.

Text Books

1) Metcalf and Eddy, Wastewater Engineering - Treatment, Disposal, and Reuse, Third Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1995.
2) Casey T.J., Unit Treatment Processes in Water and Wastewater Engineering, John Wiley & Sons England 1993.

References

1) R.Stuetz, T Stephenson, Principles of Water and Wastewater Treatment Processes, IWA Publications, 2009
2) Kuruvilla Mathew, Stewart Dallas, Goen Ho, Decentralized Water and Wastewater Systems, IWA Publications, 2008.

09CE3112 IWRM IMPLEMENTATION: GENDER ISSUES, ECONOMICS, POLICIES, INSTITUTIONAL MECHANISMS

Credit 4:0:0
Objectives

1. To improve the understanding and awareness of gender concepts, the water law and policy, economic and social drivers for effective and efficient water sector management
2. To provide a general idea on emerging issues in the field of water resources management.

Unit 1: Gender Issues in Water Resources Management

Defining gender - Historical framework of gender - Using gender perspective in integrated water resources management - Gender approach in IWRM-Gender competency issues in water - Gender and capacity building - Institutional capacity to promote gender in IWRM projects- Gender analysis tools-- Building gender awareness- Knowledge and skills - Effects of gender-Sensitive assessment on gender relations

Unit 2: Water Pricing and Economics

Implementing IWRM: Why are economic and financial tools needed? -Sustainable development: valuation of water -Water uses and water rights -Components of full water costs and values - Social and cost benefit analysis for water related projects- Introduction to the water finance system- Water pricing: concept and methods– Cost recovery implications of water pricing

Unit 3: Water Law and Policy

Water policies: goal and strategies-Water policy of India-Water rights: international and Indian scenario-Power, function and regulatory role of state and central pollution control board-Environmental guidelines and regulations for water management-Water auditing-Water monitoring and sustainability issues-Understanding UN law on non-navigable uses of international water courses.

Unit 4: Institutional Mechanisms

Analysis of the laws and administrative structure that constitute the institutional framework of the environmental aspects of water resources management -Corporate organizations-Participatory planning-Incentives for water quality enhancement-Monitoring-Institutional capacity-PPP.

Unit 5: Emerging Issues

Rehabilitation and resettlement issues-Risk and reliability analysis of water resources projects.

Text Books

1) Cech Thomas V., Principles of Water Resources: History, Development, Management and Policy. John Wiley and Sons Inc., New York. 2003.
2) N. Handy and C L Spesh, Cost Benefit Analysis of the Environment, Edward Elgav, Alderslot, UK, 1993.

References

1) Gender Analysis and Reform of Irrigation Management: Concepts, Cases, and Gaps in Knowledge: Proceedings of the Workshop on Gender and Water, 15-19 September 1997, Habarana, Sri Lanka. IWMI, 1998. Environmental Publications from UNEP
2) The Gender Approach to Water Management. Findings of an Electronic Conference Series, Gender and Water Alliance. January - September 2002. Published for the Gender and Water Alliance by WEDC.www://wedc.lboro.ac.uk/ publications.

3) Technical Advisory Committee, Regulation and Private Participation in Water and Sanitation sectors, Technical Advisory Committee Background paper No: 1. Global Water Partnership, Stockholm, Sweden. 1998.
4) Technical Advisory Committee, Dublin Principles for Water as Reflected in Comparative Assessment of Institutional and Legal Arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
5) Technical Advisory Committee, Water as Social and Economic Good: How to Put the Principles to Practice. Technical Advisory Committee Background paper No: 2. Global water Partnership, Stockholm, Sweden. 1998.
6) Technical Advisory Committee, Effective Water Governance. Technical Advisory Committee Background paper No: 7. Global Water Partnership, Stockholm, Sweden. 2003.

WATER INSTITUTE

LIST OF SUBJECTS AND SYLLABI

Sub. Code	Name of the Subject	Credits
12CE333	Introduction to IWRM	4:0:0
12CE334	Hydrologic Processes	3:1:0
12CE335	Groundwater Hydrology	3:1:0
12CE336	Ecosystem Management	4:0:0
12CE337	Systems Analysis	3:1:0
12CE338	Computational Methods and Techniques	3:1:0
12CE339	Participatory Water Management	3:0:0
12CE340	Water Resources Planning and Development	4:0:0
12CE341	Irrigation Water Management	4:0:0
12CE342	Remote Sensing and GIS	3:1:0
12CE343	MATLAB	3:0:0
12CE344	Water Quality Laboratory	0:0:2
12CE345	Hydrology Laboratory	0:0:2
12CE346	Computational Laboratory	0:0:2
12CE347	Environmental Impact Assessment	4:0:0
12CE348	Isotope Techniques in Water Resources Management	4:0:0
12CE349	Water and Wastewater Treatment	3:1:0
12CE350	IWRM Implementation - Case Studies	4:0:0
12CE351	Fluvial Hydraulics	4:0:0
12CE352	Basic Hydraulic Structures	4:0:0
12CE353	Advanced Remote Sensing	3:1:0
12CE354	Forest, Urban and Agricultural Watershed Management	4:0:0

12CE333 INTRODUCTION TO IWRM

Credits 4:0:0

Course Objective:

- Concepts of IWRM will be introduced and the inter-disciplinary nature highlighted
- Students will be exposed to sustainable water resources management, water security and public-private participation issues
- They will be briefed about integrated multi-sectoral and multi-dimensional issues in developing water resource management plans

Course Outcome:

- Students enabled to plan integrated water resources development considering sustainability aspects
- Students capacitated to take up water management projects from a multi-objective and multi-purpose perspective
- Students prepared for taking up other subjects related to IWRM

Unit I

CONCEPTS, PRINCIPLES AND TERMINOLOGIES: IWRM: definition and principles-Social, economic, environmental and institutional factors in water management – Water crisis: national and international perspectives- Water needs for human beings and nature-Concepts of 'blue', 'green' and 'grey' water- Ecosystem approach- Global climate change and its effect on water resources.

Unit II

SUSTAINABLE WATER RESOURCES MANAGEMENT: Concept of sustainable development-Dublin Conference and Earth Summit- National Water Policy: highlights and limitations –River basin approach – Small watershed management – Role of forest, cultivated watersheds and wetlands in sustainable water resources management- Matching water resources with demands – Water allocation-Environmental flows- Minimum water table.

Unit III

WATER RELATED ENVIRONMENTAL AND HEALTH PROBLEMS: Floods – Droughts- Soil erosion- Reservoir sedimentation-Salinity intrusion into surface and groundwater sources-Soil salinity- Waterlogging in command areas-Sand mining-Impact of population and anthropogenic activities on water resources- Pollution due to domestic and urban sewage, industrial effluents, agro-chemicals-Water borne and related diseases-Impact of water resources projects on human health.

Unit IV

TRADITIONAL AND MODERN TECHNIQUES FOR WATER SECURITY: Role of water in development - Rainwater harvesting – Artificial recharge – Conjunctive use of surface and groundwater-Interbasin transfer-Conservation of 'green' water – Treatment of 'grey' water-Basics of desalination and water treatment and recycling-Control in use of agro-chemicals-Sanitation and health care in the context of IWRM-Virtual water trade for achieving global water security-Need for awareness programmes and participatory approach.

Unit V

PPP AND PRIVATE MARKETS: Introduction to water economics- Water pricing - Private sector involvement in water resources management: PPP objectives, options, process and limitations-PPP case studies- PPP in the context of IWRM-Role of government in the context of IWRM-Private water markets-Problems associated with private water markets in developing and under developed countries.

Text Books

1. Negi S.S., "Integrated Watershed Management", Oriental Enterprises, 2001
2. Cech Thomas V.," Principles of Water Resources: History, Development, Management and Policy", John Wiley and Sons Inc., New York, 2003.
3. Cap-Net, Tutorial on Basic Principles of Integrated Water Resources Management, Cap-Net, IRC, IWMI, HRWallingford, IUCN, WSS, UNDP (www.cap.net.org).
4. Integrated Water Resources Management Plans, Training Manual and Operational Guide, CIDA, 2005.
5. Training Course Report in Water Assessment in Sub-Saharan Africa: Prediction in Unguaged and Data Scarce Basins, 21-25 January 2008, Cap – Net.

Reference Books

1. Vinita Bhati., "India's Water Resources: Planning and Management", Universal Scientific, 2003
2. Technical Advisory Committee, "Integrated Water Resources Management", Technical Advisory Committee, Background Paper 4, Global Water Partnership, Stockholm, Sweden. 2002.
3. Technical Advisory Committee, "Poverty Reduction and IWRM" Technical Advisory Committee, Background paper 8, Global Water Partnership, Stockholm, Sweden, 2003.

12CE334 HYDROLOGIC PROCESSES

Credits 3:1:0

Course Objective:

- To provide a basic knowledge on different components of hydrologic cycle
- To impart practical experience in hydrological data acquisition, analysis and interpretation on temporal and spatial scales

Course Outcome:

- Students enabled to analyse basic hydrologic data
- Students learnt basics of data management system
- Students capacitated to estimate water availability

Unit I

BASIC HYDRAULICS AND HYDROLOGY: Definition and introduction to hydraulics and hydrological science-Structure and properties of water-Conservation of mass and energy-Hydrologic cycle: global to local scales- Radiation balance –Evaporation and condensation.

Unit II

CONCEPTS OF FREQUENCY ANALYSIS AND STOCHASTIC HYDROLOGY: Return period - Random variable – Frequency distributions – Frequency analysis – Correlation co-efficient – Method of least squares – Variance analysis - Simple and multiple regression

analysis – Deterministic approach in hydrology - Stochastic hydrology - Introduction to: time series, deterministic and stochastic models.

Unit III

PRECIPITATION: Precipitation- Types of precipitation- Temporal and spatial distribution of precipitation- Precipitation measurement: precipitation gauges, satellite estimates of precipitation, radar measurement of precipitation- Interpretation of precipitation data: estimating missing precipitation data, double-mass analysis-Average precipitation over area: isohyets and Thiessan polygon-Depth-area-duration analysis.

Unit IV

RUNOFF AND STREAM FLOW: Phenomenon of runoff - Surface retention - Infiltration-Runoff cycle- Estimating the volume of storm runoff: storm analysis- Basin characteristics-Streamflow measurements and rating curves- Flood estimation: unit hydrograph, flood frequency analysis, flood routing - Sediment yield and reservoir sedimentation.

Unit V

EVAPORATION, TRANSPIRATION AND OTHER LOSSES: Factors affecting evaporation process- Water budget - Determination of reservoir evaporation- Energy budget - Determination of reservoir operation-Estimation of evaporation using Pan evaporimeter data-Thornthwaite and Penman-Monteith methods- Lysimeter determination of evapotranspiration-Interception – Soil moisture - Infiltration loss estimation.

Text books

1. Subramanya K., "Engineering Hydrology", Tata McGraw Hill, New Delhi, I994 (Second Edition)
2. Chow V.T., Maidment D.R., Mays L.W., "Applied Hydrology", McGraw Hill Publications, New York, 1995.

Reference Books

1. Maidment, D.R. (editor), "Handbook of Hydrology". McGraw-Hill, New York,I993.
2. Linsley R., and Paulhus, J., "Hydrology for Engineers", McGraw Hill, I975.
3. Ragunath H.M., "Hydrology", Wiley Eastern Ltd., New Delhi, 1994.
4. Singh V.P., "Elementary Hydrology", Prentice Hall of India, New Delhi, I994.

12CE335 GROUNDWATER HYDROLOGY

Credits 3:1:0

Course Objective:

- To provide the student an introduction to the occurrence, distribution and movement of ground water
- To equip the student with analytical techniques to solve groundwater problems

Course Outcome:

- Students enabled to resolve groundwater related problems including response of aquifers to pumping wells
- Students made capable to develop a basic model for contaminant transport in subsurface media

Unit I

OCCURRENCE AND MOVEMENT OF GROUNDWATER: Origin and age of groundwater - Groundwater in hydrologic cycle – Subsurface distribution - Groundwater budget - Groundwater column -Zones of aeration and saturation - Aquifers and their characteristics/classification.

Unit II

PHYSICAL PROPERTIES AND PRINCIPLES: Properties of aquifers - Darcy's law: groundwater velocity, hydraulic head and fluid potential, hydraulic conductivity and permeability - Heterogeneity and anisotropy of hydraulic conductivity - Porosity and void ratio - Unsaturated flow and water table - Compressibility and effective stress - Transmissivity and storativity - Steady state flow and transient flow - Limitations of Darcian approach.

Unit III

GROUNDWATER HYDRAULICS : Steady state equations of flow (confined and unconfined aquifers) – Uniform and radial flow to a well (confined and unconfined) - Theis equation- Dupuit equation- Unsteady state flow in confined and unconfined aquifers - Thiem method for estimating drawdown using observation wells–Pumping test and estimation of parameters.

Unit IV

GROUNDWATER TRANSPORT PROCESSES: Mass balance for transport of an ideal tracer – Contaminant transport mechanisms: advection, dispersion and diffusion – 1D, 2D and 3D solute transport – Pulse and step inputs – Solutions to advection, dispersion equation.

Unit V

GROUNDWATER MANAGEMENT: Types of wells- Measurement and interpretation of groundwater level data -Surface water-groundwater interactions -Land subsidence -Salt water intrusion – Artificial recharge.

Text Books

1. Fetter C. W., "Applied Hydrogeology", Merril Publishing Co., Columbus, OH, 2001.
2. Hiscock K., "Hydrogeology, Principles and Practice", Blackwell Publishing, Oxford, UK, 2005.
3. Todd D. K., "Groundwater Hydrology", John Willey & Sons Inc., 2007.

Reference Books

1.Bear J.," Hydraulics of Groundwater", McGraw Hill, New York, 1979.

2. Thangarajan,M., "Groundwater: Resource Evaluation, Augmentation, Contamination, Restoration, Modeling and Management", Capital Pub., 2006.

3.Freeze A. R., and Cherry J. A., "Groundwater", John Willey Publishers, 1979.

12CE336 ECOSYSTEM MANAGEMENT

Credits: 4:0:0

Course Objective:

- To develop an understanding on the ecosystem and its management to natural resources stewardship
- To develop preliminary knowledge of ecosystem modeling for developing management plans

Course Outcome:

- Students developed skills to examine ecologic, economic and social processes and apply for sustainable practices into management plan and policies

Unit I

TERRESTRIAL ECOSYSTEMS: Forest, grass land, savannas, desert, tundra -Ecosystems: functions and biodiversity – Food chain and food web – Energy and nutrient flow – Carbon sequestration.

Unit II

AQUATIC ECOSYSTEMS: Lentic, lotic, wetland and marine ecosystems - Functions and biodiversity – Food chain and food web – Energy and nutrient flow – Carbon sequestration.

Unit III

ARTIFICIAL ECOSYSTEMS: Soil infiltration systems – Wetlands and ponds – Source separation systems – Aquacultural systems – Agroecosystems – Detritus based treatment for solid wastes – Marine systems- Case studies.

Unit IV

ECOSANITATION: Chemistry of natural water - Principles and applications of aqueous chemistry – Properties of water - pE-pH diagrams-Acid-base chemistry: CO_2 in water, CO_2 dissolution in water -Experimental methods – Principles: pH meter,electrical conductivity meter, UV visible spectrometer, flame photometer, atomic absorption spectrometer, gas chromatograph – Electro analytical techniques.

Unit V

ECOSYSTEM MODELING AND MANAGEMENT: Classification of ecosystem models – Applications – Economics of ecosystems - Self-organizing design and processes – Multi seeded microcosms – Sustainable loading of ecosystems – Social and management aspects.

Text Books

1. Kangas P.C., and Kangas, P., "Ecological Engineering: Principles and Practice", Lewis Publishers, New York, 2003.
2. Sawyer C.N., McCarty, P.L., and Parkin, G.F., "Chemistry for Environmental Engineers", IV Edition, McGraw Hill, New Delhi, 1994

Reference Books

1. Etnier C. and Guterstam, B., "Ecological Engineering for Wastewater Treatment", Lewis Publishers, New York, 1997.
2. Odum E.P., "Basic Ecology", Saunders & Co., Philadelphia. 1984
3. Gary K. M., Larry A. N., Richard L. K., and Dennis A. S., "Ecosystem Management Adaptive, Community-Based Conservation". Island Press, Washington, DC. 2002.

12CE337 SYSTEMS ANALYSIS

Credit 3:1:0

Course Objective:

- Students will be introduced to application of systems concept to water resources planning and management
- Students will be exposed to optimization techniques for modeling water resources systems

Course Outcome:

- Students learnt to simulate the operation of a reservoir system
- Students enabled to frame operation policies

Unit I

INTRODUCTION TO SYSTEMS ANALYSIS: Concepts of systems analysis: definition, systems approach to water resources planning and management - Role of optimization models - Objective function and constraints - Types of optimization techniques.

Unit II

LINEAR PROGRAMMING: Formulation of linear programming models-Graphical method-Simplex method-Application of linear programming in water resources- Sensitivity analysis - Application to design and operation of reservoirs.

Unit III

DYNAMIC PROGRAMMING: Belman's principle of optimality:forward and backward recursive dynamic programming-Curse of dimensionality-Application of dynamic programming for resource allocation – Reservoir capacity expansion.

Unit IV

SIMULATION: Basic principles and concepts – Random variate and random process – Monte Carlo techniques – Model development – Inputs and outputs – Reservoir simulation models – Reliability analysis .

Unit V

WATER RESOURCES MANAGEMENT: Reservoir operation policy-Optimal operation of single reservoir system-Allocation of water resources-Optimal cropping pattern-Conjunctive use of surface and groundwater.

Text Books

1. Vedula, P.P., and Mujumdar, S., "Water Resources Systems: Modelling Techniques and Analysis", Tata-McGraw Hill, 2005
2. Gupta, P.K., and Man Mohan, "Problems in Operations Research (Methods and Solutions)", Sultan Chand and Sons, New Delhi (Seventh Edition). I995.

Reference Books

1. Leonard Douglas James and Robert Rue Lee, "Water Resources Economics", Oxford Publishers, 2005.
2. Bhave P. R., "Optimal Design of Water Distribution Networks", Narosa Publishing house, 2003.

3. Hiller F.S., and Liebermann G.J., "Operations Research", CBS Publications and Distributions, New Delhi (IInd edition). 1992.
4. Chaturvedi M.C., "Water Resources Systems Planning and Management", Tata McGraw Hill Inc., New Delhi. I997.
5. Rao S. S., "Optimization: Theory and Applications", Wiley Eastern, 1978.

12CE338 COMPUTATIONAL METHODS AND TECHNIQUES

Credits 3:1:0

Course Objective:

- To develop skills in computational techniques and programming for developing and validating simple models in hydrology
- To improve computing knowledge for applications in water resources management

Course Outcome:

- Students enabled to solve the water resources management issues using computational techniques and application software
- Students learnt to assess, predict and forecast water quality using heuristic techniques

Unit I

NUMERICAL METHODS: Ordinary differential equations – Initial value problem: Taylor series and Runge-Kutta methods – Boundary value problem: finite difference method –Curve fitting: linear regression, polynomial regression, multiple linear regression.

Unit II

DIGITAL DATA MANAGEMENT: Data format – Data analysis - RDBMS – Statistical Package for Social Science (SPSS)- Regression - Factor analysis – Histogram – Scatter diagram – Goodness of fit.

Unit III

SOFT COMPUTING TECHNIQUES: Principle of Artificial Neural Network (ANN) – Application of ANN in prediction and forecasting - Fuzzy logic concepts and applications.

Unit IV

INTRODUCTION TO MODELING: Principles of modeling – Types of models: physical, mathematical and numerical models – Calibration, verification and validation of models - Parameter estimation -Sensitivity analysis – Errors in modeling.

Unit V

APPLICATION SOFTWARE IN WATER MANAGEMENT: Hydrologic modeling – SWAT (Soil and Water Assessment Tool) – Groundwater flow and transport model (Visual MODFLOW) - WEAP (Water Evaluation and Planning system)

Text Books

1. Rastogi A.K., "Numerical Groundwater Hydrology", Penram International Publishing (India), 2006
2. Rao S.S., "Applied Numerical Methods for Engineers and Scientists", Prentice-Hall, 2002.

Reference Books

1. John E. G., "Introduction to Hydraulics and Hydrology with Applications for Stormwater Management", DELMAR, Thomson Learning, USA, 2002.
2. Remson I., Hornberger G.M., and Moiz F.J., "Numerical Methods in Sub-Surface Hydrology", Wiley Inter Science, 1985.
3. Stephen A, T., "Hydrology for Water Management", A.A.Balkema Rotten Publications,1999.
4. Vijay P. Singh, "Kinematic Wave Modelling in Water Resources-Surface Water Hydrology", John Wiley and Sons Inc, 1996.

12CE339 PARTICIPATORY WATER MANAGEMENT

Credits 3:0:0

Course Objective:

- To introduce students to the concept of participation, participatory development and practice of participation in management of water resources
- To help students to learn the practice of participatory appraisal, planning, implementation and management of water resources

Course Outcome:

- Students realized the importance of participatory approach in water resources sector
- Students enabled to plan and monitor water management projects in a participatory mode
- Students capacitated to introduce social concepts in water management

Unit I

FUNDAMENTALS OF SOCIOLOGY AND DEVELOPMENT: Sociology as a science: basic concept – Social system- Development: concept, stages, categories: socio-political and economic.

Unit II

CONCEPT OF PARTICIPATION IN DEVELOPMENT AND PARTICIPATORY PLATFORMS: Definition and meaning of participation-Principles of participation-Participatory Rural Appraisal (PRA): history, meaning, principles, pillars of PRA - SHGs and their role as a participatory platform -NGOs and their role in participatory development- Water user association in irrigation – Participation in drinking water sector - Participatory planning of watershed projects .

Unit III

TOOLS AND TECHNIQUES FOR PARTICIPATION IN WATER RESOURCES MANAGEMENT: Tools and techniques in PRA for water sector: semi-structured interview, daily routine analysis, time lines and local history preparation, participatory mapping and transect study tours, seasonality calendars, Venn diagram- Institutions and organizations in water management -Socio-economic dimension ranking/ wealth ranking - Scoring and ranking (Pair Wise Ranking & Matrix Ranking) -Inventory of local management systems and resources - Case studies and profiles - Problem tree analysis - Participatory water path analysis -Livelihood analysis-SWOT analysis.

Unit IV

PARTICIPATORY APPRAISAL OF WATER RESOURCES MANAGEMENT: Unit of study: micro catchment/panchayath or municipal ward/mini water supply project/ micro lift irrigation system (field based learning and appraisal)

Unit V

DOCUMENTATION: Report writing - Process reporting and documentation -Preparation of case studies with reference to field visit and appraisal.

Text Books

1. Neela Mukherjee, "Participatory Rural Appraisal: Methodology and Applications", Concept Publishing Company, 1993ISBN8170226376, 9788170226376.
2. Narayanasamy N., "Participatory Rural Appraisal-Principles, Methods and Application", Gandhigram Rural University, Tamil Nadu SAGE Publications Pvt. Ltd.

Reference Books

1. Andrea Cornwall, "Pathways to Participation-Reflections on Participatory Rural Appraisal", Garrett Pratt Publishers.
2. Robert Chambers, "The Origins and Practice of Participatory Rural Appraisal", Institute of Development Studies, Brighton.
3. Robert Chambers, "Rural Appraisal", 1997.
4. ABC of PRA: Attitude Behavior Change,1996.
5. Robert Chambers, "Rural Appraisal: Rapid, Relaxed and Participatory", University of Sussex, IDS.

12CE340 WATER RESOURCES PLANNING AND DEVELOPMENT

Credits 4:0:0

Course Objective:

- To impart knowledge on national water policy envisaged to develop water resources
- To introduce the diversion and storage schemes in water resources development

Course Outcome:

- The students capacitated to implement conventional and non- conventional methods in planning water resources projects
- The students enabled to apply management strategies in the areas of excess and deficit water imbalances

Unit I

WATER RESOURCES PLANNING: Water resources planning: concepts and definitions – Functions and role of water resources – Phases of water resources planning – Data requirements for water resources planning - National policy: planning objectives, public involvement in identifying objectives, project scale, implementation of water resources projects – Planning strategies for water resources projects - Constitutional provisions for water resources development.

Unit II

ECONOMIC PRINCIPLES: Economic policy – Water allocation priorities -Master plan approach – Mechanics of water resources plan - Shadow pricing on project costs, finance – Shadow pricing of water supply in underdeveloped countries: definition, calculation, problems – International funding agencies.

Unit III

DIVERSION SCHEMES: Diversion headworks : components and their functions - Distribution of water: canal systems -Basics of canal alignment and design -Types of canal works:falls, regulators, cross drainage works etc.

Unit IV

STORAGE SCHEMES: Reservoir planning - Reservoir sizing: mass flow methods, storage-draft-frequency analysis, storage-draft calculation – Reservoirs in series and parallel –Flood routing - Types of dams and their suitability for different conditions

Unit V

MANAGEMENT STRATEGIES: Flood control and management: flood cushioning, embankments and dykes, flood forecast and warning, flood plain zoning, flood proofing - Drought prone area development: soil water conservation practices, water harvesting practices, development of groundwater potential, conjunctive use - Decision Support Systems in single and multipurpose projects – preliminary concepts .

Text Books

1. Chaturvedi, M.C., "Water Resources Systems Planning and Management", Tata McGraw Hill, 1987.
2. Cech Thomas V.," Principles of Water Resources: History, Development, Management and Policy", John Wiley and Sons Inc., New York. 2003.

Reference Books

1. Goodman A.S., and David, C., " Principles of Water Resources Planning", Prentice Hall College Div., 1983.
2. Stephenson D., and Petersen,M.S., "Water Resources Development in Developing Countries", Elsevier Science, 1991.

12CE341 IRRIGATION WATER MANAGEMENT

Credits 4:0:0

Course Objective:

- To introduce soil-water-plant relationships in the context of irrigation
- To introduce the concepts of scheduling, water distribution, design and methods of irrigation

Course Outcome:

- Students learnt estimation of crop water and irrigation requirements
- Students enabled in implementing major medium irrigation projects
- Students capacitated in selecting appropriate irrigation methods

Unit I

DEVELOPMENT OF IRRIGATION: Importance of irrigation – Impact of irrigation on development of humanity – Need for irrigation– Development of irrigation in India – National Water Policy vis-à-vis irrigation– Irrigation using canal, tank and groundwater.

Unit II

CROP WATER REQUIREMENT: Infiltration and movement of water in soil – Soil-water-plant relationships-Role of climate – Water requirement of crops – Evapotranspiration (ET) and consumptive use - Methods of estimating ET – Effective rainfall-Soil and water quality-Leaching requirements – Irrigation requirements- Duty of water – Irrigation of lowland and upland crops.

Unit II

WATER DISTRIBUTION: Canal network and canal regulation – Methods of distribution: supply based and demand based – Delivery of water to farms – Measurement of water – Scheduling of irrigation – Criteria for scheduling – Frequency and interval of irrigation-Warabandhi system.

Unit IV

SURFACE IRRIGATION METHODS: Classification of irrigation methods – Border irrigation: design parameters, evaluation and ideal wetting pattern – Furrow irrigation: design parameters, types of furrows, evaluation, ideal wetting pattern and planting techniques – Basin irrigation: types of basins, suitable crops, soils and slopes, ideal wetting pattern, shapes and size – Efficiency of surface irrigation methods-Drainage systems.

Unit V

DRIP AND SPRINKLER IRRIGATION METHODS: Drip irrigation: components, suitable crops and land types – Sprinkler irrigation: types, components, and suitable crops, slope, soils and climate – Case studies from India and Israel.

Text Books

1. Majumdar D. P., "Irrigation Water Management: Principles and Practices", Prentice Hall of India, New Delhi, 2005.
2. Dewasish Choudhary, "Irrigation Theory and Practice", Anmol Pub., 2008.

Reference Books

1. Michael A.M., "Irrigation Theory and Practice", Vikas Publishing House, New Delhi, 1999.
2. Van den Bosch B.E., Hoevenaars J. and Broumer C., "Irrigation Water Management Training Manual" No.1 to 7, FAO, Rome, 1999.
3. Asawa G.L., "Irrigation Engineering", New Age International Private Limited, New Delhi, 1996.

12CE342 REMOTE SENSING AND GIS

Credits: 3:1:0

Course Objective:

- To teach the principles and applications of remote sensing, GPS and GIS in the context of water resources

Course Outcome:

- Student enabled to apply Remote sensing and GIS tools to solve the spatial problems in water resources

Unit I

REMOTE SENSING : Basic Concepts of remote sensing - Electromagnetic radiation (EMR), Interaction of EMR with atmosphere, earth surface, soil, water and vegetation - Remote sensing platforms – Monitoring atmosphere, land and water resources - LANDSAT, SPOT, ERS, IKONOS – Scanners, radiometers - Data types and format.

Unit II

DIGITAL IMAGE PROCESSING: Satellite Data analysis - Image interpretation: multi-spectral, multi-temporal and multi-sensoral – Digital image processing – Image preprocessing – Image enhancement – Image classification – Data merging.

Unit III

GEOGRAPHIC INFORMATION SYSTEM: Definition – Components of GIS – Map projections and co-ordinate systems – Data structures: raster, vector – Spatial relationship – Topology – Geodatabase models: hierarchical, network, relational, object oriented models – Integrated GIS database - Sources of error – Data quality: macro, micro and usage level components - Meta data - Spatial data transfer standards.

Unit IV

SPATIAL ANALYSIS: Thematic mapping – Measurement in GIS: length, perimeter and areas – Query analysis – Reclassification – Buffering - Neighbourhood functions - Map overlay: vector and raster overlay – Spatial interpolation – Network analysis – Digital elevation modeling - Analytical hierarchy process – Object oriented GIS.

Unit V

WATER RESOURCES APPLICATIONS: Spatial data sources – GIS approach for water resources system – Thematic maps - Rainfall-runoff modeling – Groundwater modeling – Water quality modeling - Flood inundation mapping and modeling – Drought monitoring – Cropping pattern change analysis – Landuse/landcover mapping - Performance evaluation of irrigation commands - Site selection for artificial recharge - Reservoir sedimentation.

Text Books

1. Lillesand, T.M. and Kiefer, R.W., "Remote Sensing and Image Interpretation", 3rd Edn., John Wiley and Sons, New York. 1993.
2. Burrough P.A. and McDonnell. R.A., "Principles of Geographical Information Systems", Oxford University Press, New York. 1998.
3. Ian Heywood Sarah, Cornelius and Steve Carver, "An Introduction to Geographical Information Systems", Pearson Education, New Delhi, 2002.

Reference books

1. John R. Jensen, "Introductory Digital Image Processing: A Remote Sensing Perspective" , 2nd Edition, 1995.
2. Paul Curran P.J., "Principles of Remote Sensing", ELBS, 1995.
3. Burgh P.A., "Principles of Geographic Information System for Land Resources Assessment", Clarendon Press, Oxford, 1986.

4. Lo.C.P., Yeung. K.W. Albert, "Concepts And Techniques of Geographic Information Systems", Prentice Hall of India Pvt. Ltd., New Delhi, 2002.

12CE343 MATLAB

Credits 3:0:0

Course Objective:

- To introduce the elements and application of computer programming through the MATLAB mathematical computing environment

Course Outcome:

- Students enabled to apply MATLAB in their project work
- Students learnt to tackle other procedural languages for computing, such as C++ or Visual Basic

Unit I

PROGRAMMING ENVIRONMENT: Computer algorithm - Pseudo-code - Flowchart – Introduction to programming logic and MATLAB interface- Data types: expressions, constants, variables -Assignment statement – Matrix operations – Arrays.

Unit II

CONTROL STATEMENTS: Flow control - Conditional statements: If, Else, Elseif - Repetition statements: While, For loop –Nested loops – Switch/ Case.

Unit III

FUNCTIONS AND SCRIPTS: Creating functions – Functions as arguments - Returning functions as values- M-files: script files, function files - Formatted console input-output – String handling - Writing to a text file - Reading from a text file - Randomising and sorting a list.

Unit IV

PLOTTING AND VISUALIZATION OF DATA: Basic plotting - Built in functions – 2D, 3D plots – Mesh and surface plots - Figures and subplots.

Unit V

GRAPHICAL USER INTERFACE: Attaching buttons to action – Handle graphics – Graphics objects – Properties of objects – Menu driven programs - Controls: uimenu and uicontrol.

Text Books

1. Holly M., "MATLAB for Engineers", Prentice Hall, 3rd Edition, 2012.
2. Rudra P., "Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers", Oxford University Press, 2010.

Reference Books

1. Duane C.H., "Mastering MATLAB", Pearson Education Inc., 2012
2. Amos G., "MATLAB: An Introduction with Applications", 4rth Edition, 2011.

12CE344 WATER QUALITY LABORATORY

Credits 0:0:2

Course Objective:

- To make the students carry out the water quality analysis using analytical methods in the laboratory
- To help the students to understand the principles of instrumentation in water quality analysis

Course Outcome:

- Enabled the students to carry out water quality assessment in project work
- Enabled the students to come out with suitable water treatment method

LIST OF EXPERIMENTS

Water sampling

1. Preservation-insitu analysis

Physical and Chemical Analysis of Water and Wastewater Quality

2. pH, Conductivity , Total Dissolved Solids
3. Turbidity, Colour, Total, Suspended, Dissolved solids and Volatile soilds
4. Chloride
5. Sulphate
6. Hardness
7. Alkalinity
8. Acidity
9. Dissolved Oxygen (Analytical)
10. BOD
11. COD
12. Iron, Copper, Chromium, Nitra, Fluoride (spectrophotometry),
13. Sodium and Potassium (Flame photometry)

Bacteriological Analysis

14. Analysis of total coliforms
15. Fecal Coliforms and e-coli by MPN Technique

Reference Books

1. "Standard Methods for the Examination of Water and Wastewater", 14th edn, American Public Health Association, Washington, DC.
2. Vogel A.I., "Inorganic Quantitative Analysis", - VI Edition, Prentice Hall Inc., 1998
3. Sawyer C.N., McCarty, P.L., and Parkin, G.F., "Chemistry for Environmental Engineers", IV Edition, McGraw Hill, New Delhi, 1994

12CE345 HYDROLOGY LABORATORY

Credits 0:0:2

Course Objective:

- To impart practical knowledge in hydrologic processes
- To help the students in understanding the practical implications of aquifer parameters

Course Outcome:

- Students gained better understanding of physical processes and phenomena involved in the evaluation and prediction of water movement in all phases of the hydrologic cycle
- Students capacitated to develop groundwater flow and transport models

LIST OF EXPERIMENTS

1. Rainfall data collection by natural siphon recording type raingauge and determination of mass curve and hyetograph from obtained data
2. Determination of Φ- index by double ring type infiltrometer
3. Measurement of permeability
4. Determination of rate of evaporation
5. Pumping test on well
6. Design of rain water harvesting system
7. Calculation of crop water requirement
8. Determination of soil particle size distribution for textural analysis
9. Determination of hydraulic conductivity
10. Determination of groundwater velocity using Darcy's law
11. Tracer test
12. Electrical resistivity method

12CE346 COMPUTATIONAL LABORATORY

Credits 0:0:2

Course Objective:

- To apply computational techniques in the analysis of interactions of hydrology in regional water resources systems

Course Outcome:

- Students learnt to develop programs to better understand and analyse numerical solutions for linear and nonlinear hydrologic system
- Students enabled to develop forecasting and prediction models using statistical methods and artificial intelligence techniques

LIST OF EXPERIMENTS

1. Regression and correlation
2. Numerical analysis
3. Factor analysis
4. Application of Artificial Neural Network
5. Application of fuzzy logic
6. Application of SPSS
7. Application of WEAP
8. Finite difference model
9. Curve fitting

10. Rainfall-runoff model
11. Probability distributions
12. Interpolation

Reference Books

1. Rastogi A.K., "Numerical Groundwater Hydrology", Penram International Publishing (India), 2006.
2. John E. G., "Introduction to Hydraulics and Hydrology with Applications for Stormwater Management", DELMAR, Thomson Learning, USA, 2002.

12CE347 ENVIRONMENTAL IMPACT ASSESSMENT

Credits 4:0:0

Course Objective:

- To enable students to acquire necessary skills to assess the impact of water resources projects
- To help students in taking necessary steps to bring down the adverse impacts

Course Outcome:

- Students developed skills to assess the environmental impacts of different projects
- Students gained knowledge to suggest suitable recommendations to reduce the impacts on the environment

Unit I

INTRODUCTION TO EIA: Basic concept of EIA: Initial environmental examination - Elements of EIA - Factors affecting EIA - Impact evaluation and analysis-Preparation of Environmental base map -Classification of environmental parameters.

Unit II

METHODS OF EIA: EIA methodologies: introduction, criteria for selection of EIA methodology- EIA methods: ad-hoc methods, matrix methods, network method, environmental media quality index method, overlay methods -Cost/benefit analysis.

Unit III

ENVIRONMENTAL IMPACTS: Hydrologic and water quality impacts – Ecological and biological impacts – Social and cultural impacts – Soil and landscape changes – Agro economic issues – Human health impacts – Ecosystem changes.

Unit IV

ENVIRONMENTAL AUDITING: Environmental audit and environmental legislation - Objectives of environmental audit- Types of environmental audit -Audit protocol- Stages of environmental audit -Onsite activities- Evaluation of audit data -Preparation of audit report.

Unit V:

APPLICATION OF EIA: Case studies and preparation of environmental impact assessment statement for a few water resources development projects.

Text Books

1. John, G., Riki, T., Andrew, C., "Introduction to Environmental Impact Assessment", Routledge Taylor & Francis Group, III Edition, 2005.
2. Prabhakar, V.K., "Environmental Impact Assessment", Anmol Publications, 2001.

Reference Books

1. Marriott Betty B., "Environmental Impact Assessment: a Practical Guide", McGraw-Hill, 1997.
2. Richard K.M., "Environmental Impact Assessment- a Methodological Perspective", Kluwer Academic Publishers, 2002.

12CE348 ISOTOPE TECHNIQUES IN WATER RESOURCES MANAGEMENT

Credits: 4:0:0

Course Objective:

- To introduce the student to emerging tools such as isotope hydrology
- To demonstrate the application of this tool to solve simple practical problems in hydrology and water resources engineering

Course Outcome:

- Students enabled to apply isotope footprints in identifying the recharge sources, pollution source, salt water intrusion
- Students learnt to estimate isotope footprints for water resources study

Unit I

INTRODUCTION TO ISOTOPES: Introduction: elements, nuclides, isotopes- Isotopes and their characteristics- Natural abundance of radioactive and environment isotopes- Isotope fractionation.

Unit II

ISOTOPE MEASUREMENT TECHNIQUES: Standards and measurement techniques- - Mass spectrometric sampling and analysis of stable isotopes.

Unit III

TRACING THE HYDROLOGIC CYCLE: Meteoric Water Line (MWL) -Partitioning of isotopes in the hydrologic cycle-Deuterium excess and source identification-Condensation/precipitation- Rayleigh distillation-Evaporation.

Unit IV

ISOTOPE APPLICATIONS IN SURFACE WATER HYDROLOGY: Stream flow measurement – Lake dynamics – Water balance: groundwater inflow and outflow estimates – Estimation of lake sedimentation rates – Seepage from dams and reservoirs – Seepage from canals - Percolation tank hydrology.

Unit V

ISOTOPE APPLICATIONS IN GROUNDWATER HYDROLOGY: Determination of groundwater velocity in saturated zone -Identification of recharge processes – Seawater intrusion - Migration of pollutants.

Text Books

1. Rao S.M., "Practical Isotope Hydrology", New India Publishing Agency, 2006.
2. Mook W.G. (Editor), "Environmental Isotopes in Hydrological Cycle, Principles and Applications", IHP-V, Technical Documents in Hydrology, No 39, Vol 1, UNESCO, Paris, 2000.

Reference Books

1. "Use of Artificial Tracers in Hydrology", Proc. Adv. Group Meeting, Vienna, IAEA, 1990.
2. Kendal C.,and McDonnell J.J., "Isotopes in Catchment Hydrology", Elsevier, 1998.

12CE349 WATER AND WASTEWATER TREATMENT

Credit 3:1:0

Course Objective:

- To make the student learn about the issues involved in water and wastewater quality aspects
- To make the student understand physical, chemical and biological techniques available for managing water quality

Course Outcome:

- Students enabled to undertake projects on water and waste water management and also to design the treatment units

Unit I

CHARACTERISATION OF WATER AND WASTEWATER: Population forecast-Water demand for various purposes- Estimation of wastewater quantity- Temporal and spatial variation in quantity of water and wastewater - Wastewater characteristics - Water supply/distribution systems -Wastewater collection systems-Underground drainage systems.

Unit II

PRIMARY AND PHYSICAL TREATMENT UNITS: Philosophy of treatment-Unit operations and processes- Introduction to physical, chemical and biological methods- Primary, secondary and tertiary treatment-Physical unit processes: screening, commutation, grit removal, equalization, sedimentation.

Unit III

BIOLOGICAL TREATMENT UNITS: Types of microorganisms-Aerobic *vs*. anaerobic processes-Aerobic treatment: suspended growth aerobic treatment processes-Activated sludge process and its modifications-Attached growth aerobic processes: trickling filters and rotating

biological contactors- Nitrification-Denitrification- Anaerobic treatment: fluidized bed and sludge blanket systems.

Unit IV

TERTIARY TREATMENT UNITS: Coagulation-Flocculation-Filtration-Disinfection-Aeration and gas transfer- Precipitation- Softening- Adsorption and ion exchange-Membrane technology.

Unit V

NATURAL WASTEWATER TREATMENT SYSTEMS: Ponds and lagoons-Wetlands and root-zone systems-Surface and ground water treatment for potable water supply- Rural water supply-Low cost sanitation-Septic tanks -Soak-pits- Bioremediation.

Text Books

1. Metcalf and Eddy, "Wastewater Engineering - Treatment, Disposal, and Reuse", Third Edition , Tata McGraw-Hill Publishing Company Limited, New Delhi, 1995.
2. Casey T.J., "Unit Treatment Processes in Water and Wastewater Engineering", John Wiley & Sons England 1993.

Reference Books

1. Stuetz R., T Stephenson, "Principles of Water and Wastewater Treatment Processes", IWA Publications, 2009
2. Kuruvilla M., Stewart D., Goen Ho, Decentralized Water and Wastewater Systems, IWA Publications, 2008.

12CE350 IWRM IMPLEMENTATION: CASE STUDIES

Credits 4:0:0

Course Objective:

- To improve the understanding and awareness of gender concepts, the water law and policy, economic and social drivers for effective and efficient water sector management
- To provide a general idea on emerging issues in the field of water resources management

Course Outcome:

- Students enabled to implement IWRM in the field
- Students capacitated to achieve sustainable development of water resources through IWRM principles

Unit I

GENDER ISSUES IN WATER RESOURCES MANAGEMENT: Defining gender - Historical framework of gender - Using gender perspective in integrated water resources management - Gender approach in IWRM-Gender competency issues in water - Gender and capacity building - Institutional capacity to promote gender in IWRM projects- Gender analysis tools-- Building gender awareness- Knowledge and skills.

Unit II

WATER PRICING AND ECONOMICS: Implementing IWRM: Why are economic and financial tools needed? -Sustainable development: valuation of water -Water uses and water rights -Components of full water costs and values -Social and cost benefit analysis for water related projects- Introduction to the water finance system- Water pricing: concept and methods– Cost recovery implications of water pricing.

Unit III

WATER LAW AND POLICY: Water policies: goal and strategies-Water policy of India-Water rights: international and Indian scenario-Power, function and regulatory role of State and Central Pollution Control Boards-Environmental guidelines and regulations for water management-Water auditing-Water monitoring and sustainability issues-Understanding UN law on non-navigable uses of international water courses.

Unit IV

INSTITUTIONAL MECHANISMS: Analysis of the laws and administrative structure that constitute the institutional framework of the environmental aspects of water resources management -Corporate organizations-Participatory planning-Incentives for water quality enhancement-Monitoring-Institutional capacity-PPP.

Unit V

EMERGING ISSUES: Rehabilitation and resettlement issues-Introduction to risk and reliability analysis of water resources projects.

Text Books

1. Cech Thomas V., "Principles of Water Resources: History, Development, Management and Policy". John Wiley and Sons Inc., New York. 2003.
2. N. Handy and C L Spesh, "Cost Benefit Analysis of the Environment", Edward Elgav, Alderslot, UK, 1993.
3. Cap-Net, "Tutorial on basic principles of Integrated Water Resources Management", Cap-Net, IRC, IWMI, HRWallingford, IUCN, WSS, UNDP (www.cap.net.org).
4. "Integrated Water Resources Management Plans", Training Manual and Operational Guide, CIDA, 2005.
5. Training Course Report in "Water Assessment in Sub-Saharan Africa: Prediction in Unguaged and Data Scarce Basins", 21-25 January 2008,

Reference Books

1. "Gender Analysis and Reform of Irrigation Management: Concepts, Cases, and Gaps in Knowledge", Proceedings of the Workshop on Gender and Water, 15-19 September 1997, Habarana, Sri Lanka. IWMI, 1998. Environmental Publications from UNEP
2. "The Gender Approach to Water Management", Findings of an Electronic Conference Series, Gender and Water Alliance. January - September 2002. Published for the Gender and Water Alliance by WEDC.www://wedc.lboro.ac.uk/ publications/]
3. Technical Advisory Committee, "Regulation and Private Participation in Water and Sanitation sectors", Technical Advisory Committee Background paper No: 1. Global Water Partnership, Stockholm, Sweden. 1998.
4. Technical Advisory Committee, "Dublin Principles for Water as Reflected in Xomparative Assessment of Institutional and Legal Arrangements for Integrated Water Resources Management", Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.

5. Technical Advisory Committee, "Water as Social and Economic Good: How to Put the Principles to Practice". Technical Advisory Committee Background paper No: 2. Global water Partnership, Stockholm, Sweden. 1998.
6. Technical Advisory Committee, "Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global Water Partnership, Stockholm, Sweden. 2003.

12CE351 FLUVIAL HYDRAULICS

Credit 4:0:0

Course Objective:

- To impart knowledge on qualitative and quantitative understanding of water and sediment flows in natural rivers
- To understand the concepts of stream hydraulics
-

Course Outcome:

- Students enabled to predict and model the hydrologic and geomorphologic processes, erosion, sediment transport

Unit I

INTRODUCTION TO FLUVIAL HYDRAULICS: Rivers in the global context – Role of fluvial hydraulics – Stream networks – Channel platform: major stream types, relation to environmental and hydraulic variables, meandering reaches, braided reaches.

Unit II

BASIC CONCEPTS AND EQUATIONS: Basic mathematical concepts: fluid continuum, fluid element – Kinematics and dynamics – Continuity equations: microscopic continuity relation, macroscopic continuity relation – Equations based on conservation of momentum and energy: mechanical potential energy and kinetic energy – Equations based on diffusion – Equations based on dimensional analysis.

Unit III

GRADUALLY-VARIED FLOW: The basic equation: continuity and energy equations, resistance relations – Water-surface profiles: normal depth, critical depth, mild and steep reaches – Computation of water-surface profiles: theoretical basis, standard step method.

Unit IV

RAPIDLY VARIED STEADY FLOW: Hydraulic jumps –Channel transitions: elevation transition: elevation drop, elevation rise, dimensionless specific-head curve – Flow measurements: weirs, flumes.

Unit V

SEDIMENT ENTRAINMENT AND TRANSPORT : Definitions: bed load, suspended load – Sediment transport and geomorphological concepts: load-discharge relations,sediment yield and denudation rate – Forces on sediment particles – Sediment transport: Shield's diagram,

Hjulstrom curves – Erosion of cohesive sediments – Suspended sediment: Diffusion Theory approach, sediment transport and bedforms.

Text Books

1. Lawrence Dingman, S., "Fluvial Hydraulics", Oxford University Press, 2009
2. Chaudry M.H., "Open-Channel Flow", Prentice Hall, New Jercy, 1993
3. Chow V.T., "Open Channel Hydraulics", Mc Graw- Hill, 1959.

Reference Books

1. Graf W.H., 'Fluvial Hydraulics: Flow and Transport Processes in Channels of Simple Geometry", John Wiley and Sons, 1998.
2. Jain,S.C., "Open-Channel Flow", John Wiley and Sons, New York, 2001.
3. Chein N., Wan, Zhaohui, "Mechanics of Sediment Transport", ASCE press, 1999.

12CE352 BASIC HYDRAULIC STRUCTURES

Credits: 4:0:0

Course Objective:

- To introduce the basic concepts of flow
- To understand canal networks and onfarm structure operation and maintenance

Course Outcome:

- Students enabled to design canals and canal networks
- Students learnt to design water conservation structures

Unit I

HYDRAULIC AND HYDROLOGIC CONSIDERATIONS: Review of fluid mechanics - Basic concepts of uniform flow - Flow profile computations - Introduction to HEC-RAS - Spatially varied flows and rapidly varied flows – Recent advancement in open channel flow measurements - Sediment properties – Inception of sediment motion – Bed forms - Bed load- Suspended load – Total sediment transport - Groundwater movement - Darcy's law and its limitations - Discharge and drawdown for various conditions of groundwater flow - Influent and effluent streams.

Unit II

DESIGN OF CANALS AND DRAINAGE: Design procedure for irrigation channels,- Irrigation outlets- Canal masonary works - Principles of design, use of flow net- Khosla's theory - Highway drainage: importance, principles of surface drainage, roadside drains.

Unit III

WATER CONSERVATION STRUCTURES: Augmentation of water resources – Artificial recharge – Water conservation methods – Rain water harvesting structures: types, design, yield from a catchment, losses of stored water.

Unit IV

MINOR IRRIGATION AND ONFARM STRUCTURES: River intakes: functions and types – Canal network and regulation – Delivery of water to farms - Canal sluices - Canal outlets or modules – Measurement of water – Scheduling of irrigation.

Unit V

INTRODUCTION TO MAJOR HYDRAULIC STRUCTURES: Regulation works: falls, distributors, head regulators, cross regulators -Canal head works -Earth dams- Gravity dams- Spillways and energy dissipators - Escapes - Trench weirs - Supply channel and head regulator - Cross drainage works: importance of cross drainage – Causeways - Culverts and bridges.

Text books

1. Varshney R.S., Gupta S.C. and Gupta.R.L., "Theory and Design of Irrigation Structures", Nemchand & Brothers ,Roorkee, 1992.
2. Sharma R.K., "Irrigation Engineering and Hydraulic Structures", Oxford and IBH Publishing Co., New Delhi, 1984.

Reference Books

1. Garg S.K., "Irrigation Engineering and Hydraulic Structures", Khanna Publishers, NewDelhi, 2002.
2. Arora K.R., "Irrigation Water Power and Water Resources Engineering", Standard Publishers Distributors, Delhi, 2002.

12CE353 ADVANCED REMOTE SENSING

Credits: 3:1:0

Course Objective

- To familiarize with the principles of remote sensing
- To know the procedures of data acquisition and analysis of satellite data

Course Outcome

- Students enabled to interpret digital images and use it in GIS softwares
- Students learnt to analyse satellite images for various studies

Unit I

EMR INTERACTIONS WITH ATMOSPHERE AND EARTH MATERIALS: Atmospheric characteristics – Scattering of EMR – Rayleigh, Mie, Non-selective and Raman scattering – Atmospheric windows – EMR interaction with earth surface materials :radiance, irradiance, incident, reflected, absorbed and transmitted energy – Reflectance – Specular and diffuse reflection surfaces - Spectral signature – Spectral signature curves – Image interpretation - Interpretation elements – False colour composites.

Unit II

DATA ACQUISITION: Types of platforms – Different types of aircrafts - Sun synchronous and geo-synchronous satellites – Types and characteristics of different platforms and sensors - Photographic products - B/W, colour, colour IR film and their characteristics – Area coverage - Across track and along track scanners – Multi-spectral scanners and thermal scanners – Geometric characteristics of scanner imagery - Calibration of thermal scanners - Data types and formats.

Unit III

THERMAL AND HYPER SPECTRAL REMOTE SENSING: Sensor characteristics - Principle of spectroscopy - Imaging spectroscopy - Field conditions - Compound spectral curve - Spectral library - Radiative models - Processing procedures - Derivative spectrometry - Thermal remote sensing: thermal sensors, principles, thermal data processing, applications.

Unit IV

RADAR REMOTE SENSING: SAR interferometry – Basics - Differential SAR interferometry, Radar polarimetry - Radargrammetry and applications - Altimeter and its applications- Scatterometer and its applications.

Unit V

DIGITAL IMAGE PROCESSING AND DATA ANALYSIS: Satellite data analysis - Visual interpretation – resolution – Spatial, spectral, radiometric and temporal resolution - Digital image processing – Radiometric correction - Pattern recognition - Image classification – Data merging - Boundary detection and representation - Textural and contextual analysis - Decision concepts - Fuzzy sets, evidential reasoning, expert system, Artificial Neural Network.

Text Books

1. Lillesand T.M. and Kiefer,R.W., "Remote Sensing and Image Interpretation", sixth edition of John Wiley & Sons-2000.
2. John R. Jensen, "Introductory Digital Image Processing: A Remote Sensing Perspective", 2nd Edition, 1995.

Reference Books

1. John A.Richards, "Remate Sensing Digital Image Analysis", Springer –Verlag, 1999.
2. Paul Curran P.J., " Principles of Remote Sensing", ELBS; 1995.
3. Charles Elachi and Jakob J. van Zyl , "Introduction To The Physics and Techniques of Remote Sensing" , Wiley Series in Remote Sensing and Image Processing, 2006.
4. Sabins, F.F.Jr., "Remote Sensing Principles and Image interpretation",W.H.Freeman & Co, 1978.

12CE354 FOREST, URBAN AND AGRICULTURAL WATERSHED MANAGEMENT

Credits 4:0:0

Course Objective:

- To make the student learn the underlying hydrologic science and processes associated with the flow of water through forested watersheds
- To impart knowledge on nutrient budget, agricultural management practices

Course Outcome:

- Students enabled to plan and develop a watershed
- Students learnt techniques for soil erosion control, flood management and storm management

Unit I

INTRODUCTION TO WATERSHED: Watershed development: definition and concepts, objectives and need- Integrated and multidisciplinary approach for watershed management- Characteristics of watershed: size, shape, physiography, slope, climate, drainage, land use, vegetation, geology and soils - Watershed delineation.

Unit II

FOREST WATERSHED MANAGEMENT: Influence of forests on hydrologic processes - Causes of deterioration of watershed -Forests and water yield/lowflows - Forests and peakflows – Deforestation and accelerated erosion – Forests and snow.

Unit III

AGRICULTURAL WATERSHED MANAGEMENT: Global agricultural trends – Agricultural impacts on soil and water: non-point source pollution, erosion and sediment, drainage, storage and irrigation -Nutrient budget – Soil and water conservation – Watershed development projects – Indicators – Monitoring and evaluation.

Unit IV

URBAN WATERSHED MANAGEMENT: Impacts of urbanization on hydrology- Urban site design – Landuse planning and conservation – Stormwater management- Flooding and floodplain management – Urban water supply – Water and green buildings.

Unit V

CASE STUDIES: Case study on forest hydrology of Western Ghats (MoEF) – Case study on cultivated watersheds (DST/CWRDM/JICA) – Case study on urban watershed (DST/UNDP/MATURE)

Text Books

1. Murthy J.V.S., "Watershed Management , " New Age International Publishers, 1998.
2. Martin M.K., Daniel T.R., and Kent, S.M., "Urban Watersheds: Geology, Contamination, and Sustainable Development", CRC press, Taylor & Francis Group, 2011
3. Bernier P.Y., Woodard, P.D., "Forest Hydrology and Watershed Management", IAHS Press, 1987,

Reference Books

1. Ghanshyam D., "Hydrology and Soil Conservation Engineering", Prentice-Hall of India Pvt. Ltd., New Delhi. 2000.
2. Tideman E. M., "Watershed Management". Omega Scientific Publishers", New Delhi. 1996.

LIST OF SUBJECTS

Code	Subject Name	Credits
13CE305	Basic Hydrology Lab	0:0:2
13CE306	Electrochemical Water Processing and Water Treatment	4:0:0

13CE305 BASIC HYDROLOGY LAB

Credits 0:0:2

Objective:

- To impart practical knowledge in hydrologic processes
- To help the students in understanding the practical implications of aquifer parameters

Outcome:

- Students gained better understanding of physical processes and phenomena involved in the evaluation and prediction of water movement in all phases of the hydrologic cycle
- Students capacitated to develop groundwater flow and transport models

The faculty conducting the Laboratory will prepare a list of experiments [10/5 for 2/1 credit] and get the approval of HoD and notify it at the beginning of each semester.

13CE306 ELECTROCHEMICAL WATER PROCESSING AND WATER TREATMENT

Credit 4:0:0

Objective:

- To introduce the basic concepts of electrochemistry
- To help the students understand the electrochemical approaches for waste water treatment

Outcome:

- Students would be enabled to undertake projects on waste water treatment by electrochemical approaches.

Unit I

BASIC ASPECTS OF ELECTROCHEMISTRY

Chemistry and electricity: Electroneutrality and potential differences at interfaces. Electrochemical cells: Transport of charge within the cell- Conductivity of electrolyte solutions-Cell description conventions, - Electrodes and electrode reactions- Standard half-cell potentials and reference electrode. Prediction and significance of cell potentials: Cell potentials and the electromotive series-pH and ion selective electrodes. Electrolytic cells: Electrolysis in aqueous solutions- Faraday's laws of electrolysis.

Unit II

ELECTROCHEMICAL REACTORS DESIGN

Costing an electrolytic process, Figures of merit: Materials yield-Current efficiency- Percentage conversion- Product quality- Energy consumption- Space time yield. Electrolysis parameters- Principles of cell design: Classical chemical reaction engineering- The additional technology of electrolytic processes - Mass transport in electrolytic reactors. Typical cell designs- Tank cells and Flow cells-Monopolar and Bipolor cells- Batch recycle process and Backmix reactor.

Unit III

BIOCIDING TECHNOLOGY AND ELECTROCHEMICAL METAL RECOVERY

Biociding technology: Electrolytic production of free halogens- Chlorination process description-Bromination process description. Electrolytic generation of bromine and chlorine: Design procedures-Design geometry-Metal ion removal and metal recovery- Electrochemical process for the removal of iron in acid baths- Technical approaches- Laboratory feasibility & data study suggestions-Experimental methods- Conclusions and recommendations.

Unit IV

ELECTRODIALYSIS (ED)

Electrodialysis: Performance characteristics- General purpose electrodialysis unit. ED units for specialized application. Demineralizer: Electrodialysis-Advantages of electrodialysis and general characteristics. Desalination system: Module Specifications. Residential water Softener: Product design description- Physical Description of the system- Operation- Competitive Methods.Electrochemical water processor Portable design: Present solutions- Operation of an ED system- Design prototype.

Unit V

ELECTROCOAGULATION AND ELECTROFLOTATION

Electrocoagulation in water treatment- Principle of Electrocoagulation- Reactions at the electrodes and solutions- Electrode passivation and activation - Comparison between Electrocoagulation and chemical coagulation. Typical designs of the EC Reactors : Factors affecting Electrocoagulation- Effect of current density or charge loading- Effect of conductivity- Effect of Temperature- Effect of pH. Application of electrocoagulation in water treatment: Fluoride removal- Arsenic removal- Heavy metals- Dye removal.

Electroflotation: Electrochemical reactions and gas generating rate- Electrodes system: Cathodes-Anodes- Electrodes arrangement. Typical cell designs: Single-stage EF, Two-stage EF and Combinations of EF with EC), Water and waste water treated by EF.

Text Books

1. Electrochemical Water Processing - Ralph Zito, Wiley 2011.
2. Industrial Electrochemistry - Derek Pletcher, Chapan and Hall Ltd 1982.

References

1. Electrochemistry- Chemical reactions at an electrode, galvanic and electrolytic cells - Stephen K. Lower, 2004.
2. Electrochemistry for the environment - C. Comninellis and G. Chen. Springer 2010.