Department of Environmental Science
University of Kashmir
Hazratbal Srinagar -190006

Water Management (WMG)2024

Programme objective and outcome: The main driving force to float the programme at undergraduate level is the importance of the water and the challenges the various dimensions of Water like water resource and availability, hydrology, pollution, climate change impact, water economics and governance etc. are facing. There is total dependence of humanity on the water and as such it assumes the greater significance to be in the curriculum at the undergraduate level. It is expected to prepare students having broad and robust understanding of conundrum of driving forces, pressures, State, impacts and Responses (DPSIR) of water and to help in management and tackling of such issues and challenges. Students will also be equipped to analyse complex water-related issues, develop effective strategies for water resource optimization, and implement policies that promote management and equitable access to clean water besides effective management of water systems. Students will also be well-equipped to pursue careers in various sectors such as environmental consultancy, government agencies, research institutions, and non-profit organizations, contributing significantly to the global effort of ensuring water security and management of water resources and systems for future generations.

Syllabus of Water Management (WMG) for Bachelors as Major

SEMESTER	COURSE CODE	COURSE TYPE	COURSE TITLE	CREDITS	
				THEORY	PRACTICAL
I	WMG124J	CT-1 (MAJOR)	Introduction to Water	4	2
II	WMG224J	CT-1 (MAJOR)	Hydrology and Hydraulics	4	2
III	WMG324J	CT-1 (MAJOR)	Water Chemistry	4	2
IV	WMG422J1	CT-1 (MAJOR)	Water Pollution	3	1
	WMG422J2	CT-2 (MAJOR)	Water Quality Monitoring and Assessment	4	2
	WMG422J3	CT-3 (MAJOR)	Water and Sustainable Development	4	2
V	WMG22J1	CT-1 (MAJOR)	Water Resource Management	3	1
	WMG522J2	CT-2 (MAJOR)	Water Management in Agriculture	4	2
	WMG522J3	CT-3 (MAJOR)	Flood and Drought Management	4	2
VI	WMG622J1	CT-1 (MAJOR)	Water and Wastewater Engineering	3	1
	WMG622J2	CT-2 (MAJOR)	Fresh Water Ecology	4	2
	WMG622J3	CT-3 (MAJOR)	Bioremediation and Restoration	4	2
	For students having CGPA Score of < 7.5 are eligible for Honours mode PG (Eligible for PG only)				
VII	WMG722J1	CT-1 (MAJOR)	Environmental Impact Assessment in Water Management	3	1
	WMG722J2	CT-2 (MAJOR)	Climate Change and Water	4	2
	WMG722J3	CT-3 (MAJOR)	Water Law and Policy	4	2
VIII	WMG822J1	CT-1 (MAJOR)	Water Sanitation and Public Health	3	1
	WMG822J2	CT-2 (MAJOR)	Water Economics and Governance	4	2
	WMG822J3	CT-3 (MAJOR)	Oceanography	4	2
	For students having CGPA Score of >7.5 are eligible for Research mode PG (Eligible for Ph.D if they get CGPA score of >7.5 overall)				
VIII	WMG822RJ1	CT-1 (MAJOR)	Research Methodology and Ethics	3	1
	WMG822RJP	CT-1 (MAJOR)	Research project		12

Syllabus of Water Management for UG programmes
Major
(Semester 1)

Course Title: Introduction to Water **Credits: Theory: 4,Practical:2**
Course code: WMG124J **Course Type: CT-1 (MAJOR)**

Course outcome: This paper is to offer a better insight on basics of water ranging from importance, characteristics distribution and consumption patterns.

Unit I: Water Characteristics

Origin of water on earth, Unique properties of water, Major cations (Ca, Mg, Na, K), Major anions (bicarbonate, sulphate, chloride), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), Microbial water quality-coliform bacteria

Unit II: Water Resources

Water as a resource, Types of water resources, Inland water distribution and importance, Ground water distribution and importance, Cryosphere: Distribution and importance, Marine waters: Distribution and importance, Water resources of J&K (River systems and glaciers)

Unit III: Water Consumption

Distribution of water, Availability and consumption patterns in domestic, Industrial, and agricultural sectors, Concept of water stress and scarcity, Water footprint, Domestic water demand and consumption in urban and rural India, SustainableDevelopment Goal 6 (SDG)

Unit IV: Water and Human Civilization

Importance of water in human civilization (Mesopotamian and Indus), Water catastrophes: Historical perspective and consequences, Water infrastructure andtools (Ancient, Medieval and modern)

Practical:

1. Estimation of Chloride in water
2. Estimation of hardness in water
3. Estimation of alkalinity in water
4. Estimation of water temperature
5. Evaluation of per capita domestic water consumption pattern
6. Calculation of personal water footprint
7. Visit to any archeological/ water supply scheme/ relevant site for demonstration ofwater infrastructure
8. Determination of water quality on basis of odor and color

Suggested Readings:

1. Bansil, P.C. 2004. *Water Management in India*. Concept Publishing Company, India.Brebbia,C.A. 2013. *Water Resources Management VII*. WIT Press.
2. CEA. 2011. *Water Resources and Power Maps of India*. Central Board of Irrigation & Power.
3. Grumbine, R.E. and Pandit, M.K. 2013. Threats from India's Himalaya dams. *Science* 339: 36-37.
4. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. *Water Resource Systems Planningand Analysis*. Englewood Cliffs, NJ, Prentice Hall.
5. Mays, L.W. 2006. *Water Resources Sustainability*. The McGraw-Hill Publications.
6. Schward and Zhang, 2003. *Fundamentals of Groundwater*. John Willey and Sons.
7. Souvorov, A.V. 1999. *Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management*. Elsevier Publications.
8. Vickers, A. 2001. *Handbook of Water Use and Conservation*. Water Plow Press.

Syllabus of Water Management for UG programmes
Major
(Semester 2)

Course Title: Hydrology and Hydraulics **Credits: Theory: 4, Practical: 2**
Course code: WMG224J **Course Type: CT-1 (MAJOR)**

Course outcome: The purpose of this course is to provide an introduction to the basic physical concepts behind hydrology & fluid mechanics and techniques used in analysis offluid flow and fluidic systems.

Unit I: Hydrology

Concept and scope of hydrology, Hydrological cycle: Evaporation: Process, Factors effecting evaporation, Measurement of evaporation, Transpiration: process, Factors affecting transpiration, Condensation: Process and measurement, Precipitation: Process, Types and forms, Measurement and distribution.

Unit II: Surface Water Hydrology

Runoff cycle and its components, Factors effecting runoff, Measurement of Runoff, Water balance equation, Stream flow measurement, Base flow, Hydrograph: Types,component and its applications

Unit III: Groundwater Hydrology

Aquifer and types of aquifers, Vertical distribution and movement of groundwater (Darcy's Law), Groundwater and well hydraulics: Steady and unsteady unidirectional and radial flow in different aquifers, Water wells: construction of shallow (Dug and Bored) and Deep well (Cable tool and Rotatory).

Unit IV: Fluid Kinetics and Dynamics

Basis of Hydraulics, Fluid and its Properties: Mass Density, viscosity, Vapour Pressure, Specific gravity, Surface tension & Capillarity, Fluid Types: steady and unsteady flow, laminar, Turbulent flow, uniform and non-uniform flow, Bernoulli's Equation and its application

Practical:

1. Verification of Bernoulli's Theorem, Calibration of Venturimeter,
2. Measurement of precipitation and evaporation
3. Measurement of flow and discharge of stream/spring
4. Estimation of flood using unit hydrograph
5. Computation of rate of infiltration using infiltrometer
6. Determination of capacity of well.
7. Calculation of capacity of power of a hydro-power plant
8. Estimation of recharge through water balance equation

Suggested Readings:

1. Bansil, P.C. 2004. *Water Management in India*. Concept Publishing Company, India. Brebbia, C.A. 2013. *Water Resources Management VII*. WIT Press.
2. Fluid Mechanics, 7th Edition, Frank M. White, McGraw Hill
3. CEA. 2011. *Water Resources and Power Maps of India*. Central Board of Irrigation & Power. Grumbine, R.E. and Pandit, M.K. 2013. Threats from India's Himalaya dams. *Science* 339:36-37.
4. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. *Water Resource Systems Planningand Analysis*. Englewood Cliffs, NJ, Prentice Hall.
5. Mays, L.W. 2006. *Water Resources Sustainability*. The McGraw-HillPublications.
6. Schward and Zhang, 2003. *Fundamentals of Groundwater*. John Willey andSons.
7. Souvorov, A. V. 1999. *Marine Ecologonomics: The Ecology and Economics of MarineNatural Resource Management*. Elsevier Publications.
8. Vickers, A. 2001. *Handbook of Water Use and Conservation*. Water Plow Press.
9. Gleick, P. H. 1993. *Water in Crisis*. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.

Syllabus of Water Management for UG programmes
Major/Minor Course
(Semester 3)

Course Title: Water Chemistry **Credits: Theory: 4, Practical: 2**
Course code: WMG324J **Course Type: CT-1 (MAJOR)**

Course outcome: Water chemistry is an introductory course that explores the chemical properties, composition, and behaviour of water. The aim of the course is to develop a comprehensiveunderstanding of the fundamental concepts and principles of water chemistry. The course is designed to develop critical thinking and problem-solving skills in the context of water chemistry. The student will be able to interpret and communicate results related to water quality.

Unit I: Stoichiometry

Concept: Mole, molarity, normality, molality, Chemical equilibrium, Acid-base reactions, Titrimetry, Gravimetry

Unit II: Analytical chemistry

Potentiometry, Conductometry and Turbidimetry, Spectrophotometry: UV-Visible, Flame photometry, Chromatography: principle and applications

Unit III: Water chemistry

Chemical in freshwaters, Solubility of gases in water, Redox potential, potential energy, Dissolved oxygen: Sources, forms, transformations and distribution, Carbon: forms and transformations, Carbonate-bicarbonate system

Unit IV: Nutrient and energy dynamics

Nitrogen: Sources, quantity and cycling, Phosphorus: Sources, quantity and cycling, Transport and Spiralling, factors influencing nutrient dynamics, Nutrient budgeting, Organicmatter decomposition

Practical:

1. Standardization of reagents – titrants (acids, bases)
2. Measurement of suspended solids in different water samples
3. Determine of transparency in a lake ecosystem
4. Estimation of salinity in water samples
5. Experimental verification of Beer-Lambert's law
6. Determination of turbidity of water samples
7. Determination of dissolved oxygen content in water samples
8. Determination of CO_2 in water samples

Suggested Readings:

1. Environmental Chemistry by Colin Baird and Michael Cann - Year: 2012
2. Quantitative Chemical Analysis by Daniel C. Harris - Year: 2015 (This may vary dependingon the edition.)
3. Instrumental Methods of Chemical Analysis by B.K. Sharma - Year: 2006
4. Analytical Chemistry: Principles and Techniques by Christian Gary D. - Year: 2017
5. Modern Analytical Chemistry by David Harvey - Year: 2018
6. Environmental Chemistry by Stanley E. Manahan - Year: 2016
7. Environmental Chemistry by Colin Baird and Michael Cann - Year: 2012
8. Introduction to Environmental Engineering and Science by Gilbert M. Masters and Wendell P. Ela - Year: 2020
9. Environmental Chemistry by A.K. De - Year: 2014
10. Analytical Chemistry by A.K. Srivastava - Year: 2012

Syllabus of Water Management for UG programmes
Major
(Semester 4)

Course Title: Water Pollution **Credits: Theory:3, Practical: 1**
Course code: WMG422J1 **Course Type: CT-1 (MAJOR)**

Course outcome: Students are expected to have an understanding on water pollution types and its impacts thereof. This course may lead to have theoretical and practical understanding about the issues related to water environment.

Unit I: Surface and Ground Water Pollution

Lentic and Lotic system characteristics, River and stream pollution: causes and impacts, Lake and wetland pollution: Causes and impacts, Eutrophication: causes and consequences, Ground water pollution: causes and impacts, Water borne diseases and Public health

Unit II: Marine Pollution

Marine pollution: Causes and impacts, Marine litter: Types and sources, Oil pollution: Sources and impact on aquatic life and ecosystems, Ocean acidification, Impacts of marine pollution on public health

Unit III: Thermal and Radioactive Pollution

Thermal pollution: causes and impact on water characteristics and aquatic biodiversity, Radioactive pollution: Sources and types of radiations, Impact of thermal pollution on water characteristics and aquatic biodiversity, Radiation hazard and Public health

Practical:

1. Estimation of BOD of water
2. Estimation of COD of water
3. Estimation of ammonical nitrogen of water
4. Estimation of Nitrite and Nitrate Nitrogen of water

Suggested Readings:

1. Water Pollution and Management, C K Varshney
2. Fundamentals of Water and Wastewater, Krishna Gopal
3. Groundwater Hydrology, David Keith Todd
4. Water and Wastewater Technology, Mark J.Hammer
5. Groundwater Science. Fitts, C.R.
6. Groundwater and Surface Water Pollution. Liu, D.H.F. and Liptak, B.G.

7. Wetlands: Monitoring, Modelling and Management. Okruszko, T., Maltby, E., Szaltytowicz, J., swiatek, D. and Kotowski, W.
8. Basic Environmental Technology. Nathenson, Jerry. A.

Syllabus of Water Management for UG programmes
Major
(Semester 4)

Course Title: Water Quality Monitoring and Assessment Credits: Theory: 4, Practical: 2
Course code: WMG422J2 CT-2 (MAJOR)

Course outcome: To give the students exposure about the ways and means of monitoring the water quality of various aquatic systems. Course outcome: This course offers the students understanding about equipment's/ techniques/ methods for assessment and monitoring of water quality.

Unit I: Monitoring and Assessment

Monitoring and Assessment: Context, Scope and purpose, Strategies and planning, Selection of water quality parameters for monitoring and assessment; Sampling, collection and analysis, Data management and quality assurance

Unit II: Water Quality Criteria and Standards

Concept and relevance of water quality criteria and standards, Water quality criteria and standards for Drinking water (WHO and BIS); Water quality effluent discharge standards for inland waters (CPCB); Water quality criteria for bathing, swimming and irrigation, Water quality classes and category; Water quality index

Unit III: Biomonitoring

Bio monitoring: Concept, scope and recent trends, Types of Biological assessment; Plankton as bio monitoring; Macroinveretebrates as Bio indicators; Water quality Bioindices, concept of biosensors, Total coliform as indicator of pollution

Unit IV: Water Informatics

Collection of available data and sharing through web enabled information system, Water Information Management System (WIMS), India Water Resource information system (I-WRIS), Laboratory and Human Resource, rating of laboratories; NABL accreditation; Recording and reporting of the data; Information, Education and Communication (ICE)

Practical:

1. Field visit to any or nearby water quality monitoring/ water discharge station
2. Study of few algae as bioindicators through field/slides
3. Study of few macroinveretebrates as bioindicators through field/slides
4. Case study on Water quality of Ganga/ Jhelum/ Dal lake
5. Case study on water budget of any watershed
6. Case study on Water quality index of any aquatic system
7. Sanitary inspection visit to a water quality monitoring station
8. Visit to any drinking water treatment facility

Suggested Readings:

1. Wetlands Monitoring, Modelling and Managements, Tomasz Okruszko
2. Eco- Informatics Volume IV Environmental Monitoring, S K Agarwal
3. Environmental Geoinformatics Monitoring and Management, Joseph L. Awange
4. Aquatic Insects for Biomonitoring Freshwater Ecosystems- A Methodology Manual, K. A Subramanian
5. Biological Monitoring Methods for Industrial Chemicals, Randall C. Baselt
6. Environmental Monitoring, S.K Agarwal

Syllabus of Water Management for UG programmes
Major
(Semester 4)

Course Title: Water and Sustainable Development | **Credits: Theory:4, Practical: 2**
Course code: WMG422J3 | **Course Type: CT-3 (MAJOR)**

Course outcome: The course intends to produce human resource well versed with the theoretical and practical aspects of sustainability in general and water sustainability in particular for a sustainable future.

Unit-1 Sustainable Development

Meaning and scope of sustainable development, important principles of sustainable development, major components of sustainable development, approaches to sustainable development (positivist, multidimensional and ecosystem approaches), importance of sustainable development

Unit- 2 Water Usage

Basic concepts of water use, conservation and efficiency, global water use and stress, intensive farming and water use, privileged lifestyle of rich and water crises, water and globalisation

Unit-3 Sustainable Water Management Challenges

Concept of sustainable water management, study of major barriers and challengesto sustainable water management—drinking water scarcity, climate change, pollution of water, insufficient access to safe and affordable water, degradation and loss of freshwater water ecosystems

Unit-4 Water and Sustainable Development

Importance of water for sustainable development, study of water in relation to sustainable development goals—water and food security (SDG 2), Water for health and well-being (SDG 3), clean water and sanitation (SDG 6), hydropower for sustainable development (SDG 7), water and maintenance of biodiversity (SDG 15)

Practical/Tutorials/Case studies

1. Measurement of sustainability—concept and overview of metrics and indices
2. Analysis of life cycle assessment of a product.
3. Measurement of ecological footprint of goods/services.
4. Study of environmental performance index of a country.
5. Determination of human development index for a country
6. Determination of water stress index for a country
7. Study of Green Growth Index of a country.
8. Estimation of Sustainable development Index and Global Sustainable Competitiveindex

Suggested Readings

1. Redclift, M. (1987). Sustainable Development. London: Methuen
2. Bawa, K.S. & Seidler, R. (2009). Dimensions of Sustainable Development. Oxford: EOLSS Publishers.
3. Hardisty, E. P. (2010).Environmental and Economic Sustainability. CRC Press.
4. Rogers, P.P., Jalal, K.F. & Boyd, J.A. (2008). An Introduction to Sustainable Development. Glen Educational Foundation, Inc.
5. Human Development Report (1994) United Nations Development Program, Oxford University Press.
6. World Commission on Environment and Development (1987) Our Common Future, Oxford University Press, Oxford.
7. Bindhy Wasini Pandey and Subhash Anand (2021). Water Science and Sustainability. Springer.
8. Mohammad Hadi Dehghani, Rama Rao Karri, Inderjeet Tyagi, Miklas Scholz (2023). Water, the Environment, and the Sustainable Development Goals. Elsevier.
9. Avelli, E., Mazzoleni, M., Di Baldassarre, G. *et al.* (2023).Urban water crises driven by elites' unsustainable consumption. *Nat Sustain* 6, 929–940.
10. Mahmoud A Abu-Zeid (1998). Water and sustainable development: the vision for world water, life and the environment. Water Policy, 1(1): 9-19.

Syllabus of Water Management for UG programmes
Major
(Semester 5)

Course Title: Water Resource Management **Credits: Theory:3, Practical: 1**
Course code: WMG22J1 **Course Type: CT-1 (MAJOR)**

Learning Outcomes: The student is expected to learn different tools, techniques and policies for management and conservation of water resources which are crucial for the sustenance of life on earth.

Unit-1: Integrated Water Resource Management

History of water management, Integrated water resource management: concepts and theoretical perspectives, Principles and tools for practising IWRM, Issues and challenges in IWRM, Corporate social responsibility in water resource management

Unit-2: Water Harvesting and Water shed Management

Concept and framework of watershed approach, Soil and water conservation-conservation technology, Water harvesting-importance and techniques, Integrated watershed, development, A case study of water harvesting

Unit-3: Freshwater Ecosystem Management

Artificial recharges of ground water, River basin management, Management of lakes Management of wetlands, Case study: Dal Lake, Ganga action plan

Practical:

1. Determination of importance value index (IVI) of different plant species in a lake
2. Application of diversity indices in an aquatic habitat
3. Measurement of lake area and lake volume
4. Case studies based of techniques of rainwater harvesting

Suggested Readings:

1. D. Borchardt, J.J. Bogardi and R.B. Iibish (Editors). 2016. Integrated Water Resources Management: Concept, Research and Implementation. Springer.
2. D. Borchardt abd Ralf iiblish (editors). 2013. Integrated Water Resource Management in a changing world. IWA publishing.
3. A. Castellitti and R.S.Sessa (Editors). 2007 Topics on System Analysis and Integrated Water Resource Management. Elsevier
4. B. Gopal, E.R.N. Gunawardena, and H.Kotagama (Editors). Ecosystems and Integrated Water Resources Management in South Asia. Routledge.

5. B. Vasantha Kumar. 2010. Aquatic Ecosystems and its Management. Daya Publishing House.
6. S.Jorgensen, J.G. Tundisi, and T.M. Tundisi. 2020. Handbook of Inland Aquatic Ecosystem Management (Applied Ecology and Environmental Manegement). CRC Press.
7. Q. Zhu, J.G.Y. Li and C. Ma (Editors). 2015. Rainwater harvesting for agriculture and water supply. Springer.
8. R.Avis and M.Avis. 2019. Rainwater harvesting: A guide to human scale system design. New Society Publishers.
9. I.W. Heatcole. 2009. Integrated Watershed Management. Wiley Publishing.
10. R.Rajora. 1998. Integrated Watershed Management. A Field Manual. Rawat Publications.

Syllabus of Water Management for UG programmes
Major
(Semester 5)

Course Title: Water Management in Agriculture **Credits: Theory:3, Practical" 1**
Course code: WMG522J2 **Course Type: CT-2 (MAJOR)**

Course Outcome: Students will get insights and develop a comprehensive understanding of irrigation systems, water management principles, and their significance in agricultural practices.

Unit I: Irrigation Systems

Historical overview of irrigation methods, Types of irrigation methods (surface irrigation, sprinkler irrigation, drip irrigation, Micro-irrigation, Centre pivot, Irrigation by lateral move, Lawn sprinkler systems, Hose-end sprinklers). Types of irrigation systems (Well and Tube Well, Canal, Tank, other types). Design and operation of irrigation systems., Efficiency and effectiveness of different irrigation methods.

Unit II: Irrigation Scheduling

Techniques and methods for scheduling irrigation (Time-based, Soil moisture-based). Factors influencing irrigation scheduling (soil moisture, climate, crop growth stage, etc.). Importance of proper timing in irrigation., Principles of water budgeting for irrigation., Decision support tools for scheduling., Net irrigation application depth.

Unit III: Crop Water Requirements

Crop water needs and Evapotranspiration., Evapotranspiration methods (Pan Evaporation, Blaney-Criddle Method)., Factors influencing crop water needs (Sunshine, temperature, humidity, windspeed)., Water requirements for different crops., Soil characteristics and their influence on irrigation., Effects of water stress oncrop growth and yield., Strategies for managing water stress in different crops.

Unit IV: Water Management Techniques

Water conservation practices in irrigation (Rainwater Harvesting, Irrigation Scheduling, Region-based Produce, cover cropping, mulching, conservation tillage, Use of AgTech Solutions)., Techniques for improving water use efficiency (Optimize Leaf Area, Improve the Rhizosphere and Root Dynamics, Optimizing Irrigation)., Managing water quality in irrigation systems., Sustainable irrigation practices., Legal and institutional frameworks for water allocation., Alternative methods of plant production (Hydroponics and aquaponics) systems.

Practical:

1. Determination of Net irrigation application depth.
2. Estimation of evaporation by Pan Evaporation transpiration method (Epan).
3. Assessment of Irrigation Scheduling for a particular crop.
4. Estimation of Discharge of canal or river.
5. Prepare a layout of surface methods of irrigation
6. Soil moisture measurement by gravimetric and volumetric methods
7. Visit to micro irrigation system unit

8. Water management practices in different crops

Suggested Readings:

1. Sultan, M. and Faiz, A. (2023). Irrigation and Drainage - Recent Advances. Intechopen.
2. Dastane, N. G. (1974). Effective rainfall in irrigated agriculture. FAO Roam.
3. Michael, A.M. (2008). Irrigation Theory and Practice. Vikas Publishing House Pvt Ltd. New Delhi.
4. Murty, V.V.N. (2002). Land and Water Management Engineering (Fourth Edition). Kalyani Publisher, New Delhi.
5. Mbava N., Mutema M., Zengeni R., et al. (2020). Factors affecting crop water use efficiency: a worldwide meta-analysis. Agricultural Water Management, 228, p. art. 105878 *11 p.+. ISSN 0378-3774.

Internet References

1. http://www.angrau.ac.in/media/7380/agro201.pdf
2. http://gilley.tamu.edu/BAEN464/Handout%20Items/Cuenca%20Book%20Chapter%203%20Soil%20Physics.pdf
3. http://ilri.org/InfoServ/Webpub/fulldocs/IWMI_IPMSmodules/Module_3.pdf
4. ftp://ftp.wcc.nrcs.usda.gov/wntsc/waterMgt/irrigation/NEH15/ch1.pdf
5. http://web.ead.anl.gov/resrad/datacoll/conuct.htm
6. http://www.fao.org/docrep/r4082e/r4082e03.htm
7. ftp://ftp.wcc.nrcs.usda.gov/wntsc/waterMgt/irrigation/NEH15/ch1.pdf
8. http://storm.okstate.edu/bae3313/Lecture/8)%20soil-waterplant%20relationships/soil-water-plant%20relationships.pdf
9. http://www.angrau.ac.in/media/7380/agro201.pdf

Syllabus of Water Management for UG programmes
Major
(Semester 5)

Course Title: Flood and Drought Management **Credits: Theory: 4, Practical: 2**
Course code: WMG522J3 **Course Type: CT-3 (MAJOR)**

Course outcome: This course provides an in-depth exploration of the principles and practices of flood and drought management. The course typically focuses on ensuring that students gain a comprehensive understanding of the principles, strategies, and techniques related to managing and mitigating the impacts of floods and droughts.

Unit 1 Floods

Definition and types of floods; Causes of floods (natural and man-made factors); Impacts of Floods: Social, Environmental, Economic and Political

Unit 2 Droughts

Definition and types of droughts; Causes of Drought (natural and human-induced factors); Impacts of droughts: Social, Environmental and Economic

Unit 3 Flood Management

Floodplain Management; Land use planning; Early warning systems; Infrastructure development; Community preparedness; Insurance and risk deduction

Unit 4 Drought Management

Water Conservation; Drought monitoring and early warning system; Diversificationof water sources; Drought-resilient agriculture; Water management policies; Community engagement; Research and innovation

Practical:

1. Predict floods with unit hydrographs from discharge data
2. Survey on flood exposure and risk analysis based on socio-economic and Highest flood level (HFL) data
3. Exercise on the preparation of disaster kit for floods
4. Delineation of drought indices from the meteorological data
5. Survey on calculating the roof top rain water harvesting potential of your institute
6. Mapping the occurrence of flood and droughts from geophysical map of India
7. Delineation of drainage pattern
8. Flood plain zonation and mapping

Suggested Readings:

1. Drought and Water Crises Science, Technology, and Management Issues ByDonald A. Wilhite, 1st Edition Published22 March 2005, CRC Press
2. Chow V.T., Maidment D.R., Mays L.W., "Applied Hydrology", McGraw Hill Publications, New York, 1995.
3. Andreas H. Schumann., “Flood Risk Assessment and Management”, Springer Science+Business Media B.V.2011.
4. Vijay P.Singh., "Elementary Hydrology", Prentice Hall of India, New Delhi, 1994.
5. Rangapathy V., Karmegam M., and Sakthivadivel R., Monograph in Flood Routing Methods as Applied to Indian Rivers, Anna University Publications.
6. Yevjevich V., Drought Research Needs, Water Resources Publications, Colorado State University, USA, 1977.
7. Drought and Water Crises Integrating Science, Management, and Policy, Second Edition (2017) By Donald Wilhite, Roger S. Pulwarty, CRC press.
8. Robert Willis and William W.G.Yenth, Groundwater System Planning and Management, Prentice Hall, Englewood Cliffs, New Jersey, 1987

Syllabus of Water Management for UG programmes

Major

(Semester 6)

Course Title: Water and Waste Water Engineering **Credits: Theory: 3, Practical: 1**

Course code: WMG622J1 **Course Type: CT-1 (MAJOR)**

Course outcome: This course is framed to give the basic understanding of water and waste waters and application of theoretical principles and processes for water and waste water treatment processes and operations. Design and working of STP is taught through the intensive field visits. This course has also potential to provide a good technical human resource to cope up with the ever increasing demand for water and waste water resource management.

Unit I: Fundamentals of Waste Water Engineering

Waste water and waste water Engineering: Historical context and an overview, Composition and classification of microbes in waste water treatment, Characteristics of diverse constituents in waste water: Physical, metallic, nonmetallic, organic and biological, Health and environmental concerns in waste water treatment

Unit II: Physical and Chemical Treatments Processes

Flow equalization, Screening, sedimentation, Filtration, coagulation and flocculation, aeration, floatation, Precipitation, oxidation, adsorption, ion exchange, distillation, Membrane filtration

Unit III: Biological Treatment and Disinfection

Treatment methods and technologies: Primary, Secondary and Tertiary (Advanced), Trickling filter, Activated sludge, Rotating Biological contractors, Fluidized Bed Reactor (FBR), Sequencing Batch Reactor (SBR), Membrane Bioreactor (MBR), Disinfection theory: methods and means

Practical:

1. Field visit to a nearby Sewage Treatment Plant
2. Determination of Sedimentation rate in STPs
3. Determination of optimum coagulant dosage
4. Determination of Sludge volume index (SVI) and F/M ratio

Suggested Readings:

1. Basic of Environmental Technology: Nathanson
2. Environmental Engineering: P. Venugopala Rao.
3. Elements of Environmental Engineering: Kalliat T. Valsaraj
4. Pollution Management: S.K. Agarwal
5. Handbook of Induastrial Pollution and Control: Bhatia
6. Fundamental of Water and wastewater: Krishna Gopal
7. Water Pollution Control: Helmer and Hespenhol
8. Waste water microbiology: Gabriel Bitton

9. Waste water and disposal: Paul T.Williams
10. Waste water management: Klein Gomes
11. Waste water treatment-concepts and design approach: G.L.Karia and R.A.Christian
12. Water and waste water technology: Merk.J.Hammer and Mark.J.Hammer Jr.
13. Waste Water Engineering, Metcalf and Eddy

Syllabus of Water Management for UG programmes
Major
(Semester 6)

Course Title: Fresh Water Ecology **Credits: Theory: 4, Practical:2**

Course Code: WMG622J2 **Course Type: CT-2 (MAJOR)**

Course outcome:: It offers students a snapshot of the physical, chemical, and biological processes that characterize inland waters such as lakes, streams, rivers, and wetlands and focuses on understanding the relationships between humans and freshwater, and discusses these challenges in Management. Field and laboratory study of the ecology of freshwater systems lead to provide experience by sampling and identifying freshwater organisms, designing and analyzing ecological experiments.

Unit I: Freshwater Biodiversity

Major taxonomic groups of freshwater biodiversity: Algae, Zooplankton, Macrophytes, Macroinvertebrates and Fish, Measures of diversity; Endemism and Biological invasionin freshwater ecosystems

Unit II: Stream and River Ecology

Fluvial ecosystem diversity, Stream classification, Stream flow and Hydrograph, Environmental Flow, Influence of thermal regime and substrate on aquatic biota, streams and rivers as products of Landscapes

Unit III: Lakes and Wetland Ecology

Lakes: Origin, diversity, distribution and Classification, Wetlands: Origin, diversity, distribution and Classification, Lake stratification, Paleolimnology, Ontogeny of freshwater systems

Unit IV: Threats to Freshwater Systems

Threats to freshwater systems: Habitat and hydrology modification, Channelization, mining, invasion, pollution, overexploitation, acidification, dams, Climate change, Harmful algal blooms

Practical:

1. Collection/Identification of some freshwater Plankton specimen
2. Collection/Identification of some freshwater Periphyton specimen
3. Collection/Identification of some freshwater Zooplankton specimen
4. Collection/Identification of some Macroinverebrates Specimen
5. Calculation of species diversity indices from a given data
6. Calculation of Nygaards Indices and water Pollution index
7. Field visit to any lake/wetland/river/stream/spring
8. Identification and study of bioindicator species

Suggested Readings:

1. How to know the freshwater Algae by G W Prescott
2. Stream Ecology: Structure and Functioning of running waters JD Allan
3. The ecology of running waters by HBN Hynes
4. Ecology of Streams and Rivers by Eugene Angelier
5. Stream Hydrology: An introduction for ecologists by Nancy D. Gordon
6. Freshwater Ecology: Concepts and environmental applications of Limnology by Walter K. Dodds and Matt R. Whiles.
7. Encyclopedia of inland waters by Gene E Likens
8. Limnological Analysis by Robert G Wetzel
9. Introduction to Limnology by Stanely I Dodson
10. Treatise on Limnology by GE Hutchinson
11. An introduction to the Aquatic Insects of North America by Richard Merritt,Kenneth Cumminis, and Martin B Berg.

Syllabus of Water Management for UG programmes
Major
(Semester 6)

Course Title: Bioremediation and Restoration **Credits: Theory: 4, Practical:2**
Course code: WMG622J3 **Course Type: CT-3 (MAJOR)**

Course outcome: The course will focus on the underlying principles and approaches used in microbiology and ecological restoration and also to enable students to critically analyze theory and techniques of bioremediation and restoration and apply them to the problem of restoring a degraded ecosystem. Upon completing this course, students will be able to articulate the historical development of restoration concepts and the role that restoration can serve in the future stewardship of natural resources.

Unit I: Bioremediation

Bioremediation: evolution, scope and relevance; Types of bioremediation (In situ and Ex situ bioremediation); In-situ bioremediation of soil and Groundwater; Ex-situ bioremediation of soil; Advantages and disadvantages of bioremediation; Role of bioremediation in oil degradation, pesticides and synthetic polymer

Unit II: Phytoremediation

Scope and importance of phytoremediation; Mechanism of phytoremediation; Application of phytoremediation in heavy metal removal; Role of phytoremediation in restoring mine sites; Advantages and disadvantages of phytoremediation

Unit III: Restoration Ecology

History and scope of Ecological Restoration; Basic principles of restoration; Characteristics of degraded and restored ecosystems (aquatic and terrestrial ecosystems); Ecological indicators in restoration; Success stories in restoration ecology.

Unit IV: Restoration Planning

Goals and objectives; Approaches to ecological restoration; Adaptive management and monitoring; Principles; steps and benefits of ecological restoration; Ethics of restoration; Role of public-private partnership in restoration; Constraints in progress and success of restoration programs.

Practical:

1. Identification of bacterial samples following differential staining technique.
2. Case Study on bioremediation of mines.
3. Case study on phytoremediation of oil spills areas.

4. Study of most important phytoremediating plants.
5. Identification and management practices of various degraded lands.
6. Study of plants/tree species suitable for waterlogged areas.
7. Study of plants/tree species suitable for prevention of denuded hilly slopes and landslides.
8. Case studies on successful restoration programmes.

Suggested Readings:

1. Environmental Microbiology: Fundamentals and Applications: Microbial Ecology, Bertrand, J. C., Caumette, P. and Lebaron, P. (2015), Springer
2. Environmental Microbiology – Theory and Application, Jjemba, P.K. (2004), Science Pub. Inc., USA.
3. Environmental Biotechnology-Theory and Application, Evano, G.H. and Furlong, J.C. (2004), John Wiley and Sons, USA
4. Environmental Biotechnology and Cleaner Bioprocesses, Olguin, C. J., Sanchez, G., Hernandez. E. (2000), Taylor & Francis
5. Restoring Ecological Health to Your Land. Washington, DC: Island Press. Apfelbaum, Steven I., and Alan Haney. 2010 ISBN 978-1-59726-571-3. http://islandpress.org/ip/books/book/islandpress/R/bo8041031.html.
6. Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change. Cole, David N. and Laurie Yung. 2010. Washington, DC: Island Press.

7 Restoring Nature: Perspectives from the Social Sciences and Humanities. Gobster, Paul H., and R. Bruce Hull. 2000. Washington, DC: Island Press.

8. Restoration Ecology. Greipsson, Sigurdur. 2011. ISBN-13: 9780763742195. http://www.jblearning.com/catalog/9780763742195/
9. Introduction to Restoration Ecology. Howell, Evelyn A., John A. Harrington, and Stephen B. Glass. 2012. Washington, D.C.: Island Press.
10. A handbook for stream enhancement & stewardship. Izaak Walton League of America. 2006. McDonald & Woodward Publishing Co. 2nd ed.
11. Restoring wildlife: ecological concepts and practical applications. Morrison, Michael L. 2009. Washington, DC: Island Press. 2nd ed.
12. The Tallgrass Restoration Handbook for Prairies, Savannas, and Woodlands. Packard, Stephen, and Cornelia F. Mutel. 2005. Washington, DC: Island Press. 2nd ed.

Syllabus of Water Management for UG programmes
Major
(Semester 7)

Course Title: Environmental Impact Assessment in Water Management

Credits: Theory: 3, Practical: 1

Course code: WMG722J1 **CourseType: CT-1 (MAJOR)**

Course Outcome: It is expected that students will acquire the skill of critical analysis and evaluation of impacts on various components of environment.

Unit I: Fundamentals of EIA and SEA

Environment impact assessment: Concept and objectives, EIA process, Impact evaluation and prediction, EIA guidelines 2006 and amendments, SEA: Concept and process

Unit II: EIA Methodologies

Protocol for EIS, Baseline data generation, EIA methods, Water quality assessment, Environmental audit

Unit III: EIA Case Studies

Hydro power, Irrigation and drainage, Common effluent treat plants, Thermal power projects, Risk assessment, characterization and management

Practical:

1. EIA – Leopold Matrix method and
2. Presentations based on EIA case studies
3. Socio-economic studies – preparing of questionnaire and case studies
4. Waste auditing of any institution/ organization
5. Visit to any developmental/Project area for identification of impacts on the environment

Suggested Readings:

1. Anjaneyulu Y. and Manickam Valli 2011. Environmental Impact Assessment Methodologies. CRC Press 2011.
2. Petts. J. Handbook of Environmental Impact Assessment, Volume 1 and Volume II. 1999. Wiley-Blackwell.
3. Wathern, P. 1990. Environmental Impact Assessment: Theory and Practice. Routledge Publishers.
4. Glasson J. Therivel Riki and Chadwick Andrew 2012. Introduction to Environmental Impact Assessment 4th Edition. Oxford Brookes University.
5. Marriott B. 1997. Environmental Impact Assessment: A Practical Guide. McGraw-Hill Publication.
6. Shrivastava A.K., Baxter Nicola, and Grimm Jacob 2003. Environmental Impact

Assessment. APH Publishers, 2003.
7. Lawrence, D.P. 2003. Environmental Impact Assessment. Practical Solutions to Recurrent Problems. John-Willey and Sons.
8. Glasson J. and Therivel Riki. 2019. Introduction to Environmental Impact Assessment. 5th Edition. Routledge Publishers.
9. Arjum Kumaar.A. Rathi. 2021 Handbook of Environmental Impact Assessment. Concepts and practice. Cambridge Scholars Publishing.
10. Anji Reddy Mareddy, Anil Shah. 2017. Environmental Impact Assessment. Theory and Practice. Elsevier Science.

Syllabus of Water Management for UG programmes

Major

(Semester 7)

Course Title: Climate Change and Water **Credits: Theory:4, Practical:2**

Course code: WMG722J2 **Course Type: CT-2 (MAJOR)**

Course outcome: This course provides an in-depth examination of climate change, including its causes,consequences, and potential solutions. Students will explore the science behind climate change, its impacts on water resources, socioeconomics, policies and mitigation strategies.

Unit I: Climate Science

Earth's climate system, Greenhouse gases and radiative forcing, climate change indicators Extreme weather events, concept of climate models and predictions

Unit II: Climate Policy and International Agreements

United Nations Framework Convention on Climate Change (UNFCCC), IPCC and emission scenarios International initiatives: Kyoto protocol and Paris Agreement Clean Development Mechanism (CDM)Grassroots activism and climate movements

Unit III: Climatic Change Impacts on Water Resources

Impact of climate change on precipitation patterns, glacier retreat and its implications, Implications of Extreme weather events, water availability and security under climate change, Economic costs ofclimate change

Unit IV: Adaptation and Mitigation Strategies

Concept of climate vulnerability and risk Mitigation in hydrological events, Water resources vulnerability and risk mitigation under climate change, Adaptation strategies for water use in industry, domestic and agriculture sectors, National action plan on climate change (NAPCC) and national water mission, Mitigation of storm water runoff and urban floods Climate-resilient cities: concept and importance

Practical:

1. Calculation of water footprint of institutions/organisations
2. Survey to understand climate change impacts
3. Analyse and interpret temperature trends, and precipitation patterns from meteorologicaldata
4. Study of local glacier retreat from satellite imagery
5. Calculation of water scarcity and stress
6. Demonstration and Designing a vertical farming practice in urban/ rural areas.
7. Demonstration of waste water auditing of an institution/ organization colleges

Suggested Readings:

1. Bates, B. C., Kundzewicz, Z. W., Wu, S., & Palutikof, J. P. (Eds.). (2008). Climate change and water. Intergovernmental Panel on Climate Change (IPCC).

2. Babel, M. S., & Wahid, S. M. (Eds.). (2016). Climate change and water resources management inSouth Asia. CRC Press.

3. Islam, M. M., & Sadoon, A. M. (Eds.). (2016). Climate Change and Water Resources in West Asia:The Environmental Impact of Climate Change on Water Resources in the Middle East. Springer.

4. Khatri, K., & Gupta, S. (2014). Climate change impacts on water resources in South Asia. International Journal of Advanced Research in Management and Social Sciences, 3(6), 145-161.

5. Mukherjee, S., & Gupta, A. (Eds.). (2013). Climate Change and Water Resources in South Asia:Adaptation Strategies in Small Island States (Vol. 2). Springer.

6. Shah, T., & van Koppen, B. (Eds.). (2006). Economic valuation and sustainable water management.Earthscan.

7. Sharma, B., & Nepal, S. (Eds.). (2014). Climate change and its impacts on water resources: Issuesof national and global security. Springer.

8. Sharma, U. R., & Panu, U. S. (2010). Climate change and water resources. Wiley-Blackwell.

9. Smakhtin, V., Revenga, C., & Döll, P. (2004). A pilot global assessment of environmental waterrequirements and scarcity. Water International, 29(3), 307-317.

10. Taylor, R. G., Scanlon, B., Döll, P., Rodell, M., van Beek, R., Wada, Y., ... & Famiglietti, J. S. (2013). Ground water and climate change. Nature Climate Change, 3(4), 322-329.

Syllabus of Water Management for UG programmes
Major
(Semester 7)

Course Title: Water Law and Policy **Credits: Theory: 4, Tutorials/Case study:2**
Course code: WMG722J3 **Course Type: CT-3 (MAJOR)**

Course outcome: Students are expected to attain a better understanding about laws relating to water at the international and national level and causes for water conflicts, resolution mechanisms.

Unit 1: International Water Law and Conventions

Overview of international water laws and conventions, UNECE Water Convention, UN Watercourses Convention, Espoo convention, Right to water, Water for Life (2005-2015), Doctrine of absolute territorial sovereignty

Unit 2. National Water Law and Doctrines

Water prevention and control of pollution Act, 1974. Water Cess Act, 1977, Environmental Pollution Act, 1986, Public trust doctrine, Righto to water, Riparian rights, Principle of no fault, Polluter pay principle.

Unit 3. Water Policy

National Water Policy, 2012, J and K Water Resource (Regulation and Management) act 2010 National Water mission, 2011, National River Linking Project (NRLP), Groundwater regulations, Indus water treaty, 1960, Kosi Treaty, 1975

Unit 4. Water Governance

Water Governance: Elements and dimensions of water governance, Effective water governance schemes, Water Financing and pricing policy: Financial sustainability, Funding of water resource infrastructure, private sector participation, Water allocation and apportionment, Water pricing: volumetric, non-volumetric and market-based methods. Interstate water conflicts and role of Judiciary

Tutorials/Case Studies:

1. The South Asia Water Governance Programme Initiative (SAWGP)
2. Indus Water Treaty
3. M.C. Mehta vs Union of India (1986)
4. Jal Shakti Abhiyaan (Catch the rain)
5. The Paani Program case study from Nepal
6. The “Four Taps” strategy in Singapore
7. Pradhan Mantri Krishi Sinchayee Yojana
8. The Krishna and Cauvery water Disputes

Suggested Readings:

1. Environmental Law in India by P Leelakrishnan. ISBN: 9789391211509 6th Edition, 2021.
2. Water Governance: Challenges and Prospects. 2019. Editors: Amarjit Singh, Avinash C. Tyagi, Dipankar Saha. SBN:9789811327001, 9811327009. Springer Nature Singapore.
3. Inter-State and International Water Disputes: P Ishwara Bhat, 2013. Ebook
4. Water Governance and Management in India Issues and Perspectives, 1: 2019. Editors: Ashwin B. Pandya, Girish Chadha. ISBN:9789811364006, 9811364001. Springer Nature Singapore.
5. Water Law in India: An Introduction to Legal Instruments. (2017) by OUP India (Author), Editors: Philippe Cullet and Sujith Koonan . ISBN: 9780199472475
6. The Harmon Doctrine One Hundred Years Later: Buried, Not Praised Praised https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1774&context=nrj
7. Territorial Sovereignty and Scope of the Dispute. https://legal.un.org/riaa/cases/vol_XXII/209-332.pdf
8. The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes Its Contribution to International Water Cooperation 2015. Editors:Alexandros Kolliopoulos, Alistair Rieu-Clarke, Attila Tanzi, Owen McIntyre, Rémy Kinna. ISBN:9789004291584, 900429158X
9. Environmental Law & Policy in India: Diven Rosencranz
10. Environmental Protection and Law: V. K. Prabhakar.

Syllabus of Water Management for UG programmes
Major
(Semester 8)

Course Title: Water Sanitation and Public Health **Credits: Theory:3, Practical: 1**
Course code: WMG822J1 **Course Type: CT-1 (MAJOR)**

Course outcome: This course will offer a better understanding of the varied perspectives on sanitation and Health interface. Students are expected to have a better understanding of indicators Water, Sanitation and Hygiene (WASH).

Unit I: Public Health

Overview of the importance of clean water; Epidemiology: concept, types, uses and principles; Water borne diseases (cholera, diarrhea, typhoid, amoebiasis, hepatitis, gastroenteritis, giardiasis); Health burden in third world countries

Unit II: Sanitation Practices

Sanitation practices and their impact on public health; On-site excreta disposal systems: pit latrines, Ventilated Improved Pit (VIP) latrines, pour-flush latrines, composting latrines, septic tanks, soakage systems, ecological sanitation; Urban sanitation: Conventional and low-cost sewerage, container-based sanitation, faecal sludge management; Community engagement and behavior change

Unit III: WASH and Development

WASH: need and importance; Evaluating WASH scarcity across scales (transboundary, national, urban & rural); Common Challenges in WASH - Bureaucracy and Users; Circular economy (transition to Circular sanitation systems) and challenges in implementing; Third world scenario: poor and multidimensional deprivation.

Practical:

1. Questionnaire based survey for evaluation of some water borne diseases
2. Working and design of septic tank
3. A case study on SWACHHA Bharat Mission
4. WASH fit assessment through checklist method

Suggested Readings:

1. Bonitha R., Beaglehole R.,Kjellstorm, “Basic Epidemiology”, 2nd Edition, World Health Organization, 2006
2. WHO/UNICEF. Global Water supply and sanitation assessment report. Geneva and New York: WHO and UNICEF; 2000.
3. Griffiths JK and Winant E (2007) Environmental health in the global context. In: Markle W, Fisher M and Smego R (eds.) Understanding Global Health. New York: McGraw-Hill Professional.
4. Water, Sanitation and Health (WSH), World Health Organization (WHO). http://www.who.int/water_sanitation_health/en –
5. CDC, C. for D. C. and P.2015. Sanitation & hygiene.
6. https://www.cdc.gov/healthywater/global/sanitation/index.html
7. WHO.2015. Improving nutrition outcomes with better water, sanitation and hygiene: practical solutions for policies and programme. Geneva.
8. Clasen T.2015. Household water treatment and safe storage to prevent diarrheal disease in developing countries. Curr Environ Health Rep. 2(1):69–74. doi:10.1007/s40572-014-0033-9.

Syllabus of Water Management for UG Programmes
Major
(Semester 8)

Course Title: Water Economics and Governance **Credits: Theory:4, Practical: 2**
Course code: WMG822J2 **Course Type: CT-2 (MAJOR)**

Course outcome: Students are expected to have a broader sense of water as a resource linking economic, environmental, and social and governance aspects.

Unit I: Water Resource Economics

Water as an economic good, Valuing water: Use and nonuse value, Global water availability and uses, Water availability and uses in India, Surface water and ground water resources, Water use practices and major challenges

Unit II: Water Tariffs

Right to water, Entitlements and criteria, Water Pricing: Approaches and models, Criteria for water tariffs, Metering water uses, Revenue sufficiency, Economic efficiency, Environmental sustainability

Unit III Water Market and Trading

Water market: Emergence and development, Water market types: Formal and informal, Water market and reallocation conundrum, advantages and disadvantages of water trading, Global bottled water market: Size, share, trends and impact

Unit IV: Water Governance

Water Governance: Elements and dimensions of water governance, Indicators of good governance, Effective water governance schemes, Water governance in India, interstate water management initiatives, Water dispute management: Interstate and intrastate

Practical/Case studies:

1. Estimation of water in a river/stream through float method
2. Estimation of volume of water in lake/wetland
3. Estimation of discharge of springs
4. Case study on prevalent water use practices in the locality
5. Assessment of value of any water system/landscape (Lake, river, pond, park, gardenetc.) through Travel cost method
6. Assessment of value of any water system/landscape (Lake, river, pond, park, gardenetc.) through Contingent method
7. Case study on any success story of water on water Governance
8. Case study on interstate water disputes

Suggested Readings:

1. Water Resource Economics Hardcover by Ronald C. Griffin.2016
2. The Economics of Water- Rules and Institutions by Georg Meran, Markus Siehlow, Christian von Hirschhausen. 2021
3. Water Resource Economics: Towards a Sustainable Use of Water for Irrigation by Ariel Dinar. 2015
4. Water Institutions: Policies, Performance and Prospects by Ariel Dinar and RashidHassan. 2005
5. Governance of Water: Institutional Alternatives and Political Economy edited by Vishwa Ballabh. 2007
6. Handbook of Water Economics by Ariel Dinar. 2015
7. Policy and Strategic Behaviour in Water Resource Management by Ariel Dinar. 2012
8. Markets for Water: Potential and Performance by K. William Easter, M.W. Rosegrant, Ariel Dinar · 2007
9. Water Pricing Experiences and Innovations by Ariel Dinar, Víctor Pochat and José Albiac-Murillo · 2015
10. Environmental Economics and Policy by Thomas H. Tietenberg · 2004 ·

Syllabus of Water Management for UG programmes
Major
(Semester 8)

Course Title: Oceanography | **Credits: Theory: 4, Practical: 2**
Course code: WMG822J3 | **Course Type: CT-3 (MAJOR)**

Course outcome: This is expected to help students develop a greater appreciation for the complex processes that occur in the world's oceans. This could involve learning about the role of oceans in regulating Earth's climate, their biodiversity, andtheir impact on the environment.

Unit I Fundamentals of Oceanography

Introduction to Oceanography, Topographic features of the ocean floor, Oceanographic Tools and Methods, Classification of marine sediments, Ocean Circulation Patterns, Coastal Processes and Dynamics

Unit II Physical Oceanography

Physical Properties of Oceans: Temperature, Salinity, Density; Ocean Currents and Gyres; Waves and Tides; Thermohaline circulations; Ocean-atmosphere InteractionsImpact of Climate Change on Oceanography

Unit III Chemical Oceanography

Seawater Composition and Chemical Properties; Nutrient Cycling in Oceans; Ocean Acidification; Trace Elements and Pollutants in Ocean waters; Dissolved gases in Oceanic waters; Biogeochemical Cycles in the Ocean; Human Impact on Ocean Chemistry

Unit IV Biological Oceanography and Marine Ecology

Marine Life: Adaptations and Diversity; Plankton and Primary Productivity: conceptof food chain and food web in oceans; Coral Reefs and Coral Bleaching; Deep-Sea Ecology: Phyto-zoo plankton dynamics in the marine ecosystem; Marine Fisheries and Sustainable Resource Management; Conservation Challenges in the Marine Environment

Practical:

1. Determination of salinity of the water
2. Determination of chloride content in water
3. Estimation of Free carbon dioxide
4. Identification of some key marine plankton

Suggested Readings:

1. Garrison, T.1996Oceanography- An invitation to Marine Science. Wadsworth Publishing Company.
2. Qasim, S.Z. &Roonwal, G.S.(eds). 1996India's Exclusive Economic Zone.Omega Scientific Publishers.
3. Gross, M.G.1972Oceanography - A view of the Earth. Prentice-Hall.
4. S. Davis, R.A. Jr. 1972 Principles of Oeanography. Addison -Wesley Publishing Company.
5. Roonwal, G.S.1986The Indian Ocean: Exploitable mineral & petroleumResources. Narosa Pub. house
6. Haq, B.U. & Milliman, J.D. 1984 Marine Geology and oceanography ofArabian Sea and coastal Pakistan. Elite Publishers Limited.
7. Francis P. Shepard Geological Oceanography.
8. Bhatt, J.J. 1978 Oceanography - Exploring "the planet Ocean. D. vanNostrand Company.
9. Duxbury, A.B. & Duxbury, A.C. 1993Fundamentals of Oceanography. Wm. C.Brown Publishers.
10. Turekian, K.K.Oceans.
11. A.P. Trujillo &H.V. Thurman 2012Essentials of Oceanography.PHI LearningPrivate Limited
12. Singh, S. 2013. Physical Geography, Prayag Pub., Allahabad.
13. Strahaler, A.H. 2014. Introducing Physical Geography, Wiley Pub.

Syllabus of Water Management for UG programmes
Major
(Semester 8)

Course Title: Research Methodology and Ethics **Credits: Theory:3, Practical:1**
Course code: WMG822RJ1 **Course Type: CT-1 (MAJOR)**

Course outcome: This is designed to have a better understanding how research should be conducted and adhering to the ethics in the profession**.**

Unit I Research Philosophy and Design

Research Philosophy (Positivism and Interpretivism), Meaning, objectives and nature of Research, Defining and selection of research problem, Research Design: Planning, research question (Hypothesis), testing of hypothesis, Literature review, types of Research -Exploratory, experimental and descriptive.

Unit II Research Methodology

Sampling design, Data collection methods, Processing and data analysis, interpretation and writing, Project report and dissertation/thesis writing, References writing, Quality assurance and quality control.

Unit III Scientific Conduct and Ethics

Values underlying research integrity, Scientific misconducts: Falsification, Fabrication, Plagiarism and misrepresentation, Collaboration and authorship, conflict of interest, Mentor-Mentee relationship, Right publication venues, Predatory journals, Research metrics

Practical:

1. Exercise and data analysis using ANOVA, Multiple correlation and regression analysis
2. Factor Analysis and PCA for a given data set
3. Operation of statistical softwares: SPSS,
4. Operation of statistical softwares: R

Recommended Books:

1. Research design: Qualitative, quantitative, and mixed methods approach by JohnW Cresswell.
2. The craft of Research (3rd Ed) by Wayne C Booth et al.
3. Doing your research project by Judith Bell.

4. Introducing Research Methodology: A Beginners Guide to doing a research projectby Uwe Flick.
5. Ecological Methods (4th Ed) by Peter A Henderson and T R E South wood.
6. Scientific Methods for Ecological Research by E D Ford.
7. Handbook of Research Methods for Social-Ecological Systems by R Biggs et al.
8. The Ecological Detective: Confronting models with data by Hilborn and Mangel.
9. Eco-Stats: Data Analysis in Ecology by David I Wharton.
10. Handbook of Environmental and Ecological Statistics by Alan E Gelfand et al.

Syllabus of Water Management for UG programmes
Major
(Semester 8)

Course Title: Project Work **Credits: Practical-12**
Course code: WMG822RJP **Course Type: CT-1 (MAJOR)**

Course Outcome: The course will enable the students to do independent research by working on the research problem of local relevance but having global significance. It will prepare the students to venture into research ahead and take on various water related issues and challenges the humanity is facing.

Research Project:

This shall include a dissertation of the project work, submitted by the student, for the evaluation. Each student will be required to submit the dissertation of the project work for the evaluation. The project work could either be of laboratory or a survey based. The student has to give seminar (internal) and viva voce (external) of the project work before external examiner. There will be 20% mark for internal assessment, 60% marks for the dissertation and 20% marks for Viva Voce.