

SOIL SCIENCE

Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
SOILS 501*	SOIL PHYSICS	2+1
SOILS 502*	SOIL FERTILITY AND FERTILIZER USE	2+1
SOILS 503*	SOIL CHEMISTRY	2+1
SOILS 504*	SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY	2+1
SOILS 505	SOIL EROSION AND CONSERVATION	2+1
SOILS 506	PHYSICAL CHEMISTRY	1+0
SOILS 507*	SOIL BIOLOGY AND BIOCHEMISTRY	2+1
SOILS 508	GEOMORPHOLOGY AND GEOCHEMISTRY	2+0
SOILS 509	RADIOISOTOPES IN SOIL AND PLANT STUDIES	1+1
SOILS 510	SOIL, WATER AND AIR POLLUTION	2+1
SOILS 511	REMOTE SENSING AND GIS TECHNIQUES FOR SOIL AND CROP STUDIES	2+1
SOILS 512	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	0+1
SOILS 513	SYSTEM APPROACHES IN SOIL AND CROP STUDIES	2+1
SOILS 514	MANAGEMENT OF PROBLEMATIC SOILS AND WATER	2+1
SOILS 515	FERTILIZER TECHNOLOGY	1+0
SOILS 516	LAND DEGRADATION AND RESTORATION	1+0
SOILS 591	MASTER'S SEMINAR	1+0
SOILS 599	MASTER'S RESEARCH	20
SOILS 601	ADVANCE IN SOIL PHYSICS	2+0
SOILS 602	ADVANCES IN SOIL FERTILITY	2+0
SOILS 603	PHYSICAL CHEMISTRY OF SOILS	2+1
SOILS 604	SOIL GENESIS AND MICROPEDOLOGY	2+0
SOILS 605	BIOCHEMISTRY OF SOIL ORGANIC MATTER	2+0
SOILS 606	LAND USE PLANNING AND WATERSHED MANAGEMENT	2+0
SOILS 691	DOCTORAL SEMINAR I	1+0
SOILS 692	DOCTORAL SEMINAR II	1+0
SOILS 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme

SOIL SCIENCE

Course Contents

SOILS 501 **SOIL PHYSICS** **2+1**

Objective

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory

UNIT I

Scope of soil physics and its relation with other branches of soil science; soil as a three phase system.

UNIT II

Soil texture, textural classes, mechanical analysis, specific surface.

UNIT III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts.

UNIT IV

Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

UNIT V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

UNIT VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

UNIT VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

UNIT IX

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

UNIT X

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

- Mechanical analysis by pipette and international methods
- Measurement of Atterberg limits
- Aggregate analysis - dry and wet
- Measurement of soil-water content by different methods
- Measurement of soil-water potential by using tensiometer and gypsum blocks

- Determination of soil-moisture characteristics curve and computation of pore-size distribution
- Determination of hydraulic conductivity under saturated and unsaturated conditions
- Determination of infiltration rate of soil
- Determination of aeration porosity and oxygen diffusion rate
- Soil temperature measurements by different methods
- Estimation of water balance components in bare and cropped fields

Suggested Readings

- Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Ghildyal BP & Tripathi RP. 2001. *Soil Physics*. New Age International.
- Hanks JR & Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.
- Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.
- Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
- Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.
- Hillel D. 1998. *Environmental Soil Physics*. Academic Press.
- Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.
- Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
- Kohnke H. 1968. *Soil Physics*. McGraw Hill.
- Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.
- Saha AK. 2004. *Text Book of Soil Physics*. Kalyani.

SOILS 502

Objective

SOIL FERTILITY AND FERTILIZER USE

3+1

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

UNIT I

Soil fertility and soil productivity; nutrient sources - fertilizers and manures; essential plant nutrients - functions and deficiency symptoms.

UNIT II

Soil and fertilizer nitrogen - sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation - types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

UNIT III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions.

UNIT IV

Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

UNIT V

Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium- factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

UNIT VI

Micronutrients - critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

UNIT VII

Common soil test methods for fertilizer recommendations; quantity-intensity relationships; soil test crop response correlations and response functions.

UNIT VIII

Fertilizer use efficiency; blanket fertilizer recommendations - usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management.

UNIT IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

- Principles of colorimetry
- Flame-photometry and atomic absorption spectroscopy
- Chemical analysis of soil for total and available nutrients
- Analysis of plants for essential elements

Suggested Readings

- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Kabata-Pendias A & Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.
- Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Leigh JG. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K & Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ & Vance JF. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.
- Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.
- Troeh FR & Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

Objective

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

UNIT I

Chemical (elemental) composition of the earth's crust and soils.

UNIT II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

UNIT III

Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions.

UNIT IV

Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange - inner-sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

UNIT V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects.

UNIT VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

UNIT VII

Chemistry of salt-affected soils and amendments; soil pH, EC_e , ESP, SAR and important relations; soil management and amendments.

UNIT VIII

Chemistry and electrochemistry of submerged soils.

Practical

- Determination of CEC and AEC of soils
- Analysis of equilibrium soil solution for pH, EC, E_h by the use of E_h -pH meter and conductivity meter
- Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method
- Potentiometric and conductometric titration of soil humic and fulvic acids
- (E_4/E_6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the $\Delta(E_4/E_6)$ values at two pH values

- Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm
- Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved
- Determination of titratable acidity of an acid soil by BaCl₂-TEA method
- Determination of lime requirement of an acid soil by buffer method
- Determination of gypsum requirement of an alkali soil

Suggested Readings

- Bear RE. 1964. *Chemistry of the Soil*. Oxford and IBH.
- Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
- Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ & Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.
- McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford Univ. Press.
- Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.
- Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.
- Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.
- Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
- Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 504

SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY

2+1

Objective

To acquaint students with basic structure of aluminosilicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

UNIT I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

UNIT II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils.

UNIT III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

UNIT IV

Concept of soil individual; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps - usefulness.

UNIT V

Soil survey and its types; soil survey techniques - conventional and modern; soil series - characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps.

UNIT VI

Landform - soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) - concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Practical

- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available data base in terms of soil quality
- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercises using conventional and RS tools

Suggested Readings

- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
- Dixon JB & Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soilnd Science Society of America, Madison.
- Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.
- USDA. 1999. *Soil Taxonomy*. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
- Wade FA & Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
- Wilding LP & Smeck NE. 1983. *Pedogenesis and Soil Taxonomy: II. The Soil Orders*. Elsevier.
- Wilding NE & Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy. I. Concept and Interaction*. Elsevier.

SOILS 505

SOIL EROSION AND CONSERVATION

2+1

Objective

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

UNIT I

History, distribution, identification and description of soil erosion problems in India.

UNIT II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI_{30} index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

UNIT III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

UNIT IV

Principles of erosion control; erosion control measures - agronomical and engineering; erosion control structures - their design and layout.

UNIT V

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

UNIT VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical

- Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI_{30}) using rain gauge data
- Visits to a watersheds

Suggested Readings

- Biswas TD & Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.
- Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
- Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.
- Hudson N. 1995. *Soil Conservation*. Iowa State Univ. Press.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Kinetic theory of gases. First, second and third laws of thermodynamics. Free energy and work function relationships. Nernst's heat theorem, entropy and probability, dilute solutions, colligative properties, Lechatelier principle, electrolytic dissociation, transport numbers, electrochemistry, ionic equilibria, electromotive force and electrode potential, ionic activity, phase rule, chemical kinetics, colloids, electrical phenomena – application to clay-water systems.

Objective

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

TheoryUNIT I

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora.

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV

Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

UNIT V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

UNIT VI

Biofertilizers - definition, classification, specifications, method of production and role in crop production.

Practical

- Determination of soil microbial population
- Soil microbial biomass
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N₂ fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect

Suggested Readings

- Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.
- Burges A & Raw F. 1967. *Soil Biology*. Academic Press.
- McLaren AD & Peterson GH. 1967. *Soil Biochemistry*. Vol. XI. Marcel Dekker.
- Metting FB. 1993. *Soil Microbial Ecology - Applications in Agricultural and Environmental Management*. Marcel Dekker.
- Paul EA & Ladd JN. 1981. *Soil Biochemistry*. Marcel Dekker.
- Reddy MV. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.
- Russel RS. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill.

UNIT IV

Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

- Storage and handling of radioactive materials
- Determination of half life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes
- Determination of A, E and L values of soil using $P/^{32}Zn$ ⁶⁵
- Use of neutron probe for moisture determination
- Sample preparation and measurement of ¹⁵N enrichment by mass spectrophotometry/ emission spectrometry

Suggested Readings

Comer CL. 1955. *Radioisotopes in Biology and Agriculture: Principles and Practice*. Tata McGraw Hill.

Glasstone S. 1967. *Source Book on Atomic Energy*. East West Press.

Michael FL & Annunziata. 2003. *Handbook of Radioactivity Analysis*. Academic Press.

SOILS 510

SOIL, WATER AND AIR POLLUTION

2+1

Objective

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

UNIT I

Soil, water and air pollution problems associated with agriculture, nature and extent.

UNIT II

Nature and sources of pollutants - agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings.

UNIT III

Sewage and industrial effluents - their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal.

UNIT IV

Pesticides - their classification, behavior in soil and effect on soil micro-organisms.

UNIT V

Toxic elements - their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

UNIT VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases - carbon dioxide, methane and nitrous oxide.

UNIT VIII

Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

- Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants
- Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents
- Heavy metals in contaminated soils and plants
- Management of contaminants in soil and plants to safeguard food safety
- Air sampling and determination of particulate matter and oxides of sulphur
- Visit to various industrial sites to study the impact of pollutants on soil and plants

Suggested Readings

Lal R, Kimble J, Levine E & Stewart BA. 1995. *Soil Management and Greenhouse Effect*. CRC Press.

Middlebrooks EJ. 1979. *Industrial Pollution Control*. Vol. I. *Agro-Industries*. John Wiley Interscience.

Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.

Vesilund PA & Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.

SOILS 511

REMOTE SENSING AND GIS TECHNIQUES FOR SOIL, WATER AND CROP STUDIES

2+1

Objective

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

Theory

UNIT I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter.

UNIT II

Sensor systems - camera, microwave radiometers and scanners; fundamentals of aerial photographs and image processing and interpretations.

UNIT III

Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management.

UNIT IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

UNIT V

Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical

- Familiarization with different remote sensing equipments and data products
- Interpretation of aerial photographs and satellite data for mapping of land resources
- Analysis of variability of different soil properties with classical and geo-statistical techniques
- Creation of data files in a database programme
- Use of GIS for soil spatial simulation and analysis
- To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning

Suggested Readings

- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.
- Lillesand TM & Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.
- Nielsen DR & Wendroth O. 2003. *Spatial and Temporal Statistics*. Catena Verloggbmh.
- Star J & Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

SOILS 512

ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS

0+2

Objective

To familiarize the students with commonly used instruments - their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Practical

UNIT I

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation-reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

UNIT II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

UNIT III

Principles of visible, ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractometry; identification of minerals by X-ray by different methods.

UNIT IV

Electrochemical titration of clays; determination of cation and anion exchange capacities of soils; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

UNIT V

Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods.

UNIT VI

Determination of lime and gypsum requirement of soil; drawing normalized exchange isotherms; measurement of redox potential.

UNIT VII

Analysis of soil extracts and irrigation waters for their soluble cations and anions and interpretation of results.

Suggested Readings

- Hesse P. 1971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.
Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.
Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.
Kenneth Helrich 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.
Page AL, Miller RH & Keeney DR. 1982. *Methods of Soil Analysis*. Part II. SSSA, Madison.
Piper CE. *Soil and Plant Analysis*. Hans Publ.
Singh D, Chhonkar PK & Pandey RN. 1999. *Soil Plant Water Analysis - A Methods Manual*. IARI, New Delhi.
Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.
Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Waters*. FDCO, New Delhi.
Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

SOILS 513

SYSTEM APPROACHES IN SOIL AND CROP STUDIES

2+1

Objective

To train the students in concepts, methodology, technology and use of systems simulation in soil and crops studies.

Theory

UNIT I

Systems concepts - definitions, general characteristics; general systems theory; systems thinking, systems dynamics, systems behavior and systems study.

UNIT II

Model: definition and types; mathematical models and their types; modeling: concepts, objectives, processes, abstraction techniques; simulation models, their verification and validation, calibration; representation of continuous systems simulation models - procedural and declarative.

UNIT III

Simulation - meaning and threats; simulation experiment, its design and analysis.

UNIT IV

Application of simulation models in understanding system behavior, optimizing system performance, evaluation of policy options under

different soil, water, nutrient, climatic and cultural conditions; decision support system, use of simulation models in decision support system.

Practical

- Use of flow chart or pseudo-code in the program writing
- Writing a small example simulation model program - declarative (in Vensim PLE, Stella or Simile) and procedural (in Java, Fortran, QBasic or V Basic)
- Conducting simulation experiments in DSSAT, WOFOST or EPIC with requirement of report and conclusion

Suggested Readings

- Benbi DK & Nieder R. (Eds.). 2003. *Handbook of Processes and Modelling in the Soil - Plant System*. Haworth Press.
- Hanks J & Ritchie JT. (Eds.). 1991. *Modelling Plant and Soil System. Agronomy*. Bull. No 31. Soil Sci. Society of America, Madison.
- Rajaraman V. 2004. *Computer Programming in Fortran 90 and 95*. PHI.
- Tsuji GY, Gerrit H & Philip T. 1998. *Understanding Options for Agricultural Production*. Kluwer.
- von Bertalanffy Ludwig 1969. *General Systems Theory: Foundation Development and Application*. Revised Ed. George Braziller Reprint 1998.

Web sites

- Documentation of the respective models. (<http://www.simulistics.com/> for Simile; <http://www.iseesystems.com> for Stella; and <http://www.vensim.com/software.html> for vensim PLE)
- <http://www.icasa.net/dssat/index.html> for DSSAT; <http://www.brc.tamus.edu/epic/> for EPIC
- <http://www.nrel.colostate.edu/projects/century/> for Century
- [http://www.alterra.wur.nl/NL/for WOFOST](http://www.alterra.wur.nl/NL/for_WOFOST)
- <http://www.apsru.gov.au/apsru/Default.htm> for APSIM
- <http://eco.wiz.uni-kassel.de/ecobas.html> online Register of ecological models
- Plentinger MC Penning de Vries FWT, Editors (1996) CAMASE Register of Agro-ecosystems Models. DLO-Research Institute for Agrobiological and Soil Fertility (AB-DLO)
- Agricultural Systems - Elsevier at http://www.elsevier.com/wps/product/cws_home/405851
- Ecological Modeling - Elsevier at <http://www.elsevier.com/locate/ecolmodel>

SOILS 514

MANAGEMENT OF PROBLEM SOILS AND WATERS

2+1

Objective

To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

Theory

UNIT I

Area and distribution of problem soils - acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

UNIT II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties.

UNIT III

Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.

UNIT IV

Acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

UNIT V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

UNIT VI

Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

- Characterization of acid, acid sulfate, salt-affected and calcareous soils
- Determination of cations (Na^+ , K^+ , Ca^{2+} and Mg^{2+}) in ground water and soil samples
- Determination of anions (Cl^- , SO_4^{2-} , CO_3^{2-} and HCO_3^-) in ground waters and soil samples
- Lime and gypsum requirements of acid and sodic soils

Suggested Readings

Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.

Jurinak JJ. 1978. *Salt-affected Soils*. Department of Soil Science & Biometeorology. Utah State Univ.

USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.

SOILS 515

FERTILIZER TECHNOLOGY

1+0

Objective

To impart knowledge about how different fertilizers are manufactured using different kinds of raw materials and handling of fertilizers and manures.

Theory

UNIT I

Fertilizers - production, consumption and future projections with regard to nutrient use in the country and respective states; fertilizer control order.

UNIT II

Manufacturing processes for different fertilizers using various raw materials, characteristics and nutrient contents.

UNIT III

Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order.

Objective

To provide knowledge of modern concepts in soil physics.

TheoryUNIT I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system.

UNIT II

Fundamentals of fluid flow, Poiseuille's law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow.

UNIT III

Theories of horizontal and vertical infiltration under different boundary conditions.

UNIT IV

Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

UNIT V

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil.

UNIT VI

Soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soil conditioners - types, characteristics, working principles, significance in agriculture.

UNIT VII

Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Suggested Readings

- Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Hanks and Ascheroff. 1980. *Applied Soil Physics*. Springer Verlag.
- Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
- Hillel D. 1980. *Environmental Soil Physics*. Academic Press.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley Interscience.
- Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Objective

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

TheoryUNIT I

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices.

UNIT II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

UNIT III

Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils, particularly in submerged soils.

UNIT IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

UNIT V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

UNIT VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Suggested Readings

- Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.
- Barker V Allen & Pilbeam David J. 2007. *Handbook of Plant Nutrition*. CRC / Taylor & Francis.
- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Educ.
- Cooke GW. 1979. *The Control of Soil Fertility*. Crosby Lockwood & Sons.
- Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives*. International Potash Institute, Switzerland.
- Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC / Taylor & Francis.
- Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991. *Micronutrients in Agriculture*. 2nd Ed. Soil Science Society of America, Madison.
- Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
- Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.

van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 604 SOIL GENESIS AND MICROPEDOLOGY 2+0

Objective

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

UNIT I

Pedogenic evolution of soils; soil composition and characterization.

UNIT II

Weathering and soil formation - factors and pedogenic processes; stability and weathering sequences of minerals.

UNIT III

Assessment of soil profile development by mineralogical and chemical analysis.

UNIT IV

Micro-pedological features of soils - their structure, fabric analysis, role in genesis and classification.

Suggested Readings

Boul SW, Hole ED, MacCraken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.

Brewer R. 1976. *Fabric and Mineral Analysis of Soils*. John Wiley & Sons.

SOILS 605 BIOCHEMISTRY OF SOIL ORGANIC MATTER 2+0

Objective

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

UNIT I

Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter pools.

UNIT II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

UNIT III

Nutrient transformation - N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.

UNIT IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.

UNIT V

Humus - pesticide interactions in soil, mechanisms.

Suggested Readings

Beck AJ, Jones KC, Hayes MHB & Mingelgrin U. 1993. *Organic Substances in Soil and Water: Natural Constituents and their*

- Influences on Contaminant Behavior*. Royal Society of Chemistry, London.
- Gieseking JE. 1975. *Soil Components*. Vol. 1. *Organic Components*. Springer-Verlag.
- Kristiansen P, Taji A & Reganold J. 2006. *Organic Agriculture: A Global Perspective*. CSIRO Publ.
- Magdoff F & Weil RR 2004. *Soil Organic Matter in Sustainable Agriculture*. CRC Press.
- Mercky R & Mulongoy K. 1991. *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture*. John Wiley & Sons.
- Paul EA. 1996. *Soil Microbiology and Biochemistry*. Academic Press.
- Stevenson FJ. 1994. *Humus Chemistry - Genesis, Composition and Reactions*. John Wiley & Sons.

SOILS 606

**LAND USE PLANNING AND WATERSHED
MANAGEMENT**

2+0

Objective

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

UNIT I

Concept and techniques of land use planning; factors governing present land use.

UNIT II

Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

UNIT III

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production.

UNIT IV

Water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity.

UNIT V

Watershed development/management - concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Suggested Readings

- All India Soil and Land Use Survey Organisation 1970. *Soil Survey Manual*. IARI, New Delhi.
- FAO. 1976. *A Framework for Land Evaluation*, Handbook 32. FAO.
- Sehgal JL, Mandal DK, Mandal C & Vadivelu S. 1990. *Agro-Ecological Regions of India*. NBSS & LUP, Nagpur.
- Soil Survey Staff 1998. *Keys to Soil Taxonomy*. 8 Ed. USDA & NRCS, Washington, DC.
- USDA 1974. *A Manual on Conservation of Soil and Water Handbook of Professional Agricultural Workers*. Oxford & IBH.

SOIL SCIENCE

List of Journals

- Advances in Agronomy
- Annals of Arid Zone
- Australian Journal of Agricultural Research
- Australian Journal of Soil Research
- Biology and Fertility of Soils
- Communications in Soil Science and Plant Analysis
- Clays and Clay minerals
- European Journal of Soil Science
- Geoderma
- Indian Journal of Agricultural Sciences
- Journal of Plant Nutrition and Soil Science
- Journal of the Indian Society of Soil Science
- Nutrient Cycling in Agroecosystems
- Plant and Soil
- Soil and Tillage Research
- Soil Biology and Biochemistry
- Soil Science
- Soil Science Society of America Journal
- Soil Use and Management
- Water, Air and Soil Pollution
- Water Resources Research

Suggested Broad Topics for Master's and Doctoral Research

- Degradation and restoration of soil as natural resource
- Biochemistry of processes at the soil-root interface
- Impact of current agricultural practices and agrochemicals on soil quality/biodiversity
- Integrated nutrient management for sustainable agriculture
- Fertilizer use efficiency in different soil conditions/cropping systems
- Use of remote sensing and GIS as diagnostic tool for natural resource management
- Role of biological agents in soil productivity
- Modeling solute (salt, fertilizer, pesticides) transport in soil
- Use of poor quality waters in Agriculture
- Soil testing and crop response
- Site-specific nutrient management and precision agriculture
- Nutrient dynamics in soil-plant system and modeling nutrient uptake
- Tillage and crop residue management in crop production
- Utilization of urban and industrial wastes/effluents in Agriculture
- Management of problematic soils
- Impact of climate change on soil processes
- Micronutrients in soil, plant and human health
- Water management strategies in different cropping systems
- Simulation models for growth and production of different crops
- Varietals response to soil salinity/ sodicity/ nutrients/ pollutants, etc
- Soil and water pollution - monitoring and control
- Genesis, formation and classification of soils
- Soil conservation, preservation and management for sustainable agriculture
- Remediation of polluted and contaminated soils