

## Courses Catered by the Department of Agricultural Chemistry and Soil Science in Master Degree Programme of Soil Science

Semester	Course No.	Name of the course	Credits
1 <sup>st</sup> Semester	*SOIL 501	Soil Physics	2+1
	* SOIL 502	Soil fertility and fertilizer use	2+1
	* SOIL 503	Soil chemistry	2+1
	* SOIL 504	Soil mineralogy, genesis and classification	2+1
2 <sup>nd</sup> Semester	SOIL 505	Soil erosion and conservation	2+1
	SOIL 506	Soil biology and biochemistry	2+1
	SOIL 507	Radioisotopes in soil and plant studies	1+1
	SOIL 508	Soil, water and air pollution	2+1
	SOIL 509	Remote sensing and GIS technique for soil and crop studies	2+1
3 <sup>rd</sup> Semester	SOIL 510	Analytical technique and instrumental methods in soil and plant analysis	0+2
	SOIL 511	Management of problematic soils and water	1+1
	SOIL 512	Land degradation and restoration	1+0
	SOIL 513	Soil survey and land use planning	2+0
	SOIL 591	Master's Seminar	1+0
	SOIL 599	Master's Research	30

- **Core courses**

### **Soil Physics : Soil 501 (2+1)**

#### **Theory**

##### Unit I

Basic principles of physics applied to soils, 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. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

## 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 VIII

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 IX

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

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- 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.

## **Soil Fertility and Fertilizer Use : Soil 502 (2+1)**

### **Theory**

#### **Unit I**

Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity

#### **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. 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; role in crops and human health; 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; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers use in soils and crops of India;

#### **Unit IX**

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

## Unit X

Definition and concepts of soil health and soil quality; Longterm effects of fertilizersand soil quality.

### Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients(major and micro)
- Analysis of plants for essential elements(major and micro)

## Soil Chemistry : Soil 503 (2+1)

### Theory

#### Unit I

Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

#### 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, Characterization of OM; clay-organic interactions.

#### Unit IV

Ion exchange processes in soil; cation exchange- theories based on law of massaction (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorptionisotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionicactivity measurement, thermodynamics, statistical mechanics; anion and ligand exchange– innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresisin sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomenaand practical implications in plant nutrition.

#### Unit V

Potassium, phosphate and ammonium fixation in soils covering specificand non- specific sorption; precipitation-dissolution equilibria; Conceptof quantity/intensity(Q/ I)relationship; step and constant-rate K; managementaspects.

#### 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, E<sub>ce</sub>, ESP, SAR and important relations; soil management and amendments.

## Unit VIII

Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

## Practical

Preparation of saturation extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E<sub>4</sub>/E<sub>6</sub>) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E<sub>4</sub>/E<sub>6</sub>) 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 BaCl<sub>2</sub>-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

## Soil Mineralogy, Genesis and Classification : Soil 504 (2+1)

### 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 crystal line and non-crystal line clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

#### 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.

## **Practical**

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soil using available database in terms of soil quality

## **Soil Erosion and Conservation : Soil 505 ( 2+1)**

### **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 EI30 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; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

### **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 (EI30) using rain gauge data
- Land capability classification of a watershed
- Visits to a watersheds

## **Soil Biology and Biochemistry : Soil 506 (2+1)**

### **Theory**

#### **Unit I**

Soilbiota, soil microbialecolgy, types of organisms indifferent soils; soil microbialbiomass; microbial interactions; un-culturable soilbiota.

#### **Unit II**

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

#### **Unit III**

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganesein soil; biochemical composition and biodegradation of soil organic matter and crop

residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients.

#### **Unit IV**

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; FCO specifications and quality control of biofertilizers.

#### **Unit VII**

Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms inpedogenesis – important mechanisms and controlling factors; soil genomics and bioprospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

### **Practical**

- Determination of soil microbial population
- Soil microbial biomass carbon
- 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, N<sub>2</sub> fixation, S oxidation, P solubilization and mineralization of other micronutrients

## **Radioisotopes in Soil and Plant Studies : Soil 507 (1+1)**

### **Theory**

#### Unit I

Atomic structure, radio activity and units; radio isotopes-properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity

#### Unit II

Principles and use of radiation monitoring instruments-proportional, Geiger Muller counter, solid and liquids cintillation counters; neutron moisture meter, mass spectrometry, autoradiography

#### Unit III

Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

#### 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
- Settingup of experiment on fertilizer use efficiency and cation exchange equilibriausing radio isotopes
- Determination of A, E and L values of soil using <sup>32</sup>P/<sup>65</sup>Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of <sup>15</sup>N enrichment by mass spectro photometry/ emission spectrometry

## **Soil, Water and Air Pollution : Soil 508 (2+1)**

### **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, behaviour in soil and effect on soil microorganisms.

#### Unit V

Toxic elements—their sources, behaviour 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 green house gases—carbon dioxide, methane and nitrous oxide.

#### Unit VII

Risk assessment of polluted soil, 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 and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), 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 safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO<sub>2</sub> and O<sub>2</sub> conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

## **Remote Sensing and GIS Technique for Soil, Water and Crop Studies Soil 509 (2+1)**

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### **Theory**

#### Unit I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

#### Unit II

Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging; image processing and interpretations.

### Unit III

Application of remote sensing techniques-landuse soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land 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 evolutionof soil variability.

### Unit V

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

### **Practical**

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photo graphs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of datafiles 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.

## **Analytical Technique and Instrumental Methods in Soil and Plant Analysis**

### **Soil 510 (0+2)**

### **Practical**

#### Unit I

Preparation of solutions for standard curves, 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, ultra violet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometry; identification of minerals by X-ray by different methods, CHNS analyzer.

#### Unit IV

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

#### Unit V

Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; triacid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg,

Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

#### Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

### **Management of Problem Soils and Water : Soil 511 (2+1)**

#### **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; salt stress meaning and its effect on crop growth, monitoring of soils alinity in the field; management principles for sandy, clayey, red lateritic and dryland 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.

#### **Practical**

Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>++</sup> and Mg<sup>++</sup>) in groundwater and soil samples, Determination of anions (Cl<sup>-</sup>, SO<sub>4</sub><sup>-</sup>, CO<sub>3</sub><sup>-</sup> and HCO<sub>3</sub><sup>-</sup>) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils.

### **Land Degradation and Restoration : Soil 512 (1+0)**

#### **Theory**

##### Unit I

Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.

## Unit II

Land restoration and conservation techniques-erosion control, reclamation of salt-affected soils; mineral land reclamation, afforestation, organic products.

## Unit III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

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## **Soil Survey and Land Use Planning : Soil 513 (2+0)**

### **Theory**

#### Unit I

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; thematic soil maps, cartography, mapping units, techniques for generalization of soil maps, application of remote sensing and GIS in soil survey and mapping of major soil group of India

#### Unit II

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.

#### Unit III

Concept and techniques of land use planning; factors governing present land use; Land evaluation method and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

#### Unit IV

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

### **Practical**

- 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 construction of maps in different scales
- Land use planning exercises using conventional and RS tools