Department of Soil Science

Master Degree Programme

Course No.	Title of the Course	Credits
	1st Semester	
ACSS 501	Soil Physics	2+1
ACSS 502	Soil Fertility & Fertilizer Use	2+1
ACSS 503	Soil Chemistry	2+1
ACSS 504	Fundamentals of Soil Microbiology	2+1
	2nd Semester	
ACSS 551	Soil Mineralogy, Genesis, Classification & Survey	2+1
ACSS 552	Soil Biology & Biochemistry	2+1
ACSS 553	Physical Chemistry of Soil	2+0
ACSS 554	Management of Problem Soil & Water	2+1
	3rd Semester	
ACSS 601	Soil, Water and Air Pollution	2+1
ACSS 602	Analytical Techniques & Instrumental Methods in Soil & Plant Analysis	0+2
ACSS-649	Seminar I	1+0
	4th Semester	
ACSS 651	Fertilizer Technology	1+0
ACSS-699	Seminar II	1+0
ACSS-700	Master's Research	0+20

1st Semester

ACSS- 501 Soil Physics 2+1

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

ACSS- 502 Soil Fertility & Fertilizer Use 2+1

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 - behaviour 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 behaviour 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 VII: 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

ACSS- 503 Soil Chemistry 2+1

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 – innersphere 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, ECe, 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, 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

• Potentiometric and conductometric titration of soil humic and fulvic acids

• (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the Δ (E4/E6) 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

ACSS – 504 Fundamentals of Soil Microbiology 2+ 1

Scope of the science of Microbiology. History and Development of soil Microbiology, Use of Microscope. Stains and staining principles, characterization of different microorganisms. Nutrition of microorganisms. Growth and death of microorganisms. Soil environment, Microorganisms occurring in soil, their distribution, isolation and classification. Decomposition of organic matter. Nitrogen cycle, Mineralisation and immobilization of nitrogen. Nitrification, Denitrification, Nitrogen fixation-non-symbiotic and symbiotic. Phosphorus and sulphur cycles in nature.

2nd Semester

ACSS- 551 Soil Minerology, Genesis, Classification & Survey 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 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

ACSS- 552 Soil Biology & Biochemistry 2+1

Theory

UNIT 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

ACSS-553 Physical Chemistry of Soils 2+0

Theory

UNIT I: Colloidal chemistry of inorganic and organic components of soils – their formation, clay organic interaction.

UNIT II: Predictive approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer.

UNIT III: Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction.

UNIT IV: Adsorption/desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

UNIT V: Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminium silicate, aluminium phosphate; electrochemical properties of clays (citation of examples from agricultural use).

ACSS- 554 Management of Problem Soils & Water 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; 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++ and Mg++) in ground water and soil samples

• Determination of anions (Cl-, SO4--, CO3-- and HCO3-) in ground waters and soil samples

• Lime and gypsum requirements of acid and sodic soils

3rd Semester

ACSS- 601 Soil. Water & Air Pollution 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 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

ACSS- 602 Analytical Techniques & Instrumental Methods in Soil & Plant Analysis 2+1

Theory

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.

4th Semester

ACSS- 651 Fertilizer Technology 1+0

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.

UNIT IV: New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, super granules fertilizers and fertilizers for specific crops/situations.