

Department of Agricultural Chemistry & Soil Science

M.Sc. Programme

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

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

Objective

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

ACSS- 503 Soil Chemistry

2+1

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 - 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, 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, 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, Micro organisms 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.

ACSS- 551 Soil Mineralogy, 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, aluminum silicate, aluminum 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^- , SO_4^{--} , CO_3^{--} and HCO_3^-) in ground waters and soil samples
- Lime and gypsum requirements of acid and sodic soils

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, behavior in soil and effect on soil microorganisms.

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

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.

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, supergranules fertilizers and fertilizers for specific crops/situations.

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
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes
- Determination of A, E and L values of soil using $^{32}\text{P}/^{65}\text{Zn}$
- Use of neutron probe for moisture determination
- Sample preparation and measurement of ^{15}N enrichment by mass spectrophotometry/ emission spectrometry

ACSS-702 Soil Genesis & Micropedology

2+0

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.

ACSS-703

Biochemistries of Soil Organic Matter

2+0

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.

ACSS-704 Advances in Soil Microbial Ecology

2+1

Ecological interrelationships- Biological, equilibrium, Microbiology of rhizosphere and phyllosphere, Microbial synthesis of polysaccharides and their effect on soil structure. Interaction

between soil particles and microorganisms at colloidal and aggregate level. Soil enzyme and their significance. Microbes in geochemical changes.

Introduction, systematic position of algae, classification of algae-their distinguishing characters, occurrence and economic importance. Prokaryotic algae-cyanophytes-general morphology and structure, cellular and thallus organization. Movement of blue green algae; gas vacuoles; cell differentiation, reproduction and life cycle of BGA. Classification of cyanophyte with their characteristics, abundance. Evolution and phylogeny-relationship of BGA with bacteria.

ACSS- 751 Geomorphology & Geochemistry 2+0

Theory

UNIT I: General introduction to geology and geochemistry, major and minor morphogenic and genetic landforms, study of schematic landforms and their elements with special reference to India.

UNIT II: Methodology of geomorphology, its agencies, erosion and weathering; soil and physiography relationships; erosion surface of soil landscape.

UNIT III: Geochemical classification of elements; geo-chemical aspects of weathering and migration of elements; geochemistry of major and micronutrients and trace elements.

ACSS- 752 Remote Sensing & GIS Techniques for Soil & Crop Studies 2+1

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 geostatistical 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

ACSS- 753 Advances in Soil Physics**2+0****Objective**

To provide knowledge of modern concepts in soil physics.

Theory

UNIT 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, soils 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.

ACSS-754 Advances in Soil Fertility**2+0****Theory**

UNIT 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.
