SYLLABUS: DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Course offered by Department of Soil Science and Agricultural Chemistry

Course No	Course Title	Credit	Semester
SSC-501*	Soil physics	2+1	I
SSC-502*	Soil fertility and fertilizer use	3+1	I
SSC-503 *	Soil chemistry	2+1	I
SSC-504*	Soil mineralogy, genesis, classification and survey	2+1	I
SSC-505*	Soil biology and biochemistry	3+1	I
SSC-506	Soil erosion and conservation	2+1	II
SSC-507	Radioisotopes in soil and plant studies	1+0	II
SSC-508	Soil, water and air pollution	2+1	II
SSC-509	Analytical techniques and instrumental Methods in soil and plant analysis	1+2	II
SSC-510	Chemistry of pesticides	1+1	II
SSC-511	Management of problem soils	2+1	III
SSC-512	Fertilizer technology	1+1	III
SSC-513	Land degradation and restoration	1+0	III
SSC- 591	Credit seminar	0+1	IV
SSC- 599	Master's Research (Thesis)	0+20	I to IV

*CORE COURSE

SSC-501 Soil physics (2+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on different aspects of soil physics like soil textural classes, particle size distribution analysis, specific surface, soil consistence; dispersion, soil compaction, soil strength, swelling, soil structure, soil aggregation, soil crusting, soil conditioners, soil water potential, soil water retention, movement, hydraulic conductivity, hydrologic cycle, field water balance, soil air, soil thermal properties etc

Syllabus:

Theory

Soil Physics as a branch of Soil Science, Soil as a three-phase system, volume and mass relationships of soil constituents. Soil texture, textural classes, particle size distribution analysis, specific surface. Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Soil structure - genesis, types, characterization and management of 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. 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. 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. Infiltration; internal drainage and

redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum. Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management. 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

Particle size distribution analysis by pipette and international methods; Measurement of Atterburg 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 characteristic 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.

Learning Outcome:

Students will acquire both theoretical and practical knowledge on various soil physical properties, their influence on plant growth, their management etc.

SSC-502 Soil fertility and fertilizer use (3+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on different aspects of soil fertility and fertilizer use like essential nutrient elements, chemistry and transformation of nutrient elements and their management, soil test methods and fertilizer recommendations, soil test crop response correlations and response functions, fertilizer use efficiency, site-specific nutrient management, plant need based nutrient management; integrated nutrient management, soil fertility evaluation techniques, soil quality etc.

Syllabus:

Theory

Soil fertility and soil productivity; factors affecting soil fertility; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms. Criteria of essentiality of elements in plant nutrition. Mitcherlich's equation, Spillman's equation and baule unit; essentials of plant growth. Chemistry and transformation of nutrient elements including micronutrients in soil and their role in plant nutrition-their sources, forms, retention behaviour and movement; correction of micronutrient deficiencies in plants. Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions. Principles of fertilizer application and residual effects of fertilizers and organic manures; Fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management. Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

Extraction and determination of available plant nutrients in soil; Soil fertility evaluation by chemical and biological methods; Analysis of plants for essential elements

Learning Outcome:

Students will acquire both theoretical and practical knowledge on various aspects of soil fertility, soil fertility management and fertilizer use.

SSC-503 Soil chemistry (2+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on different aspects of soil chemistry like soil water chemistry; dynamic nature of soil; thermodynamics, chemical equilibria, electrochemistry and chemical kinetics, soil colloids, surface charge characteristics of soils; fractionation of soil organic matter, clay-organic interactions, ion exchange processes in soil, cation, anion and ligand exchange, sorption-desorption, chemistry of acid soils, salt affected soils and their management, chemistry and electrochemistry of submerged soils etc.

Syllabus:

Theory

Modern concept of soil; Chemical (elemental) composition of the earth's crust and soils. Soil as a disperse system. Concept and importance of soil solution; chemistry of soil water; dynamic nature of soil; soil and plant nutrition. Thermodynamics, chemical equilibria, electrochemistry and chemical kinetics. 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. 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. Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity, soil acidity reclamation. Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments. 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 Ä (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 $BaCl_2$-TEA method; Determination of lime requirement of an acid soil by buffer method; Determination of gypsum requirement of an alkali soil

Learning Outcome:

Students will acquire theoretical and practical knowledge on various aspects of soil chemistry or different soil chemical properties.

SSC-504 Soil mineralogy, genesis, classification and survey (2+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on soil mineralogical properties, soil forming processes; weathering of rocks and mineral transformations; modern systems of soil classification, soil taxonomy; soil classification, soil survey techniques soil mapping, land capability classification etc.

Syllabus:

Theory

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism. 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. 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. 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. 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. Landform – soil relationship; major soil groups of India with special reference to West Bengal; 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- determination of soil texture by feel method, studies on soil structure, colour, pH (colorimetric method), consistence; Classification of soils using soil taxonomy; Grouping soils using available data base in terms of soil quality.

Learning Outcome:

Students will acquire theoretical and practical knowledge on genesis of soil, mineralogy of soil, classification of soil and soil survey techniques.

SSC-505 Soil biology and biochemistry (3+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on various aspects of soil biology and soil biochemistry like soil microbial ecology; soil microbial biomass; microbial interactions; phyllosphere; soil enzymes, biochemical composition and biodegradation of soil organic matter; humus formation, biogas and manures production

using organic wastes, preparation and preservation of farmyard manure, animal manures, compost, vermicompost., biofertilizers etc.

Syllabus:

Theory

Soil biota; soil microbial ecology; types of organisms in different soils; soil microbial biomass; microbial interactions; un-cultivable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes – origin, activities and importance; soil characteristics influencing growth and activity of microflora. Biochemical composition and biodegradation of soil organic matter, carbohydrates, protein, lipid and nucleic acids; humus formation; cycles of important organic nutrients. Organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers-definition, classification, specification, 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, N_2 fixation, S oxidation, P solubilization and mineralization of other micronutrients.

Learning Outcome:

Students will acquire theoretical and practical knowledge on various aspects of soil biology and soil chemical properties.

SSC-506 Soil erosion and conservation (2+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on soil erosion problems in India, forms/types, factors and effect of soil erosion; factors affecting water erosion; estimation of water erosion; types, mechanism and factors affecting wind erosion; various erosion control measures, soil conservation planning, watershed management, use of remote sensing in assessment and planning of watersheds etc.

Syllabus:

Theory

History, distribution, identification and description of soil erosion problems in India. 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. Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country. Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout. Soil conservation planning; land capability classification; soil conservation in special problem

areas such as hilly, arid and semi-arid regions, waterlogged and wet lands. Watershed management - concept, objectives and approach; water harvesting and recycling; run-off and flood control in watershed management areas; safe drainage of excess water; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; catchment and concentrate areas and their treatments for improving efficiencies; use of remote sensing in assessment and planning of watersheds.

Practical

Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, infiltration and run-off 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; Visits to areas having watersheds, water harvesting and erosion control structures.

Learning Outcome:

Students will acquire theoretical and practical knowledge on factors affecting soil erosion, types and mechanism of soil erosion, effect of soil erosion on plant growth and soil erosion control measures or techniques.

SSC-507 Radioisotopes in soil and plant studies (1+0)

Objectives:

The students are expected to gain knowledge on nature, properties and decay principles of radioisotopes and nuclear radiations; radiation monitoring, neutron moisture meter, mass spectrometry, auto radiography, isotopic dilution techniques for soil and plant research; use of stable isotopes etc.

Syllabus:

Theory

Atomic structure, radioactivity and units; radioisotopes - properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter. Principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography. 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. Doses of radiation exposure, radiation safety aspects, regulatory aspects, collection, storage and disposal of radioactive wastes

Learning Outcome:

Students will acquire knowledge on nature, properties and decay principles of radioisotopes and their use in soil, plant studies.

SSC-508 Soil, water and air pollution (2+1)

Objectives:

The students are expected to gain knowledge on nature, sources, extent of soil, water and air pollution; their effects on soil nutrients availability, plant and human health and their remediation/amelioration.

Syllabus:

Theory

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

Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal. Pesticides – their classification, behavior in soil and effect on soil microorganisms. Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health. Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide. 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

Learning Outcome:

Students will acquire knowledge on soil, water and air pollution; their effects on soil nutrients availability, plant and human health and their remediation/amelioration.

SSC-509 Analytical techniques and instrumental methods in soil and plant analysis (1+2)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on analytical techniques and instrumental methods used soil and plant analysis.

Syllabus:

Theory

Chemical analysis-concept of chemical analysis. Volumetric analysis-principles of acid-base titration, neutralization indicators; redox titration-permanganometry, dichrometry, iodometry, use of redox indicators; precipitation titration, argentometric titration, use of adsorption indicators; complexometric titration, metal ion indicators, concept of masking and demasking reactions. Principles of conductometry and potentiometric titrations. Principles of colorimetry, flame photometry, and atomic absorption spectrophotometry. Radiotracer technique and its methodology

Practical

Preparation of solutions for standard solutions; Titrimetric analysis- acid-base, redox, complexometric, potentiometric and precipitation titrations; Use of pH meter, conductivity meter, visible, ultraviolet and infrared spectrophotometer, atomic absorption spectrophotometer, flame-photometer; 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.

Learning Outcome:

Students will acquire knowledge on analytical techniques and instrumental methods used soil and plant analysis.

SSC-510 Chemistry of pesticides (1+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on various types of pesticides, their fate and behaviour in soil, plant and water bodies, impact of pesticide residues on environment, pesticide contamination of food, biodegradation of pesticides, effect of pesticides on microbial activity and so on.

Syllabus:

Theory

Classification of pesticides with respect to chemical composition, chemistry of some commonly used pesticides; Fate and behaviour of pesticides in soil, plant and water bodies. Pesticide residues and their impact on environment, pesticide contamination of food. Mineralization and metabolism of pesticides, bound pesticides. Effect of concentration on pesticide transport, retention and leaching. Biodegradation of pesticides, effect on microbial activity, microbial adaptation. Toxicological properties of pesticides and nutrient transformations, precautions in pesticide use. Biotechnology in pest management.

Practical

Estimation of active ingredients in different pesticides by chemical methods; Extraction, isolation and purification of pesticide residues on soil and plants. Techniques of GC and HPLC analysis of pesticide residues, Immuno asays, ELISA test.

Learning Outcome:

Students will acquire knowledge on chemistry of pesticides, their impact on environment, pesticide contamination of food, biodegradation of pesticides etc.

SSC-511. Management of problem soils (2+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on area, distribution, characteristic, impact on plant growth and reclamation/management of various problem soils like saline, sodic, saline-sodic, acid soil and others.

Syllabus:

Theory

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

Morphological features of saline and saline-sodic soils; characterization of salt-affected soils; soluble salts, ESP, pH; physical, chemical and microbiological properties; Management of salt-affected soils; quality of irrigation water; salt balance under irrigation; characterization

of brackish waters, area and extent; relationship in water use and quality; management of brackish water for irrigation. Salt tolerance of crops- mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dryland soils. Acid soils- nature of soil acidity, sources of soil acidity; effect on plant growth; lime requirement of acid soils; management of acid soils. Agronomic practices in relation to problem soils; cropping pattern for utilizing poor quality ground waters.

Practical

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

Learning Outcome:

Students will acquire knowledge on various problem soils and their reclamation and management.

SSC-512 Fertilizer technology (1+1)

Objectives:

The students are expected to gain theoretical as well as practical knowledge on manufacturing process for different fertilizers, secondary and micronutrient fertilizers, quality control of fertilizers, production of slow release fertilizers, super granules fertilizers, fertilizer control order etc.

Syllabus:

Theory

Fertilizers- production, consumption and future projects with regard to nutrient use in the country and respective states: fertilizer control order. Manufacturing process for different fertilizers using various raw materials, characteristics and nutrient contents. Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order. 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.

Practical

Identification of fertilizers. Nutrient contents in nitrogenous, phosphatic and potassic fertilizers. Determination of biureate content in urea.

Learning Outcome:

Students will acquire knowledge on manufacture, nutrient content and use of various fertilizers, slow release fertilizers, fertilizer control order etc.

SSC-513 Land degradation and restoration (1+0)

Objectives:

The students are expected to gain knowledge on different type, factors and processes of land degradation, its impact on soil productivity and restoration of land degradation.

Syllabus:

Theory

Type, factors and processes of soil/land degradation and its impact on soil productivity, including soil fauna; biodegradation and environment. Land restoration and conservation techniques- erosion control, reclamation of salt-affected soils, mine land reclamation, afforestation, organic products. Extent, diagnosis and mapping of conventional and modern RS-GIS tools, monitoring land degradation by fast assessment, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Learning Outcome:

Students will acquire knowledge on land degradation processes, factors, its impact and its restoration.