

## **Courses Catered by the Department of Agricultural Chemistry and Soil Science in Ph. D. Programme of Soil Science**

<b>Semester</b>	<b>Course No.</b>	<b>Name of the course</b>	<b>Credits</b>
1 <sup>st</sup> Semester	SOIL601	Recent trends in soil physics	2+0
	SOIL602	Modern concept in soil fertility	2+0
	* SOIL603	Physical chemistry of soil	2+0
	* SOIL604	Soil genesis and micromorphology	2+0
	SOIL 605	Biochemistry of soil organic matter	2+0
2 <sup>nd</sup> Semester	SOIL606	Soil resource management	3+0
	SOIL608	Clay mineralogy	2+1
	SOIL609	Recent trends in soil microbial biodiversity	2+1
	SOIL 691	Doctoral Seminar (ORW)	1+0
6 <sup>th</sup> Semester	SOIL 692	Doctoral Seminar (Thesis)	1+0
	SOIL 699	Doctoral Research	75

- **Core courses**

### **Recent Trends in Soil Physics : Soil 601 ( 2+0)**

#### **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, soil-plant-atmospheric continuum (SPAC).

##### Unit II

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

### 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 heatflow, measurement of thermal conductivity of soil; Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.

### Unit VI

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

### Unit VII

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

## **Modern Concept in Soil Fertility : Soil 602 (2+0)**

### **Theory**

#### Unit I

Nutrient availability-concept and relationships, modern concepts of nutrient availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, 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 nutrients in soils, particularly in submerged soils; Kinetic studies of nutrients in 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 manorial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

## Unit VII

Carbon—a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.

## **Physical Chemistry of Soil : Soil 603 (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; Climate change effects on mineralogy and surface properties of variable charge; 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, ironoxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

## **Soil Genesis and Micromorphology : Soil 604 (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.

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### **Biochemistry of Soil Organic Matter : Soil 605 (2+0)**

#### **Theory**

##### Unit I

Organic matter in soils and its maintenance Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration.

##### 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.

### **Soil Resource Management: Soil 606 (3+0)**

#### **Theory**

##### Unit I

Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, gene reserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases.

##### Unit II

Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

### Unit III

Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diaralands. Management of forest, peat and muck soils.

### Unit IV

Soil conservation planning; land capability classification; soil conservation in special problem are as such as hilly, arid and semi-arid regions, waterlogged and wetlands; land restoration and conservation techniques–erosion control, reclamation of saltaffected soils; mine land reclamation, afforestation, organic products, soil faunaand biodegradation.

### Unit V

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

### Unit VI

Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

## **Clay Mineralogy : Soil 608 (2+1)**

### **Theory**

#### Unit I

Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations, crystal systems.

## Unit II

Structures and classification of silicate minerals, basics of phyllosilicates, laws governing structural characteristics of phyllosilicates, Goldschmidt's laws – Laws I and Law II, Classification of Phyllosilicates.

## Unit III

Kaolinite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins.

## Unit IV

Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann-Marshall-Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils.

## Unit V

Micas: occurrence and origin in soils, polytypes of micas, structure and formation of muscovites and illite.

## Unit VI

Vermiculites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite.

## Unit VII

Chlorite: occurrence and structure of chlorites, "swelling chlorites", formation of chlorite.

## Unit VIII

Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties.

## Unit IX

Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

## Unit X

Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

## Unit XI

Surface chemistry of clay minerals, clay-organic complexes, nanoclay mineralogy.

## Unit XII

Clay minerals in different soil orders, role of clay minerals in soil fertility management.

## Practicals

- Separation of clay for mineralogical study
- X-ray diffraction analysis of clay
- Selective dissolution of clay minerals
- IR, DTA and SEM of clay minerals
- Identification and quantification of clay minerals

- Determination of surface charge of clay minerals
- Potentiometric titration of clay minerals.
- Wilding LP and Smeck NE. 1983. Pedogenesis and Soil Taxonomy Part II – Soil Orders.

## **Recent Trends in Soil Microbial Biodiversity : Soil 609 (2+1)**

### **Theory**

#### Unit I

Microbial evaluation and biodiversity, Microbial communities in ecosystems, Newinsights in below ground diverse of plant performance.

#### Unit II

Qualitative ecology of microorganisms; Biomass and activities.

#### Unit III

Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterising N fixing microorganisms.

#### Unit IV

Serology and molecular characterization, ecological aspects of bio determination, soil waste and water management

#### Unit V

Biodegradability, testing and monitoring of the bioremediation of pollutants and bacterial fertilizers.

### **Practicals**

- Determination of soil microbes using classical techniques.
- Determination of soil microbial diversity using molecular techniques.
- Estimation of soil microbial biomass carbon, nitrogen and phosphorus.
- Estimation of key soil enzyme activities.
- Community level physiological profiling of microbial diversity