



**UNIVERSITY OF SARGODHA  
OFFICE OF THE REGISTRAR  
(ACAD BRANCH)**

**NOTIFICATION**

On the recommendations of Academic Council made in its 21<sup>st</sup> (2/2024) meeting held on 07.06.2024, the Syndicate in its 67<sup>th</sup> (3/2024) meeting held on 12.07.2024 approved revised curricula of following programs for implementation w.e.f. Fall 2024:

- |     |                              |             |
|-----|------------------------------|-------------|
| i.  | M.Sc (Hons.) in Soil Science | (Annex-'A') |
| ii. | Ph.D in Soil Science         | (Annex-'B') |

  
(WAQAR AHMAD)  
Additional Registrar (General)

No. SU/Acad/24/769

Dated: 03.10.2024

**Distribution:**

- Chairman, Department of Soil and Environmental Sciences
- Controller of Examinations
- Director Academics

**C.C:**

- Dean, Faculty of Agriculture
- Principal, College of Agriculture
- Director, QEC
- Secretary to the Vice-Chancellor
- PA to Registrar
- Notification File

Annex-'A'

**CURRICULUM  
FOR THE DEGREE OF M.Sc. (Hons.) SOIL SCIENCE**



**Implementation w.e.f. Fall Semester, 2024**

**DEPARTMENT OF SOIL & ENVIRONMENTAL SCIENCES  
COLLEGE OF AGRICULTURE  
UNIVERSITY OF SARGODHA**

*W. Shear*

Chairman  
Department of Soil & Environmental  
Sciences, College of Agriculture,  
University of Sargodha, Sargodha

## Nomenclature of the Program: M.Sc. (Hons.) Soil Science

### 1. Department Brief

The Department of Soil & Environmental Sciences, College of Agriculture, Faculty of Agriculture, University of Sargodha, Sargodha, was established in 2012. The Department aims to deliver state of the art education mainly focusing on development of trained and skilled human resource in various fields of Soil & Environmental Sciences through quality teaching and research. Department of Soil & Environmental Sciences is developing and fostering innovative research and teaching programs keeping in view the changing needs of the society and the environment. It has five 05 faculty members. (02 Professors, 01 Associate Professor and 02 Assistant Professors). The Department has produced to-date 318 students of B.Sc. (Hons.), 105 M.Sc. (Hons.) and 07 PhD. The Department has state-of-the-art 02 labs, equipped with advanced equipment together with vast research area and screen-house facilities.

### 2. The Aim

The principal aim of the graduate and post-graduate degree programs in the discipline of Soil Science is to develop a highly skilled and well-developed human resource capable of addressing the growing challenges in the field of Soil & Environmental Sciences. These challenges are the result of different anthropogenic activities for the global transition towards an advanced society. The programs focus on providing a comprehensive training and advanced knowledge in the field of Soil Science to enabling the graduates to contribute efficiently and effectively to appropriate agricultural practices, environmental conservation and resource management. By integrating cutting-edge research, practical application and interdisciplinary approaches, the program aims to produce expert who can innovate and implement solution to the issues related to Soil & Environmental Sciences, thereby supporting the sustainability of ecosystem and communities in the world.

### 3. The Scope

Soil Science, as an interdisciplinary field of knowledge, encompasses programs with broad, multidisciplinary scope. These programs are designed to equip graduates with the skills and knowledge needed to address the complex challenges associated with maintaining environmental integrity while promoting sustainable development in relation to human activities. Through a comprehensive curriculum that integrates principles from biology, chemistry, geology, and environmental science, students will learn to analyze and manage soil resources effectively. They will gain expertise in soil conservation, fertility, soil physics, soil chemistry, soil microbiology and biochemistry as well as in the mitigation of soil related environmental issues. Furthermore, the programs emphasize the importance of sustainable land use practices, ecosystem services, and the impact of human activities on soil quality. By fostering a deep understanding of these interconnected systems, graduates will be prepared to develop innovative solutions that balance environmental sustainability with the needs of a growing global population, ultimately contributing to the preservation and enhancement of our natural resources.

### 4. Teaching Objectives

The teaching objectives of the degree programs in Soil Science are to enable its graduates with following key skills:

- Learn how to analyze and assess soil problems.
- Carry out independent scientific and technical research on soil and environmental issues.
- Propose sustainable solutions for soil problems.

### 5. Learning Objectives

The degree programs are designed to equip graduates with a comprehensive understanding of the complex interrelations between various biophysical and socioeconomic components of the



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environment. These programs aim to provide the students with the knowledge and skills necessary to analyze and address the multifaceted challenges facing our world today. Graduates will be expected to:

1. Develop a deep understanding of the intricate linkages within and between biophysical and socioeconomic systems. This includes an appreciation of the principles and requirements that facilitate the transition to sustainability within these interconnected systems.
2. Apply theoretical understanding, professional judgment, and practical skills to mitigate environmental problems effectively.
3. Formulate and implement solutions to the problems of sustainable development by utilizing their analytical skills and theoretical knowledge. They will be adept at designing and executing strategies that promote sustainability, balancing environmental, economic, and social considerations.
4. Make meaningful contributions to improving legal and administrative structures and processes relevant to sustainable development and environmental management. This involves engaging with policy-making, regulatory frameworks, and governance structures to ensure that sustainability principles are integrated into decision-making processes at all levels.

#### **6. Rationale**

The discipline of Soil Science is perceived as the systematic study of the complex and dynamic interactions within the natural world, focusing on understanding our proper place within these systems and how can we address critical issues related to socio-economic development. This field draws on principles from various disciplines of natural sciences, including biology, chemistry, physics, geology, and environmental science, to provide a comprehensive understanding of soil properties, processes, and functions. By examining the intricate relationships between soil and other environmental components, Soil Science helps us to understand how soil health and management impact agricultural productivity, ecosystem services, and overall environmental sustainability.

Through this multidisciplinary approach, Soil Science aims to develop strategies for managing soil resources sustainably, ensuring food security, and mitigating environmental degradation. It also explores the role of soils in climate regulation, water filtration, and nutrient cycling, which are vital for maintaining ecosystem health. By addressing these fundamental aspects, the discipline provides valuable insights into how can we achieve socio-economic development goals while preserving and enhancing the natural environment. In essence, Soil Science equips us with the knowledge and tools needed to make informed decisions that balance human needs with environmental stewardship, fostering a sustainable future for generations to come.

#### **7. Program Learning Objectives**

1. To empower students of M.Sc. (Hons.) Soil Science to know/apply protocols and procedures of science to resolve soil related issues of local farmers in specific and international in general
2. To polish critical thinking of students and making them skillful to grasp good careers in government/private sectors both inter-/or -nationally.
3. Further, to enable students to conduct novel researches independently, with limited resources from their supervisors, and to guide them to be skillful in technical writing for writing research articles in refereed reputed journals.
4. To make them leaders in Soil Science and sister disciplines both inter- and -nationally.



## 8. Program Structure

<b>Duration</b>	Minimum 1.5-Years (3-Semesters), Maximum 4-Years (8-Semesters)	
<b>Entry Requirements:</b>	Candidates having minimum CGPA 2.0/4.0 in BS (4-Years)/B.Sc. (Hons.) etc. degree (16 years of education) in semester system in <u>Soil Science</u> subject from HEC recognized Institutions.	
<b>Intra-disciplinary fields allowed for admission</b>	BS/B.Sc. (Hons.) in Agronomy, Plant Breeding and Genetics, Entomology, Horticulture, Forestry, Plant Pathology, Agricultural Extension, Agricultural Economics OR BS Environmental Sciences	
<b>Degree Completion Requirements:</b>	Total Credit Hours of Course Work:	24-33
	Total Credit Hours of Thesis/Courses in Lieu of thesis:	06
	Total Credit Hours of Program:	30-39
<b>Degree Completion Requirements:</b>	Total Credit Hours of Course Work:	24
	Total Credit Hours of Thesis:	06
	Total Credit Hours of Program:	30
	<i>In case of interdisciplinary admission:</i>	
	Total Credit Hours of Course Work:	24
	Total Credit Hours of Thesis:	06
	Minimum Credit Hours of deficiency Courses:	09
	Total Credit Hours of Program:	39
	Note: Deficiency courses will be offered from B.Sc. (Hons.) Soil Science courses as per decision of the Department.	
<b>Program Mode (select one)</b>	I. Thesis Track II. Coursework Track	
<b>Specialization (if any)</b>	Not Applicable	



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DEPARTMENT OF SOIL & ENVIRONMENTAL SCIENCES  
Faculty of Agriculture  
M.Sc. (Hons) Soil Science

**Semester-I**

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-1*	SAES-68xx	To be selected from list	3(2-1)	
Compulsory-1	SAES-71xx	To be selected from list	3(2-1)/ 1(0-3)	
Compulsory-2	SAES-71xx	To be selected from list	3(2-1)/ 3(0-3)	
Elective-1	SAES-71xx	To be selected from list	3(2-1)/ 3(0-3)	
Elective-2	SAES-71xx	To be selected from list	3(2-1)/ 3(0-3)	

Semester Credit Hours: 12-15

**Semester-II**

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-2*	SAES-68xx	To be selected from list	3(2-1)	
Compulsory-3	SAES-71xx	To be selected from list	3(2-1) 3(0-3)	
Compulsory-4	SAES-7109	Special Problem	1(1+0)	
Compulsory-5	STAT-7151	Statistical Methods for Agricultural Research-1	3(3-0)	
Elective-2	SAES-71xx	To be selected from list	3(2-1)/ 3(0-3)	

Semester Credit Hours: 10-13

**Semester-III**

Category	Course Code	Course Title	Credit Hours	Pre- Requisite
Deficiency-3**	SAES-68xx	To be selected from list	3(2-1)	
Compulsory-6	SAES-7110	Seminar	1(1-0)	
Elective-2	SAES-71xx	To be selected from list	3(2-1)/ 3(0-3)	

\*For intra-disciplinary admitted candidates only

Semester Credit Hours: 11

**Semester-IV**

Research & Thesis

Semester Credit Hours: 6

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### List of Compulsory Courses

Course Code	Course Title	Credit Hours
SAES-7101	Principles and Uses of Laboratory Equipment	3(0-3)
SAES-7102	Soil Chemistry	3(2-1)
SAES-7109	Special Problem	1(1-0)
SAES-7110	Seminar	1(1-0)
SAES-7103	Soil Fertility and Plant Nutrition	3(2-1)
SAES-7104	Soil Microbiology and Biochemistry	3(2-1)
SAES-7151	Statistical Methods for Agricultural Research-I	3(2-1)

### List of Elective Courses

Course Code	Course Title	Credit Hours
SAES-7107	Soil Physics	3(2-1)
SAES-7105	Soil Classification	3(2-1)
SAES-7106	Salt-Affected and Waterlogged Soils	3(3-0)
SAES-7108	Soil Mineralogy	3(3-0)
SAES-7111	Soil - Plant Relationship	3(3-0)
SAES-7112	Principles and Applications of Bioremediation	3(3-0)
SAES-7113	Soil Ecology	3(3-0)

### List of Deficiency Courses

Course Code	Course Title	Credit Hours
SAES-6803	Physical Properties of Soil	3(2-1)
SAES-6804	Chemical Properties of Soil	3(2-1)
SAES-6806	Soil Genesis and Morphology	3(2-1)
SAES-6810	Soil Fertility and Fertilizer Use	3(2-1)
SAES-6812	Salt-Affected Soils and Water Quality	3(2-1)
SAES-6815	Soil Microbiology	3(2-1)

#### Note:

- I. Mandatory and elective courses will be decided from the above lists, respectively, by the Department at the start of every semester following current HEC graduate policy and UoS graduate rules and regulations 2023.
- II. The Regulations related to MS/M.Phil. /M.Sc.(Hons) or equivalent approved by the Syndicate from time to time shall also be applicable.
- III. Deficiency Courses are to be decided by Graduate Program Committee in start of each session.
- IV. Department can change the order of Core/Compulsory and Elective Courses as per availability of resources or demand.
- V. Department can change the course offering as per available resources but shall be uniform for one session.



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**SCHEME OF STUDIES**  
**LIST OF M.Sc. (HONS) COURSES IN SOIL SCIENCE**

Course Code	Title of the Course	Credit Hours
SAES-7101	Principles and Uses of Laboratory Equipment	3(0-3)
SAES-7102	Soil Chemistry	3(2-1)
SAES-7103	Soil Fertility and Plant Nutrition	3(2-1)
SAES-7104	Soil Microbiology and Biochemistry	3(2-1)
SAES-7105	Soil Classification	3(2-1)
SAES-7106	Salt-Affected and Waterlogged Soils	3(3-0)
SAES-7107	Soil Physics	3(2-1)
SAES-7108	Soil Mineralogy	3(3-0)
SAES-7109	Special Problem	1(1-0)
SAES-7110	Seminar	1(1-0)
SAES-7111	Soil - Plant Relationship	3(3-0)
SAES-7112	Principles and Applications of Bioremediation	3(3-0)
SAES-7113	Soil Ecology	3(3-0)
STAT-7151	Statistical Methods for Agricultural Research-I	3(3-0)



## Course Contents

### SAES-7101 Principles and Uses of Laboratory Equipments

3(0-3)

The aim of this course is basically to develop understanding of the students about the use and handling of modern laboratory equipments. Students will be able to collect soil, plant, water and fertilizer samples accurately. The precise working in the laboratory regarding solution preparation and safety measures will also be taught to the students. The students will be able to use laboratory instruments, and collect, handle, and analyze soil and plant samples. It provides information to the soil science students about safety measures in laboratory, storage and disposal of chemicals. This course also helpful for all students to better understanding about instruments that are frequently used in research instruments of Pakistan.

#### *Contents*

1. Quality management, assurance and control measures
2. Analytical errors, analysis and control
3. Development of standard operating procedures
4. Use of basic laboratory equipment:
  - 4.1 Spectrophotometer: UV and visible range
  - 4.2 Flame photometer
  - 4.3 Atomic absorption spectrophotometer
  - 4.4 Ion meter: selective ion electrodes
  - 4.5 EM-38 and EC probe
5. Introduction, principles and usage of specialized equipment:
  - 5.1 Inductively coupled plasma meter and direct current plasma meter
  - 5.2 Chromatography: GC and HPLC
  - 5.3 Microscopy: Scanning and transmission
  - 5.4 X-ray diffractometry
  - 5.5 Mass spectrophotometry
  - 5.6 Electro Ultra Filtration
  - 5.7 Neutron moisture probe/time domain reflectometry (TDR)
  - 5.8 Oxygen diffusion rate meter
  - 5.9 Thermocycler PCR (polymerase chain reaction)
  - 5.10 Gel electrophoresis apparatus
6. Elements of analytical report writing

#### *Recommended Books*

1. DeLevie. *Quantitative Chemical Analysis*. (McGraw-Hill Co. Inc. New York, USA, 1997).
2. Harris. (7<sup>th</sup> ed.). *Quantitative Chemical Analysis*. (W. H. Freeman & Co. NY, USA, 2006).

#### *Suggested Books*

1. Pansu and Gautheyrou. *Handbook of soil analysis: mineralogical, organic and inorganic methods*. (Springer Science & Business Media, 2007).
2. Smith and Cresser. (3<sup>rd</sup> ed.). *Soil and Environmental Analysis: Modern Instrumental Techniques*. (Marcel & Dekker, Inc., USA, 2004).
3. Spark, D.L. (ed.) *Methods of Soil Analysis: Chemical Methods*. (SSSA, ASA Series No.5, Madison, WI, USA, 1996).



Learning of this course, understand the basic rules of soil chemical reactions. As soil chemistry is youngest branch of soil science, understanding the chemistry, explaining and illustrating the issues of soil formation and nutrient availability. This course also aims at modern soil chemistry level given information's about soil plasma and soil matrix. The soil chemistry also defines the chemical nature of mineral and rocks by which we understand the soil charge development and at environmental site learn the issues of organic and inorganic contaminates entry into earth ecosystem.

### Contents

#### Theory

1. Chemical equilibria in soil, water and solute interactions
2. Soil solution-solid interaction
3. Mineral dissolution: congruent and incongruent
4. Neo-formation of minerals in soil
5. Thermodynamics and applications in soil
6. Organic matter: composition and fractionation
7. Surface chemistry of soil matrix
8. Sorption and desorption models
9. Ion exchange: selectivity coefficients, equivalent fraction concept
  - 9.1 Hysteresis in ion exchange
  - 9.2 Anion exclusion
  - 9.3 Complementation effect
  - 9.4 Zeta potential
10. Reactions of metal chelates in soils
11. Chemical behavior of ions / elements in aerated and submerged soils
12. Buffering reactions in soil
13. Chemical remediation of contaminated soils and water

#### Practical

1. Determination of CEC and base saturation
2. Developing K vs Ca + Mg activity ratios in laboratory
3. Determination of phosphorous adsorption isotherm
4. Comparative fit (data from 3) to Freundlich and Langmuir models
5. Developing titration curves

#### Recommended Books

1. Bohn, McNeal and Connor. (3<sup>rd</sup> ed.). *Soil Chemistry*. (John Wiley & Sons Inc., NY, USA, 2001).
2. Essington. *Soil and Water Chemistry*. (CRC Press, Boca Raton, FL, USA, 2004).

#### Suggested Books

1. McBride. *Environmental Chemistry of soils*. (Oxford University Press, 1994).
2. Sparks. (2<sup>nd</sup> ed.). *Environmental Soil Chemistry*. (Academic Press, San Diego, CA, USA, 2003).
3. Sposito. (2<sup>nd</sup> ed.). *The Chemistry of Soils*. (Oxford University Press, NY, USA, 2003).



The aim of this course is basically to develop understanding of the students about the soil fertility and its impact on the productivity of crops. The course will be guided the stakeholders to maintain the soil fertility from natural and synthetic sources. The precise learning of this course will enable the students to achieve these tasks successfully. The students will be able to diagnose deficiency and toxicity symptoms of different nutrients on plants. It is evident that for optimum crop productivity the soil nutrient status, i.e. the fertility of the soil should be maintained by appropriate and efficient nutrient management. In the twenty-first century, the importance of this field is expected to increase due to limited natural resources (land and water), the need for more sustainable agricultural systems, and concern about environmental pollution.

### Contents

1. Basic soil-plant-relationship in plant nutrition
2. Plant nutrient behavior in soils
3. Nutrient behavior in submerged soils
4. Soil fertility evaluation: soil test calibration and plant analysis
  - 4.1 External and internal nutrient requirements
5. Fertilizer management strategies: nutrient availability and fertilizer use efficiency
  - 5.1 Fertigation and foliar fertilization
  - 5.2 Integrated plant nutrient management (IPNM)
  - 5.3 Variable rate fertilizer technology
6. Nutrient-water and other interactions
7. Specific effects of fertilizers: plant, human and animal health
8. Environmental implications of fertilizer use

### Practical

1. Soil and plant analysis for NPK
2. Interpretation of soil and plant analysis results
3. Create and learn deficiency symptoms of nutrients

### Recommended Books

1. Ahmad and Rashid. *Fertilizers and their use in Pakistan: An extension guide*. (Planning Commission, NFDC, Islamabad, Pakistan, 2003).
2. Barker and Pilbeam. *Handbook of Plant Nutrition*. (CRC Press, Boca Raton, FL, USA, 2007).
3. Bhatti. *Spatial Variability & its Management in Agriculture*. (Higher Education Commission, Islamabad, Pakistan, 2005).

### Suggested Books

1. Elsworth and Relay (eds.) *Fertilizers: Properties, Applications and Effects*. (Nova Science, Publ. Inc. NY, USA, 2009).
2. Havlin, Tisdale, Nelson and Beaton. (8<sup>th</sup> ed.). *Soil Fertility and Fertilizers: An Introduction to Nutrient Management*. (Pearson Education, Prentice Hall, Upper Saddle River, NJ, USA, 2013).
3. Mengel and Kirkby. (5<sup>th</sup> ed.) *Principles of Plant Nutrition* (International Potash Inst., Bern, Switzerland, 2001).



Microbial mediated transformation of elements in soil, bioremediation and biotechnological approaches are discussed. The students should be able to understand and apply microbiological approaches for crop production and to safeguard the environment. Kinds and significance of microorganisms present in soil and their role in crop productivity and environmental quality are also discussed. The students should be able to recognize different microbes, their functions in nutrient transformations under different conditions and their relationships with crops and environment. At the end of the course students will be able to have better understanding with different nutrient availability mechanisms like mineralization and immobilization.

### Contents

1. Rhizosphere: plant-microbes and microbe-microbe interactions
2. Microbial cycling of elements: macro and micronutrients and heavy metals; agricultural and environmental significance
3. Biochemistry and biotechnology of BNF; application in agriculture and environment
4. Mycorrhizal symbiosis
5. Plant growth regulators, phytotoxins and siderophores: microbiology and biochemistry
6. Composting: microbiology and biotechnology; agricultural and environmental application
7. Microbial metabolism
8. Bioremediation of contaminated soils: biodegradation and detoxification
9. Use of stable isotopes in microbiological research
10. Metabolic and nucleic acid based analysis of soil microbial diversity
11. Bio-fertilizers: present and future prospects

### Practical

1. Isolation of bacteria, actinomycetes and fungi
2. Enrichment techniques
3. Organic matter decomposition rates and C: N ratio effect
4. Inoculation techniques
5. Biological N<sub>2</sub> fixation measurement techniques

### Recommended Books

1. Barton and Northup. *Microbial Ecology*. (John Wiley & Sons, Inc., Hoboken, New Jersey, US, 2011).
2. González, M.B.R. and J. González-López. *Beneficial Plant-microbial Interactions- Ecology and Applications* (CRC Press, Taylor & Francis, Boca Raton, FL, 2014).

### Suggested Books

1. Khan, Zaidi, and Musarrat (eds.). *Microbial Strategies for Crop Improvement*. (Springer, NY, USA, 2009).
2. Maier, Pepper and Gerba. (2<sup>nd</sup> ed.). *Environmental Microbiology*. (Academic Press Inc., San Diego, CA, USA, 2009).
3. Paul, E.A. (3<sup>rd</sup> ed.). *Soil Microbiology, Ecology and Biochemistry*. (Elsevier, Oxford, UK, 2007)



## SAES-7105 Soil Classification

3(2-1)

The course is aimed to develop relation among different soil categories and their importance for particular use. The students should be able to classify soils and devise strategic and efficient land use. The students will be able to understand and describe morphological features and taxonomic relations of different soils. soil genesis, with special reference to the soil-forming factors responsible for development of the solum. or true soil, time, parent material, topography, climate and organisms. The students will know how the properties of soils affect their uses, and be able to evaluate alternative treatments, amendments and/or location of different uses of soil/substrate. Students will be able to effectively sample and describe soils. Students will appreciate the importance of soils to human civilization and survival.

### Contents

#### Theory

1. Concepts and importance
2. Introduction to soil taxonomy
3. Criteria of classification
4. Properties diagnostic to categories
5. Diagnostic horizons and other diagnostic properties
6. Soil moisture regimes: Classes and importance
7. Soil temperature regimes: Classes and importance
8. Categories and nomenclature
9. Keys to categories: Order, suborder, great group and sub group FAO and other systems of classification
10. Agro ecological zones and soils of Pakistan

#### Practical

1. Profile description representing important soil orders
2. Classify research farm soil to sub group level.
3. Designation of genetic horizons found in Pakistan.
4. Identification of taxonomic names: orders, suborders, great groups, subgroups, families and series

#### Recommended Books

1. Buol, Southard, Graham and McDaniel. (2<sup>nd</sup> ed.). *Soil Genesis and Classifications*. (CRC Press, Boca Raton, FL, USA, 2003).
2. Bhatti. *Spatial Variability & its Management in Agriculture*. (Higher Education Commission, Islamabad, Pakistan, 2005).

#### Suggested Book

1. FAO. *World Reference Base for Soil Resources*. (FAO, Rome, Italy, 1998).
2. Soil Survey Division Staff. *Soil Survey Manual*. (USDA, Washington DC, USA, 2005).
3. Soil Survey Staff. (11<sup>th</sup> ed.). *Keys to Soil Taxonomy*. (USDA, Washington DC, USA, 2011).



This course will create awareness among the students about the problems, reclamation and management of salt-affected soils. This course also aims at understanding the problems of irrigation waters and strategic treatment/management options about the sustainable and safe use of such low quality waters in agriculture. In addition, the students will be equipped with pre-requisite knowledge and skills necessary to become a good researcher. This course will create awareness among the students about the problems, reclamation and management of salt-affected and water logged soils. In addition, the students will be equipped with pre-requisite knowledge and skills necessary to become a good researcher. This will in turn help develop research aptitude among the post graduates which will go long way in their practical carrier.

### Contents

#### Theory

1. Salt-affected and waterlogged soils in Pakistan and global perspective
2. Genesis of saline and sodic soils
3. Classification systems of salt-affected soils
4. Effects of salinity and sodicity on soil characteristics
5. Derivation and applications of Gapon equation
6. Plant responses to saline and sodic conditions
7. Amelioration strategies and economic feasibility for salt-affected soils
8. Water requirements for reclamation
9. Concept of leaching fraction and its applications
10. Soil waterlogging
  - 10.1. Causes
  - 10.2. Soil and plant responses
  - 10.3. Amelioration strategies
11. Environmental and economic impacts of salinity and waterlogging

#### Recommended Books

1. Ghafoor, Qadir and Murtaza. *Salt-Affected Soils: Principles of Management*. (Allied Book Centre, Urdu Bazar, Lahore, Pakistan, 2004).
2. Maliwal and Somani. *Nature, Properties and Management of Saline and Alkali Soils*. (Agrotech Publishing Academy, Udaipur, India, 2010).

#### Suggested Books

1. Pessarakli (3<sup>rd</sup> ed.). *Hand Book of Plant and Crop Stress*. (Marcel & Dekker Inc., NY, USA, 2010).
2. Pierzynski, Sims and Vance. *Soils and Environmental Quality*. (CRC Press, Boca Raton, FL, USA, 2000).
3. Schjonning, Elmholt and Christensen. *Managing Soil Quality Challenges in Modern Agriculture* (CABI Publisher Cambridge, MA, USA, 2004).



Physical processes of water, air, heat and pollutants movement in soil and their management are taught. The students should be able to understand soil physical conditions for optimal plant growth. The aim of this course is basically to develop understanding of the students about physical properties of soils and apply their knowledge for solving physical degradation problems. This course will also help in understanding the behavior of soil physical properties in supporting the crop growth and engineering uses. At completion of course, the students will become able to understanding the importance of physical properties of soil in crop growth and its use for engineering purposes, the role of different tillage practices in crop growth and in management of water and soil, identify important problems regarding different soil physical properties and identify management practices regarding physical degradation of soil.

#### Contents

1. Soil physical properties and inter-relationships
2. Nature and physical behavior of clay and clay minerals
3. Properties of water: Molecular, fluid and colligative
4. Soil water potential and its components
5. Measurement of water in soil
6. Water characteristics curves: Hysteresis
7. Saturated and unsaturated water flow
8. Infiltration models: Horton, Kostiakov, Green and Ampt, and Philip's
  - 8.1 Flow in capillary tubes: Poiseuilles' law
  - 8.2 Extended Darcy's law and its application
  - 8.3 Richards equations for transient water flow
9. Free and artificial drainage: Drainage design equations
10. Heat flow in soil: Thermal properties: Factor affecting; heat flow equations
11. Transport of gases and water vapors through soil
12. Solute transport in soil: Solute conservation and convection-dispersion equation
  - 12.1 Miscible displacement and breakthrough curves
  - 12.2 Transport of inert, non-adsorbing and adsorbing chemicals in soil
  - 12.3 Volatile organic compounds transport in soil
13. Estimation of crop water requirement

#### Practical

1. Measurement of soil water, soil strength, particle density, soil water characteristic curves, infiltration rate and saturated hydraulic conductivity
2. Problem sets

#### Recommended Books

1. Hillel, *Environmental Soil Physics*, Elsevier Academic Press, San Diego, CA, USA, 1998).
2. Hillel, *Introduction to Environmental Soil Physics*, (Elsevier Academic Press, San Diego, CA, USA, 2004).

#### Suggested Books

1. Hillel, *Soil in the Environment: Crucible of Terrestrial Life* (Elsevier Inc., Burlington, MA, USA, 2008)
2. Jury and Horton, (5<sup>th</sup> ed.), *Soil Physics*, (John Wiley & Sons, Inc., NY, USA, 2004).
3. Marshall, Holmes and Rose, (3<sup>rd</sup> ed.), *Soil Physics*, (Cambridge Uni. Press, UK, 1996).



Soil mineralogy is concerned with the inorganic minerals found in the pedosphere and to the depth of weathering. The study of formation, occurrence, properties, composition and classification of minerals present in soil is called soil mineralogy. A knowledge of Soil Mineralogy gives the students an understanding of the nature and properties of soil which provides the basis for the existence of life. Such knowledge enables them to understand many facets of land use including misuse and is often a key to solving specific environmental problems, and to conserve the soil for future generation. At the end of the course, the students will also be able to understand that how minerals greatly influence physical properties, exert a strong influence on chemical processes, and affect soil fertility and productivity through release of and reactions with plant nutrients.

#### Contents

1. Concept and significance
2. Chemical and structural classification of soil minerals
3. Carbonate, sulphate, sulphide and phosphate minerals
4. Oxides and hydroxide of Al, Fe and Mn
5. Phyllosilicate in soils: structure and morphological characteristics
6. Kaolin, halloysite and serpentine minerals
7. Allophane and imogolite
8. Micas: structures, weathering and effect on K availability
9. Vermiculite: structure and properties in relation to K/NH<sub>4</sub>
10. Smectites: structure and properties in relation to CEC
11. Chlorites and Inter-stratification in layer silicates
12. Tectosilicates: feldspar, quartz and zeolite
13. Clay mineral economy of Pakistan
14. Impacts of soil minerals composition on environment

#### Recommended Books

1. Akhtar, Soil mineralogy. In: Bashir and Bantel (eds.), *Soil Science*. (National Book Foundation, Islamabad, Pakistan, 2001).
2. Brindley and Brown, *Crystal Structures of Clay Minerals and their X-ray Identification*. (Mineralogical Soc. Monograph No.5. London, U.K. 1984).

#### Suggested Books

1. Dixon and Weed (2<sup>nd</sup> eds.), *Minerals in Soil Environment*. (SSSA, Madison, WI, USA, 1989).  
Dixon and Schulze, *Soil Mineralogy with Environmental Applications*. (Soil Science Society of America, Madison, WI, USA, 2002).  
Brady, N.C. and R.R. Weil, 2009. *Elements of the Nature and Properties of Soils*, 3<sup>rd</sup> Ed. Pearson Education, Upper Saddle River, NJ, USA.



**SAES-7109 Special Problem**

**1(1-0)**

The special problem is intended to instruct students on proper techniques for scientific research and methodologies. The students are expected to prepare directed assignment and collect information and material related to current research interest.

**SAES-7110 Seminar**

**1(1-0)**

The seminar is intended to instruct students on proper techniques for presentation of scientific material. Each student is expected to prepare and present a scientific seminar and to submit written documentation supporting that seminar.

**SAES-7111 Soil-Plant Relationship**

**3(3-0)**

The course is designed to address the intricacies of soil and plant relations for crop production. The students should be able to understand hypoxia and salinity interactive effect on plant growth and importance of mycorrhizae, water and nutrient uptake and translocation to aerial parts. Mechanisms of nutrient movement in soils and plants, and their relationships with plant growth are discussed. The students will be able to learn that how soil texture and structure greatly influence water infiltration, permeability, and water-holding capacity. Plant growth is greatly influenced by natural resource, soil. The basic soil and plant relationships are important to agri-cultural producers. After completion of this course, the students will be able to understand nutrient movement in soil and plant and adaptation of plants to adverse soil conditions.

**Contents**

1. Soil-plant-environment relationship
2. Plant root system: growth distribution, forms and factors affecting; Root hairs and CEC of roots; shoot-root relationship
3. Rhizosphere: root exudates and factors affecting; pH, redox potential and significance
4. Mycorrhizae: types and mechanisms for water and nutrient uptake
5. Uptake and transport of ions: movement in soil and plant
6. Mechanisms of ion transport across membranes: Ion release into xylem, xylem and phloem transport, factors affecting ion uptake
7. Water movement from soil to plant root and within plant
8. Water use efficiency and transpiration ratio
9. Water stress, hypoxia and plant growth
10. Mechanisms of salt tolerance; salinity-hypoxia interaction
11. Plant responses and adaptation to extreme environments

**Recommended Books**

1. Kirkham, *Principles of Soil and Plant Water Relations*. (Elsevier Academic Press, San Diego, CA, USA, 2005).
2. Marschner, (3<sup>rd</sup> ed.), *Marschner's Mineral Nutrition of Higher Plants*. Academic Press, Inc., Orlando, FL, USA, 2012).

**Suggested Books**

1. Marschner, *Marschner's Mineral Nutrition of Higher Plants*. 2012.
2. Mengel and Kirkby, (5<sup>th</sup> ed.), *Principles of Plant Nutrition*. (Kluwer Academic Publishers, Dordrecht, The Netherlands, 2001).
3. Rendig and Taylor, *Principles of Soil-Plant Inter-relationships*. (McGraw Hill Publishing Co., NY, USA, 1989).



This course will develop understanding among the students that how organisms are used to neutralize or remove contamination from waste. It is very important to understand that this form of waste remediation uses no toxic chemicals, although it may use an organism that can be harmful under certain circumstances. Different aspects including Biodegradation and bioremediation, principles and processes of bioremediation, soil and water pollution and its impact on environment and approaches for the remediation of contaminated sites are discussed. At the end of the course the students will also be able to understand that how bioremediation provides these pollution-eating organisms with fertilizer, oxygen, and other conditions that encourage their rapid growth. These organisms would then be able to break down the organic pollutant at a correspondingly faster rate. In fact, bioremediation is often used to help clean up oil spills.

#### Contents

1. Biodegradation: Assimilation of nutrients, lag phase, enzyme induction, acclimation, activation and kinetics
2. Cometabolism: Substrates, enzymes and reaction: Environmental significance
3. Factors affecting biodegradation: Biotic and Abiotic.
4. Bioremediation: Advantages/disadvantages, strategies and applications
5. *In Situ* Bioremediation: Land farming, prepared beds and soil piles, bioventing & biosparging, composting, intrinsic bioremediation, phytoremediation
6. *Ex Situ* Bioremediation: Bioreactors, biofilters, cometabolism, anaerobic process, biological and non-biological treatments
7. Bioremediation of inorganic pollutants: Biosorption, reduction, solubilization/ oxidation, precipitation, methylation

#### Recommended Books

1. Adriano, Bollag, Frankenberger and Sims. *Bioremediation of contaminated soils*. (SSSA, Agronomy Monograph 37, Madison, WI, USA, 1999).
2. Alexander. (2<sup>nd</sup> ed.), *Biodegradation and bioremediation*. (Academic Press, San Diego, CA, USA, 1999).

#### Suggested Books

1. Sylvia, Fuhrmann, Hartel and Zuberer. *Principles and applications of soil microbiology*. (Prentice Hall, Upper Saddle River, NJ, USA, 1998).
2. Hurst, Crawford, Knudsen, McInernery and Stetzenbach. *Manual of environmental microbiology*. (American Society for Microbiology, Washington, DC, USA, 2002).



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*Soil ecology* is the study of the interactions among soil biology, and between biotic and abiotic. The nature of the substrate, although *important* in water is especially vital in terrestrial environment. The students will also be able to understand that how *soils* play an *important* role in all of our natural *ecological* cycles-carbon, nitrogen, oxygen, water and nutrient. At the end of the course the students will be able to understand that how *soil* microorganisms affect *soil* physical properties, their transformation of plant material into the more stable forms of organic compounds that make up the humus which is *important* to the maintenance of the organic fraction of *soil*.

#### *Contents*

1. Introduction, Viruses, Bacteria
2. Soil environment, Bacteria and archaea, Fungi, Algae
3. Soil animals, Microbial energetic
4. Microbial metabolism, Microbial growth and interactions
5. Environmental limits to microbial activity
6. Soil aggregates, Rhizosphere
7. Soil organic matter composition, Formation of soil organic matter
8. Decomposition and carbon mineralization
9. Composting, Xenobiotic metabolism I, Xenobiotic metabolism II, Nitrogen fixation process
10. Symbiotic nitrogen fixation (S. Boyle)
11. Nitrogen mineralization (S. Boyle)
12. Nitrogen immobilization, Nitrification, Denitrification
13. Trace gases
14. Sulfur cycle, Phosphorus cycle
15. Mycorrhizae I, Mycorrhizae II
16. Aromatic Nomenclature, Nitrogen cycle
17. Mycorrhizae
18. Metals

#### *Recommended Books*

1. Richards, *The Microbiology of Terrestrial Ecosystems*. (Longman Scientific & Technical, 1987).
2. *Soil Microbial Ecology*. (Meeting, Marcel Dekker, 1993).

#### *Suggested Books*

1. Killham, *Soil Ecology* (Cambridge University Press, 1994).
2. Alexander, *Biodegradation and Bioremediation*. (Academic Press, 1994)
3. Wood, (2<sup>nd</sup> ed.), *Environmental Soil Biology*. (Blackie A & P, 1995).



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**STAT-7151 Statistical Methods for Agricultural Research-I**

**3(3-0)**

Statistics are important because today we live in the information world and much of this information's are determined mathematically by Statistics Help. It means to be informed correct data and statics concepts are necessary. At the end of the course the students will be able to impart the knowledge of statistical software used to analyze the data. This course will also be helpful to improve the students' skills for selecting appropriate tools for analysis of their research data.

*Contents*

1. Basic principles of experimental design. Layout analysis of CRD, RCBD, Latin Square Designs.
2. Estimation of Missing Observations in RCBD and Latin Square Design
3. Split plot Designs and its variations.
4. Multiple comparison tests.
5. Effect of violation of assumptions of underlying ANOVA.
6. Simple and Multiple regression.
7. Logistic Regression and Odd Ratios.
8. Survival Analysis. Dose Response Curves.
8. Simple correlation, Multiple Correlation and Partial Correlation.
9. Analysis of Count and Frequency data.
10. Contingency Tables.
11. Diversity Indices.

*Recommended Books*

1. Mead. *The Design of Experiments*. Cambridge University Press, Cambridge (1995)
2. Steel, Torrie and Dicky. (3<sup>rd</sup> ed.). *Principles and Procedures of Statistics. A Biometrical Approach*. Mc Graw Hill, New York, USA.

*Suggested Books*

1. Box and Hunter. *Statistics for Experimenters*. (New York: Wiley, 1978).
2. Tabachnick and Fidell. *Using Multivariate Statistics*. (New York: HarperCollins College Publishers, 1996).
3. Dillon and Goldstein. *Multivariate Analysis: Methods and Applications*. (New York: Wiley, 1984)



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## Contents of Deficiency Courses

SAES-6803

PHYSICAL PROPERTIES OF SOIL

3(2-1)

### Objectives

The aim of this course is basically to develop understanding of the students about physical properties of soils and apply their knowledge for solving physical degradation problems. This course will also help in understanding the behavior of soil physical properties in supporting the crop growth and engineering uses. At the completion of the course, the students will become able to understanding the importance of physical properties of soil in crop growth and its use for engineering purposes, the role of different tillage practices in crop growth and in management of water and soil, identify important problems regarding different soil physical properties and identify the management practices regarding physical degradation of soil.

### Theory

1. Soil physical condition and plant growth
2. Soil texture, specific surface area and importance
3. Soil structure: genesis and description
4. Soil crusting and surface sealing with their role in seedling emergence
5. Particle and bulk density: description and significance
6. Total porosity and pore-size distribution and root development
7. Soil air composition and aeration
8. Soil temperature and its management
9. Soil color: causes and significance
10. Soil consistency and strength and interpretation for soil mechanics
11. Soil water and water potential and plant available water.
12. Water and solute movement through soil
13. Soil compaction: causes and remedies
14. Soil tillage systems and tilling
15. Soil physical environment and root architecture

### Practical

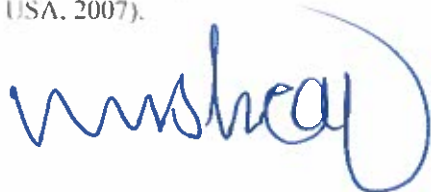
1. Textural analysis: sieve, hydrometer, pipette and feel methods
2. Determination of bulk and particle density
3. Total soil porosity estimation
4. Aggregate stability estimation
5. Measurement of soil water contents
6. Measurement of soil temperature
7. Soil color and its interpretation
8. Determination of soil strength/soil penetrometer resistance

### Recommended Books

1. Brady and Weil. (3<sup>rd</sup> ed.). Elements of the Nature and Properties of Soils. (Pearson Education. Upper Saddle River, NJ, USA. 2009).
2. Jury and Horton. (6<sup>th</sup> ed.). Soil Physics. (John Wiley & Sons. Inc., NY, USA, 2004).

### Suggested Books

1. Hillel. Introduction to Environmental Soil Physics. (Elsevier, San Diego, CA, USA. 2004).
2. Hillel. Soil in the Environment: Crucible of Terrestrial Life. (Elsevier Inc., Burlington, MA, USA. 2008).
3. Brady and Weil. (14<sup>th</sup> ed.). The Nature and Properties of Soils. (Pearson Education. Upper Saddle River, NJ, USA. 2007).



**Objectives**

The aim of this course is to teach students regarding the concept of soil chemistry, soil composition and electrochemical potentials, colloidal chemistry of inorganic constituents and impact of soil reactions on mineral nutrient availability. Chemical properties of the soil are important to soil fertility and plant growth. At the completion of this course, students will be able to understand soil chemistry and soil formations, need for acidic soil reaction, chemical characterization of saline and sodic soil, nature of clay-organics complex and its impact on soil fertility. The students will also be able to learn that how soil chemical properties are interlinked with soil biology and soil physical parameters.

**Theory**

1. Soil colloids: Inorganic and organic
2. Layer silicate clays, allophanes and sesquioxides
3. Charge characteristics of colloids: sources and significance
4. Ion exchange and Zero point of charge
5. Diffuse double layer theory
6. Soil pH and buffering capacity
7. Base saturation percentage
8. Exchange equations (Langmuir, Freundlich and Gapon)
9. Sorption and desorption in soils

**Practical**

1. pH with and without different electrolytes, and soil to water ratios
2. Soluble and extractable cations in soil
3. Cation exchange capacity of three different textured soils
4. Base saturation percentage
5. Estimation of lime content in soil

**Recommended Books**

1. Bohn, McNeal and O'Connor. (3<sup>rd</sup> ed.). Soil Chemistry. (John Wiley & Sons, Inc., NY, USA, 2001).
2. Essington. Soil and Water Chemistry: An Integrated Approach. (CRC Press, Boca Raton, FL, USA, 2004).

**Suggested Books**

1. Sparks. (2<sup>nd</sup> ed.). Environmental Soil Chemistry. (Academic Press, Inc., San Diego, CA, USA, 2003).
2. Sposito. (2<sup>nd</sup> ed.). The Chemistry of Soils. (Oxford University Press, NY, USA, 2008).
3. Tan. (3<sup>rd</sup> ed.). Environmental Soil Science. (CRC Press, Greensboro, GA, USA, 2009).



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**Objectives**

Factors and processes of soil formation, interpretative soil morphology and local pedogenic processes and introduction to USDA soil classification system are discussed. The students will be able to understand and describe morphological features and taxonomic relations of different soils. Soil genesis, with special reference to the soil-forming factors responsible for development of the solum, or true soil, time, parent material, topography, climate and organisms. The students will know how the properties of soils affect their uses, and be able to evaluate alternative treatments, amendments and/or location of different uses of soil/substrate. Students will be able to effectively sample and describe soils. Students will appreciate the importance of soils to human civilization and survival.

**Theory**

1. Weathering of rocks and minerals; types of parent materials
2. Soil genesis and factors affecting
3. Pedogenic processes
4. Soil morphology
5. Description of soil profiles; special soil features
6. Soil taxonomy: categories and nomenclature
7. Soil orders in Pakistan: extent and their significance

**Practical**

1. Soil profile description of important soil series
2. Field trips
3. Identification of soil orders

**Recommended books**

1. Buol, Walker, Southard and McDaniel. (5<sup>th</sup> ed.). Soil Genesis and Classification. (Iowa State University Press, Ames, IA, USA, 2003).
2. Wilding, Factors of Soil Formation. (SSSA Special Publ. No. 33, Madison, WI, USA, 1994)

**Suggested Books**

1. Rabenhorst, Bell, and Mc. Daniel (eds.). Quantifying Soil Hydromorphology. (SSSA Special Publ. No. 5-1, Madison, WI, USA, 1998).
2. Schaetzl and Anderson. Soils: Genesis and Geomorphology. (Cambridge University Press, Cambridge, UK, 2005).
3. Soil Survey Staff. (10<sup>th</sup> ed.). Keys to Soil Taxonomy. (USDA, Washington, DC, USA, 2006).



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**Objectives**

In the agricultural sciences, soil fertility and plant nutrition played an important role during the twentieth century in increasing crop yields. In the twenty-first century, the importance of this field is expected to increase due to limited natural resources (land and water), the need for more sustainable agricultural systems, and concern about environmental pollution. The students will be able to diagnose deficiency and toxicity symptoms of different nutrients on plants. It is evident that for optimum crop productivity the soil nutrient status, i.e. the fertility of the soil should be maintained by appropriate and efficient nutrient management. However, in order to make the best decisions on what measures and when to take one, has to obtain actual information on soil nutrient status.

**Theory**

1. Crop growth, factors affecting and growth expressions
2. Essential plant nutrients: functions, deficiency and toxicity
3. Movement of nutrients to roots, acquisition and uptake
4. Nitrogen gains and losses in soil
5. Nitrogen fertilizers and their fate in soil
6. Phosphorus forms and P-fertilizers behavior in soil
7. Potassium forms, amount and exchange equilibrium in soil
8. Calcium, magnesium and sulfur forms and amount in soil
9. Crop responses; factor affecting and residual effects
10. Integrated plant nutrient management
11. Nutrients behavior in submerged soil
12. Nutrient role in human and plant health
13. Possible new essential elements (Co, Na, Si, Se, Ni, Li and Cs)

**Practical**

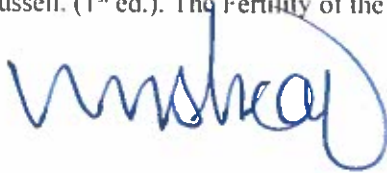
1. Fertilizers identification and composition
2. Fertilizer requirement calculation
3. Fertilizer analyses (urea, CAN, DAP and SOP)
4. Determination of available P and K in soil
5. Plant analysis for N, P and K
6. Field visits for identification of nutrients deficiency and toxicity symptoms
7. Visit to fertilizer factories, soil fertility institutes and demonstration trials

**Recommended Books**

1. Ahmad and Rashid. Fertilizer and Their Use in Pakistan: An Extension Guide. Planning Commission. (National Fertilizer Development Centre, Islamabad, Pakistan, 2003).
2. Havlin, Tisdale, Nelson and Beaton. (8<sup>th</sup> ed.). Soil Fertility and Fertilizers: An Introduction to Nutrient Management. (Pearson Education, Prentice Hall, Upper Saddle River, NJ, USA, 2013).

**Suggested Books**

1. Elsworth and Relay (eds.). Fertilizers: Properties, Applications and Effects. (Nova Science, Publ. Inc., NY, USA, 2009).
2. Mengel and Kirkby. (5<sup>th</sup> ed.). Principles of Plant Nutrition. (International Potash Inst., Bern, Switzerland, 2001).
3. Russell. (1<sup>st</sup> ed.). The Fertility of the Soil. (Cambridge Univ. Press, UK, 2011).



**Objectives**

Understanding and development of the classroom teaching (formal education) and learning activity plays a pivotal role in the education system. This course will create awareness among the students about the problems, reclamation and management of salt-affected soils. This course also aims at understanding the problems of irrigation waters and strategic treatment/management options about the sustainable and safe use of such low quality waters in agriculture. In addition, the students will be equipped with pre-requisite knowledge and skills necessary to become a good researcher. This will in turn help develop research aptitude among the graduates which will go long way in their practical carrier. At the completion of the course, the students will become able to understand issues related to salt-affected soils and low-quality waters, mathematical relationships to calculate SAR of soil solution from SAR of irrigation water, calculate average root zone salinity and salt balance and strategies for the reclamation and management of salt-affected soils.

**Theory**

1. Salt-affected soils, classification, properties and extent
2. Salination and sodication: Gapon and pHc equations
3. Systems of characterization of salt-affected soils
4. Chemistry of soil solution
5. Root zone salinity
6. Reclamation and management of salt-affected soils
7. Irrigation water: Criteria and classification
8. Groundwater: Characteristics and resources
9. Salinity build up and prediction
10. Waterlogged soils: Causes, impact and management
11. Bio-saline Agriculture

**Practical**

1. Field visits and sampling of salt-affected soils and irrigation water
2. Saturated soil extract analysis, SAR calculation and ESP prediction
3. Irrigation analysis, classification and interpretation
4. Gypsum requirement of soil and brackish irrigation water
5. Demonstration of Ex-situ soil reclamation techniques

**Recommended Books**

1. Bohn, McNeal and Connor. (3<sup>rd</sup> ed.). Soil Chemistry. (John Wiley & Sons Inc., NY, USA, 2001).
2. Ghafoor, Qadir and Murtaza. Salt-Affected Soils: Principles of Management. (Allied Book Center, Lahore, Pakistan, 2004).

**Suggested Books**

1. Essington. Soil and Water Chemistry: An Integrated Approach. (CRC Press, Boca Raton, FL, USA, 2004).
2. IWASRI manual.
3. Molden. (ed.). Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. (Earthscan Colombo, IWMI, Sri Lanka, 2007).



**Objectives**

Kinds and significance of microorganisms present in soil and their role in crop productivity and environmental quality are discussed. The students should be able to recognize different microbes, their functions in nutrient transformations under different conditions and their relationships with crops and environment. It will develop better understanding of students that how the maintenance of soil structure and fertility is of paramount importance for plant growth and because this in turn is dependent on the activities of soil organisms, soil microbiology has a significant role to play in intensive sustainable agriculture. Students will also perform different laboratory experiments regarding media preparation, measurement of microbial population and their activity in soil. At the end of the course students will be able to have better understanding with different nutrient availability mechanisms like mineralization and immobilization.

**Theory**

1. Introduction and historical prospective
2. Distribution, functions and classification of bacteria, archaea, actinomycetes, fungi, algae and fauna
3. Growth phases and environmental factors affecting soil microflora
4. Microbial ecology
5. Soil organisms and their interactions
6. Soil organic matter decomposition; immobilization and mineralization of carbon; microbial fixation and release of CO<sub>2</sub>
7. Microbial transformations of nutrients under aerobic and anaerobic soil conditions.
8. Microbial inoculants for N and P

**Practical**

1. Introduction to laboratory equipments
2. Media preparation
3. Measurement of microbial population and activity in soil
4. Algal culturing and their microscopy
5. Study of mineralization, nitrification and denitrification

**Recommended Books**

1. Barton and Northup. Microbial Ecology. (John Wiley & Sons, Inc., Hoboken, New Jersey, USA, 2011).
2. González and González-López. Beneficial Plant-microbial Interactions- Ecology and Applications. (CRC Press, Taylor & Francis, Boca Raton, FL, 2014).

**Suggested Books**

1. Paul. (3<sup>rd</sup> ed.). Soil Microbiology, Ecology and Biochemistry. (Elsevier, Oxford, UK, 2007).
2. Pommerville. (10<sup>th</sup> ed.), Fundamentals of Microbiology. (Jones & Bartlett publishers, 2014). Sylvia. Fuhrmann, Hartel and Zuberer. Principles and Applications of Soil Microbiology. (Prentice Hall International, NJ, USA, 2005).



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