ANNAMALAI UNIVERSITY

(Accredited with 'A' Grade by NAAC)

FACULTY OF AGRICULTURE

(Accredited by ICAR)

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Academic Regulations and Syllabi

DOCTOR OF PHILOSOPHY IN SOIL SCIENCE

Under Choice based credit system (CBCS) with Outcome based Education

2022-2023 Onwards

COMMON REGULATIONS FOR ALL Ph.D. PROGRAMMES OF FACULTY OF AGRICULTURE

(*w.e.f. 2022-2023*)

1. DEFINITIONS

1.1 An **"Academic year"** shall consist of two semesters.

1.2 **"Semester"** means an academic term consisting of 110 instructional days excluding final theory examinations.

1.3 **"Course"** means a unit of instruction to be covered in a semester having specific No., title and credits.

1.4 **"Credit hour"** means, one hour lecture plus two hours of library or homework or two and half hours of library/field practical per week in a semester.

1.5 **"Credit load"** of a student during a semester is the total number of credits registered by that student during that particular semester.

1.6 "**Grade Point"** of a course means the value obtained by dividing the percentage of marks earned in a course by 10 and the Grade Point is expressed on a 10 point scale and rounded off to two decimal places.

1.7 **"Credit Point"** means the grade point multiplied by corresponding credit hours.

1.8 **"Grade Point Average (GPA)"** means the quotient of the total credit points obtained by a student in various courses at the end of each semester, divided by the total credit hours taken by the student in that semester. The grading is done on a 10 scale and the GPA has to be corrected to two decimals.

1.9 **"Overall Grade Point Average (OGPA)"** means the quotient of cumulative credit points obtained by a student in all the courses taken from the beginning of the first semester of the year divided by the total credit hours of all the subjects which he/she had completed up to the end of a specified semester and determines the overall performance of a student in all subjects during the period covering more than one semester. The OGPA has to be arrived at the second decimal place.

2. SYSTEM OF EDUCATION

2.1 These rules and regulations shall govern the Ph.D. programmes leading to the award of Degree of Doctor of Philosophy in the concerned subject in the Faculty of Agriculture, Annamalai University. They shall come into force with effect from the academic year 2022-2023.

2.2 The semester system shall be followed for all the Ph.D. degree programmes. The duration of doctoral programmes is as follows:

2.2.1 The duration of the programme and the time for admission of thesis are counted from the date of provisional registration.

2.2.2 The minimum duration of the programme is three years and the maximum duration of the programme shall be seven years.

2.2.3 Break of study shall be granted up to a maximum period of one year and it can be done only after completing the course work. Such request shall be made in advance by scholar in writing with the recommendation of Supervisor, Head of the Department (HoD) and Dean,

Faculty of Agriculture and it should reach the Director, Directorate of Academic Research (DARE). The orders for the break of study shall be issued by the Director, DARE after assessing the need.

2.2.4 If prior permission is not sought and obtained, it will be considered as a case of discontinuation and action will be taken to cancel the registration of such scholars.

2.2.5 The scholars should remit the yearly fees during the break of study also.

3. PROGRAMMES OFFERED

The details of various Ph.D. programmes offered in the Faculty of Agriculture are as follows:

1. Agri Business Management
2. Agricultural Economics
3. Entomology
4. Agricultural Extension Education
5. Agricultural Microbiology
6. Agronomy
7. Genetics and Plant Breeding
8. Horticulture in Fruit Science
9. Horticulture in Vegetable Science
10. Horticulture in Floriculture and Landscaping
11. Horticulture in Plantation, Spices, Medicinal and Aromatic plants
12. Molecular Biology and Biotechnology
13. Plant Pathology
14. Seed Science and Technology
15. Soil Science

4. ELIGIBILITY FOR ADMISSION

Candidates seeking admission to Ph.D. programme should satisfy the following requirements.

4.1 Candidates with two year master's degree programmes from Universities recognized by Annamalai University are eligible to apply for Ph.D. programmes of the university (Table 1).

4.2 Candidates who have undergone the programme under conventional system should possess not less than a second class Master's degree. The candidates under trimester system should possess a minimum OGPA of 3.00 out of 4.00. For those under semester system 7.00 out of 10.00 is required for various Doctoral programmes.

Table 1: Eligibility Criteria

Doctoral Degree Programmes	Eligibility
1. Agri Business Management	MBA in Agribusiness / MBA Agri Business Management
2. Agricultural Economics	M.Sc. (Ag.) in Agrl. Economics / Agricultural Marketing Management
3. Entomology	M.Sc. (Ag.) in Entomology / Agricultural Entomology

4. Agricultural Extension Education	M.Sc. (Ag.) in Agricultural Extension / Agricultural Extension and Communication / Agricultural Extension Education / Extension Education
5. Agricultural Microbiology	M.Sc. (Ag.) in Agricultural Microbiology
6. Agronomy	M.Sc. (Ag.) in Agronomy
7. Genetics and Plant Breeding	M.Sc. (Ag.) in Genetics and Plant Breeding
8. Horticulture	M. Sc (Ag.) Hort. / M.Sc. (Hort.) / M.Sc. (Hort.) in Fruit Science / Vegetable Science / Floriculture and Landscape Gardening or Architecture / Plantation, Spices, Medicinal and Aromatic Crops
9. Plant Molecular Biology and Biotechnology	M.Sc. (Ag.) in Plant Molecular Biology / Agricultural Biotechnology
10. Plant Pathology	M.Sc. (Ag.) in Plant Pathology
11. Seed Science & Technology	M.Sc. (Ag.) in Seed Science & Technology
12. Soil Science	M.Sc. (Ag.) in Soil Science

4.3 All research scholars shall undergo course work for two semesters as prescribed by the Department. Duration of the programme will be for three years.

4.3.1 The Ph.D. scholars shall report in the Department and sign every day in the attendance register. In order to promote quality research and training in cutting edge areas, the University may permit the scholar to pursue his research work in Annamalai University or in other Universities/Research Institutes by entering with/without MOU between Annamalai University and the partner University/Institute after the completion of qualifying Viva voce examination.

4.3.2. Project staff/ fellow working in projects in the University, sponsored by Government of India/ Industries / Government of Tamil Nadu can also register.

4.3.3. Candidates in employment should be sponsored by their employer and should avail leave for the minimum duration of the programme and should be formally relieved from their duty to register.

4.3.4. Candidates who are selected under the national level fellowship programmes or by any recognized bodies and who satisfy the eligibility conditions as per the regulations shall apply in the respective discipline.

4.3.5. Admission to Foreign Students: Foreign students, who are selected under various scholarship schemes, either by the Ministry of Education and Culture or by the Ministry of External Affairs, will be given admission on the recommendation / sponsorship of the respective Ministry of Government of India. The other foreign students who seek admission should possess a research VISA issued by the Indian Embassies aboard and produce “No Objection Certificate” from the Ministry of Human Resource Development, Government of India, after clearance from the Ministry of External Affairs. They should also show proof for financial capability for staying, pursuing Ph.D. programme for three years.

5. MODE OF SELECTION

5.1. University shall issue notification for Ph.D. admission once in a year.

5.2. The candidates desirous of registering for Ph.D. programme shall apply by filling all the relevant details mentioned in the online application form posted in the University website and submit completed application online before the due date as indicated in the notification issued from time to time.

5.3 Incomplete applications and applications with false information in any respect shall be summarily rejected without any intimation to the candidate.

5.4. The Departmental Research Committee (hereafter referred to as DRC) of concerned Department shall screen the applications as per the eligibility norms and shall conduct the written test and interview only for eligible candidates.

5.5. The admission to Ph.D. students shall be based on the following criteria besides general eligibility.

5.5.1 An entrance test at post graduate level for 70 marks (70 multiple choice questions (MCQs), each question carrying one mark and duration of the test is 90 minutes followed by an interview that will have a weightage of 30 marks.

5.5.2 The candidates who secure 50% marks in entrance test and interview are eligible for admission.

5.5.3 A relaxation of 5 % marks (from 50 % to 45%) shall be allowed for the candidates belonging to SC/ST/OBC (non creamy layer)/ differentially able category.

5.5.4 Candidates with UGC- JRF / NET / ICAR/ICSSR qualified candidates and teacher fellowship holders are exempted from the Entrance test but they have to appear for the interview and evaluated for 100 marks.

5.6 Departmental Research Committee: The following is the constitution of the DRC. The members other than Head of the Department shall serve only for one academic year.

Designation	**Members**
Head of the Department	Convener
Two professors/ Senior Faculty nominated by the Vice-Chancellor in rotation	Members
One Associate Professor (in rotation)	Member
One Assistant Professor (in rotation)	Member

5.7. The DRC has the following functions

5.7.1 Selection of candidates for admission to the Ph.D. programme.

5.7.2 Facilitating research facilities in the Department.

5.7.3 Maintenance of research quality and quality of publications.

5.7.3 Sorting out any other research related issue of the Department.

5.8. If there is any dispute either in the constitution of functioning of the DRC, it shall be brought to the notice of the Director, DARE and the decision of the Vice-Chancellor shall be final.

5.9. The minutes of the DRC together with the list of selected candidates and their research supervisors along with recommendations of the Dean of the respective faculty will be placed before the Vice-Chancellor for approval.

6. ADMISSION

6.1. The selected candidates shall be issued admission cards and they will be admitted to Ph.D. programme in the respective Department based on his/her PG qualification, entrance and interview.

6.2. The provisional registration order for Ph.D. shall be issued to the candidates.

6.3. The scholar, supervisor, Research Advisor Committee members and examiners shall not be relatives to one another.

7. TUITION FEES AND OTHER FEES

7.1 The selected candidates shall pay the prescribed fees before the last date mentioned in the selection order, failing which they will forfeit the seats.

7.2. The yearly fees shall be paid by the scholars within the prescribed date till the scholar submits the thesis. The supervisors should monitor the regular payment of yearly fees by those scholars who are working under them.

7.3. The registration is liable for cancellation, if the research scholar has not paid the yearly fees within stipulated time.

7.4 Non-payment of yearly fees is a serious lapse on the part of the scholars. Explanation for non-payment of yearly fees shall be called for from the supervisors.

7.5 The various fees payable by the students will be decided by the university from time to time.

7.6 Admission to the hostel will be strictly restricted to the actual accommodation available and no associate will be allowed. A Ph.D. student may be allowed to stay in the hostel for a maximum of five years from the date of admission to the Ph.D. programme.

8. CREDIT GRADE POINT REQUIREMENTS

8.1. A student enrolled for Doctoral program is required to complete 100 credits inclusive of 75 credits of research to become eligible for the degree as detailed below:

Sl. No.	Details	Credit Hours
1	Major Courses	12
2	Minor Courses	6
3	Supporting Courses	5
4	Seminar	2
5	Research	75
	Non credit Compulsory courses	
	Research and Publication Ethics (Contact hours: 2) MOOC (Contact hours: 2)	
	Total	**100**

8.2. In a semester, a Ph.D. scholar can register a maximum of 15 credits excluding research. However, the research credits registered should not exceed 16 per semester. Semester-wise distribution of credits is given in the respective Ph.D. programmes.

8.3. Registration Card: A student shall register the courses offered in a semester by writing all the courses in registration card in quadruplicate. The Supervisor, Ph.D. Coordinator and Head of the Department are responsible to furnish the registration particulars of the students with their signature in the Registration card to the Dean. The Dean shall approve the registration cards. The approved registration cards shall be maintained by the HoD, Supervisor and the student concerned. The list of courses registered by the students in each semester shall be sent by the Dean to the DARE for preparation of Report Cards.

8.4. The Ph.D. students should complete their course work within the first two semesters in Annamalai University campus.

8.5. Requirements for Ph.D. programme shall also include successful completion of Non-Credit Compulsory Courses, thesis research in the major field of study and submission of thesis thereon.

9. ATTENDANCE REQUIREMENT

9.1 One hundred per cent attendance is expected from each scholar. A student who fails to secure 80 per cent of attendance in each subject separately for theory and practical, shall not be permitted to appear for the final examination in that subject and shall be awarded 'E' (incomplete) and will be required to repeat the course whenever offered.

9.2 In respect of the student who has absented himself / herself for classes with or without valid reasons, that period will be treated as absence only and not as leave. Also, no attendance will be given for writing make up tests.

9.3 In case of new admission, for calculating 80 percent attendance in the first semester, the number of working days will be calculated from the date of joining of the students who are permitted to join late due to administrative reasons. However, for genuine reasons, condonation of attendance deficiency may be considered by the Vice - Chancellor on the recommendation of the Research Advisory Committee, HoD and Dean, Faculty of Agriculture on payment of condonation fee prescribed by the university.

9.4 Students absenting from the classes with prior permission of the HoD on official University business shall be given due consideration in computing attendance.

9.5 In respect of students who had absented for the mid-semester examination (MSE) on university business with prior permission of the HOD and Dean, Faculty of Agriculture, the makeup first test should be conducted ordinarily within 15 working days from the date of conduct of the first test.

9.6 The students who absent himself/herself for first test in a subject on genuine reasons shall be permitted on the recommendation of the course teacher / Research Supervisor and Head of the Department concerned. Missing examination should be completed within 15 working days from the date of respective examination on payment of missing examination fee prescribed by the university.

10. RESEARCH ADVISORY COMMITTEE

10.1 Each Ph.D. scholar shall have a Research Advisory Committee (RAC) to guide the scholar in carrying out his/her programme.

10.2 A Research Advisory Committee shall be constituted with the approval of the University for each candidate separately, immediately after his/her admission. The purpose of the RAC is to provide expert opinion on frontline research.

10.3 There shall be a Research Advisory Committee for every student consisting of not fewer than four members with the Supervisor as Chairperson. The Research Advisory Committee should have representatives from the major and minor fields. The major **Advisor/Research Advisor** will be from Annamalai University and Co-Research Supervisor will be from the partner institutes (Research Scholars pursuing in other institutes/universities) besides RAC members.

The Research Supervisor should convene a meeting of the Research Advisory Committee at least once in a semester. The research credit evaluation form should be communicated to the Head of Department and the Director, DARE for information.

10.4 **Research Supervisor**

10.4.1 Every scholar shall have a Research Supervisor (among the recognized guides), who will be appointed by the Vice-Chancellor on the recommendation of the DRC, Head of the Department and the Dean, Faculty of Agriculture. Research supervisors approved by the Vice-Chancellor only can be the guide for the students.

10.4.2 A teacher having Ph.D. with 5 years of service and PG teaching is eligible for teaching and guiding Ph. D. scholars. A teacher should have a minimum of three years of service before retirement for allotment of doctoral candidates.

10.4.3 The research supervisors who wish to avail leave/lien/deputation beyond a period of six months shall propose a Co-supervisor in the concerned subject for the candidates registered with them and it may be intimated to the University well in advance. The final approval of the proposal rests with the Vice-Chancellor.

10.5 **Functions of the RAC**:

10.5.1 Discuss, advice and recommend on all matters connected with the scholar's research from admission till the completion of the programme.

10.5.2 Approve the topic of research and the synopsis.

10.5.3 Assess and approve the progress reports of Ph.D. scholars in the prescribed format and to report to the University on the fitness or otherwise of the candidate to proceed with his/her research work for the Ph.D.

10.5.4 If necessary, recommend and approve change of title of dissertation / thesis and change of Research Supervisor.

10.5.5. Conduct the pre-submission presentation (before the submission of synopsis) and to give a certificate to this effect to be submitted along with the synopsis.

10.6 The Research Advisory Committee will meet every semester

10.6.1 To scrutinize the research proposal / progress report submitted by the research scholar.

10.6.2 To assess the conduct of experiments / field work, peruse laboratory notebooks, data recording, analysis, and publication.

10.6.3 To review and endorse the annual progress report of the research scholar.

10.6.4 To approve the synopsis of the thesis.

10.6.4 The Chairperson will convene the Research Advisory Committee meetings with intimation to the Director, DARE through the Head of the Department.

10.7 **Changes in RAC**

The proposals for changes in the RAC are to be sent to the Director, DARE, through HOD and Dean for approval, if it is keenly felt that such changes are absolutely necessary.

10.8 **Change of Research Supervisor**

10.8.1 Change of Research Supervisor shall not be permitted as a routine. In exceptional cases, such change may be permitted, if valid reasons are provided by the candidates. The Committee headed by the Vice-Chancellor shall look into the request of the petitioner, if there is any conflict between the scholar and the research supervisor.

10.8.2 The Research Supervisor under whom the scholar has originally registered shall give a "No Objection Certificate" and the new proposed Research Supervisor should give a "Certificate of Willingness" to guide the candidate. The final decision will rest with the University. However, the Vice-Chancellor, on the recommendation of the RAC and Dean's Committee, has the right to assign a new research supervisor to the research scholar.

10.8.3 When the change of Research Supervisor is approved, the candidate shall work for a minimum of one year with the new Research Supervisor, if the topic of his/her research is different under the new supervisor, provided he/she fulfils the attendance requirements.

10.9 **Change of Topic of Research**

10.9.1 Change of the specific area of research may be permitted within one year from the date of admission and request must be submitted with the recommendations of the RAC. In such cases, the minutes of the RAC meeting must include whether the course work undertaken by the research scholar is relevant to the new research area and the competence of the research supervisor in this field.

10.9.2 If the RAC is of the view that there is a major change in the specific area of research and is not relevant to the course work undertaken, the research scholar will have to go through the process of fresh examination pertaining to the area of research.

10.10 Absence of Member during Qualifying / Final Viva-Voce Examination

Under extra-ordinary circumstances if the qualifying / final viva-voce examination to Ph.D. student has to be conducted in the absence of one or two RAC members, permission to conduct the examination by co-opting another member in such contingencies should be obtained from the Director, DARE in advance.

11. EVALUATION OF STUDENT'S PERFORMANCE

All students shall abide by the rules for evaluating the course work under the semester system of education, as prescribed from time to time by the University.

12. EXAMINATIONS

12.1 There will be two examinations *viz.*, first test and final examination. Wherever the course has practical, there will be a final practical examination also.

12.2 The duration of first test will be of one and half an hour and final examinations in theory and practical will be conducted for three hours each.

12.2.1 The first test will be conducted by course teachers during the ninth week of the semester as per the scheme drawn by HOD, evaluate and send the marks obtained by the students to the Director, DARE through HOD within seven working days.

12.2.2. The question paper for the final examination will be set as per Bloom's taxonomy by the concerned course teacher in consultation with the Head of the Department.

12.2.3 There will be final examination separately for theory and practical which will be conducted by the University. Each final theory and practical examinations will be evaluated by two examiners (one will be the course teacher and another will be the senior faculty of the Department).

The distribution of marks will be as indicated below:

S. No	Examination	Course with practical	Course without practical	Course without theory
1	First Test	30	30	30
2	Final theory	40	70	-
3	Final practical	30	-	70
	Total	**100**	**100**	**100**

The question paper model and distribution of marks for first test and final theory examinations are as follows:

First Test (30 marks) (1.5 hours duration)

1	Definitions/concepts	5 out of 7	(5 x 1)	5 marks
2.	Short notes	5 out of 7	(5 x 3)	15 marks
3	Essay type	2 out of 3	(2 x 5)	10 marks

Final Theory: Course without practical (70 marks) (3 hours duration)

1.	Short notes	5 out of 7	(5 x 4)	20 marks
2	Essay type	5 out of 7 (four questions must represent K6 level of Bloom's taxonomy)	(5 x 10)	50 marks

Final Theory: Course with Practical (40 marks) (3 hours duration)

1.	Short notes	5 out of 7	(5 x 2)	10 marks
2	Essay type	5 out of 7 (four questions must represent K6 level of Bloom's taxonomy)	(5 x 6)	30 marks

12.3 **Minimum Marks for Pass**

12.3.1 The student should secure a minimum of 60 per cent marks separately in the theory and practical and an aggregate of 70 per cent to secure a pass in the subject. Each subject shall carry a maximum of 100 marks for purpose of grading. The grading will be done as grade point, i.e., the percentage of marks earned in a subject is divided by 10. The grade point is expressed on a 10 point scale upto two decimals.

12.3.2 Students who secure marks below 70 per cent in a subject will be awarded 'RA' grade and students without having the required minimum attendance of 80 per cent will not be allowed to write the final examination and they will be awarded 'E' grade. Students who secure 'RA' grade should appear for re-examination in the subsequent semester. If a student secured 'E' grade, he/she has to re-register and attend the course again during the next academic year.

12.4 **Minimum GPA Requirement**

A Ph. D. student, to continue his/her studies in the University, should maintain certain minimum Average Grade Point prescribed here under:

a) Earn a Grade Point of 7.00 for a pass in each subject.
b) For purpose of continuing as a student in the university, a candidate is required to earn a Grade Point Average of not less than 7.50 at the end of each semester.
c) A Ph.D. student may repeat the course (s) in which he/she gets a Grade Point below 7.50 and above 7.0 to improve the OGPA.

12.5 Re-Examination

12.5.1 Re-examination is permitted only for the final theory and practical examinations. The students who secure 'RA' grade are permitted to write the re-examinations as and when conducted with the permission of university.

12.5.2 The re-examination fee as prescribed by university per course is to be paid on or before the prescribed date. A student is permitted to write the final theory and practical examinations only two times during the course period of three years excluding the regular final examination.

12.5.3 In the event of a student who fails to secure a pass in the two re-examinations permitted, he/she has to re-register for the course along with juniors. The marks secured in first test will be retained and the student should produce the practical record during re-examination. The registration for the re-examination shall be done after first test on the date specified by the Director, DARE. Each registration is considered as an attempt even if the student absents for the examination.

12.6 Return of Valued Answer Papers

12.6.1 The valued answer papers of first test shall be shown to the students after the examination. Discrepancies if any, in awarding marks, the student can approach the teacher concerned immediately for rectification.

12.6.2 The answer paper should be retained with the course teacher for six months and then disposed off. Evaluated final theory papers have to be retained up to six months by the Director, DARE after the conduct of examination and then disposed off.

13. SEMINAR

Seminar is compulsory for all students and each student should register and present two seminars each with 0+1 credits. A student can register only one seminar in a semester and only after successful completion of the first seminar, the student is permitted to register for the second seminar.

13.1 Seminar Topic

13.1.1 The seminar topic should be only from the major field and should not be related to the area of thesis research. The seminar topics are to be assigned to the students by the Research Supervisor in consultation with HOD within three weeks after commencement of the semester.

13.1.2 Under the guidance and supervision of the Research Supervisor of the RAC, the student should prepare a seminar paper containing not less than 50 typed and printed pages with a minimum number of 75 references covering the recent 10 years time after reviewing all the available literature and present the seminar after completion of 80% attendance in the semester in the presence of the HoD, RAC, staff and post-graduate students of the concerned department.

13.1.3 The circular on the presentation of the seminars may be sent to other Departments to enable those interested to attend the same. The Research Supervisor will monitor the progress of the preparation of the seminar and correct the manuscript.

13.1.4 The student will submit two copies of the corrected manuscript to the HOD through Research Supervisor before presentation. The student will incorporate the suggestions and carry out corrections made during the presentation and resubmit three fair copies to the HOD (one to Dept. library, the second to the Research Supervisor and the third for student) within 15 days after presentation.

13.1.5 The performance of the student in the credit seminar will be evaluated and grade point awarded by the HOD along with the RAC for 100 marks. Grade Point may be given based on the following norms

Details	Marks
Coverage of literature	40
Presentation	30
Use of audio-visual aids	10
Capacity to participate in discussion and answer the questions	20
Total	**100**

14. QUALIFYING EXAMINATION

Only those students who successfully complete the qualifying examination will be admitted to candidacy of the degree. The qualifying examination consists of only Viva-voce examination.

14.1 Minimum requirement for qualifying Viva-voce Examination

The students who have completed all the courses and earned a grade point average of not less than 7.5 will be permitted to appear for the qualifying examination. Students who do not satisfy these requirements shall not be permitted to take up the qualifying examination. The qualifying examination will be conducted after the successful completion of course work.

14.2 Selection of Examiner

A panel of five external examiners for qualifying examinations shall be given by the RAC in consultation with HOD before three months of the date of completion of the student's course work to the Director, DARE. One of them will be appointed as external examiner.

14.3 Qualifying Viva-Voce Examination

14.3.1 The evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic.

14.3.2 The RAC shall conduct the qualifying viva-voce examination with one external member, who shall be a specialist in the subject from outside the university.

14.3.3 The Head of the Department will monitor and coordinate the conduct of the qualifying viva. The performance of the candidate will be graded as Satisfactory / Unsatisfactory.

14.4 Communication of Results of Qualifying Examination

The Research Supervisor shall act as chairman for the examination committee and shall be responsible for communicating the results of the examination to the Director, DARE through HOD in the prescribed format.

14.5 **Failure /Absence in Qualifying Examination**

14.5.1 When a student fails or absents for the qualifying examination, he/she may apply again for permission to appear for re-examination to the Director, DARE with the recommendation of the RAC and Head of the Department.

14.5.2 A student, who applies for re-examination should attend viva-voce. Re-examination shall not take place earlier than one month after the first examination. It will be conducted by the RAC as previously indicated.

14.5.3 If a student fails in the re-examination, further re-examination will be considered on the recommendation of the RAC, HoD and Dean, Faculty of Agriculture. If the student fails in the qualifying examination, he/she is not permitted to register for further research credits in the next semester.

15. THESIS RESEARCH

15.1 **Selection of Topic**

15.1.1 The thesis research for the Ph.D. degree should be of the nature of a definite contribution to the subject and the results should be of sufficient importance to merit publication. The findings should have some practical utility or should lead to theoretical contribution.

15.1.2 The thesis shall be on a topic falling within the field of the major specialization and shall be the result of the student's own work. A certificate to this effect duly endorsed by the major advisor shall accompany the thesis

15.2 Research Proposal

15.2.1 The research scholars shall present their broad area of research and submit a proposal to the Research Advisory Committee at the end of the first semester.

15.2.2 The research proposal has to be presented by the student in a meeting organized by the Head of the Department to get the opinion / suggestion of the faculties of the Department for

improving it. Three copies of the research proposal in the prescribed format should be sent to the Director (DARE) through the Head of the Department for approval.

15.2.3 The distribution of research credit will be as follows:

Semester	Credit Hours
I Semester	0+2
II Semester	0+10
III Semester	0+16
IV Semester	0+16
V Semester	0+16
VI Semester	0+15
Total	**0+75**

15.3 **Evaluation of Thesis Research**

15.3.1 After assigning the research problem, for each semester, the student has to submit a detailed programme of work to be carried out by him/her during the semester in the prescribed proforma. After scrutiny and approval, a copy of the research programme has to be given to the student for carrying out the work during that semester.

15.3.2 Attendance register must be maintained in the department by HOD for all the students to monitor whether the student has 80% of attendance in research.

15.3.3 The student has to submit his/her research observation note book to the Research Supervisor, who will scrutinize the progress and sign the note book with remarks as frequently as possible. This note book will form the basis for evaluation of research progress.

15.3.4 After completion of 80% attendance for research and on or before the last day of the semester, the research scholars, shall submit Progress Reports in the prescribed format duly endorsed by the Research Advisory Committee to the Director, DARE until they submit their synopsis.

15.3.5 Failure to submit the progress reports shall entail automatic cancellation of registration.

15.3.6 The minutes of the meeting of the Research Advisory Committee along with enclosures will be sent to the Director, DARE.

15.3.7 Candidates who are recipients of fellowships such as JRF/SRF directly from any of the funding agencies/ shall send the progress reports and the utilization certificates in the format prescribed by the respective funding agency through proper channel.

15.3.8 The procedure of evaluating research credits under different situations are explained hereunder.

SITUATION – I

The student has completed the research credits as per the approved programme and awarded **SATISFACTORY** by the RAC. Under the said situation, the student can be permitted to register for fresh research credits in the subsequent semester. If the student is awarded **UNSATISFACTORY**, he/she has to re-register the same block of research credits in the subsequent semester.

SITUATION – II

The student who has not secured the minimum attendance of 80 per cent shall be awarded grade 'E'. The student has to re-register the same block of research credits for which 'E' grade was awarded earlier in the following semester with prior permission. Until the completion of re-registered credits, the student should not be allowed to register for fresh (first time) research credits.

SITUATION – III

The student could not complete the research as per the approved programme of work for reasons beyond his/her control such as,

- Failure of crop
- Non-incidence of pests or disease or lack of such necessary experimental conditions.
- Non-availability of treatment materials like planting materials chemicals, etc.
- Any other impeding / unfavorable situation for satisfying the advisory committee.
- Under the said situations, grade **EE** should be awarded.

In the mark list, it should be mentioned that E grade or EE grade was awarded due to 'lack of attendance' or 'want for favourable experimental conditions'.

SITUATION – IV

When the student fails to complete the work even in the 'second time' registration, the student will be awarded **UNSATISFACTORY** and, in the mark, list the 'second time' should be mentioned.

For the registration of research credits for the third time, permission has to be obtained from the Dean based on the recommendation of the RAC, and HOD.

Permission for registration for the fourth time shall be given only by the University based on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

16. SUBMISSION OF THESIS

16.1 The research credits registered in the last semester should be evaluated only at the time of the submission of thesis, by the RAC. Students can submit the thesis at the end of the final semester.

16.2 If a student has completed the thesis before the closure of the final semester, the research supervisor can convene the RAC meeting and take decision on the submission of the thesis, provided the student satisfies 80 per cent attendance requirement.

16.3 The candidate shall be allowed to submit his/her thesis after the completion of stipulated period. A grace period of 30 days may be allowed to submit the thesis after the prescribed

duration. If the thesis is not submitted even after the grace period, the student shall pay the tuition fee for the ensuing year.

16.4 If a student is not able to submit the thesis within the grace period, the student has to re-register for the credits in the forthcoming semester. The student who re-registers the credits after availing of the grace period will not be permitted to avail of grace period for the second time. The Head of the Department can sanction the grace period based on the recommendation of advisory committee and a copy of the permission letter along with the receipt for payment of fine should accompany the thesis while submission.

16.5 Three copies of the thesis (in the approved format) shall be submitted together with the submission fee not later than three months after the submission of the synopsis.

16.6 No dues certificates from the Department and Central Libraries, Hostel, Stores, etc. must be submitted with the thesis copies. The Research Supervisor shall forward the thesis copies with the enclosures to the Director, DARE through the HOD and the Dean. A soft copy of the thesis in PDF format as prescribed by Shodhganga, shall also be submitted.

16.7 The Ph.D. scholars have to publish a minimum of two research papers in NAAS rated journals with 5 and above rating/ Scopus / Web of Science indexed journals at the time of publication of the papers. The synopsis will be accepted for processing only after showing evidences for publications of two such research papers.

16.8 The soft copy of the thesis shall be checked for plagiarism using Turnitin software. Beyond the percentage of reproduction prescribed by UGC, the thesis will not be accepted for valuation.

16.9 **Pre-submission Presentation**

16.9.1 The pre-submission presentation of the thesis is a requirement to enrich the scholar and to fine tune his/her research presentation. This presentation shall be conducted before the submission of the synopsis in the presence of the RAC, Supervisor/Co-Supervisor, HoD, Faculty members, Research Scholars and/or P.G. Students.

16.9.2 The scholar shall present the findings. The gathering may suggest ideas / references to be consulted / suggestions to improve the work.

16.9.3 A report on this event along with an attendance sheet shall be forwarded by the Research Supervisor with the endorsement of the RAC and HOD to the Director, DARE.

16.10 Submission of Synopsis

16.10.1 The submission of synopsis may be permitted 3 months before the completion of required duration on successful completion of course work.

16.10.2 The Research Scholar shall submit 3 copies of the synopsis approved by the Research Advisory Committee along with a soft copy to the Director, DARE through the Research Supervisor, the HOD and Dean of the respective Faculty.

16.10.3 Guidelines for the preparation of the synopsis are appended in Appendix I. Name of the candidate and name of the supervisor shall not be mentioned anywhere in the synopsis; enrolment number of the candidate alone shall be given. A model cover page for a synopsis is given in Appendix III.

16.11 **Guidelines for Preparation of Thesis**

16.11.1 The thesis shall not exceed 250 pages excluding the Bibliography, Appendices, etc. If it exceeds the specified number of pages, the Research Supervisor should write to university with the reasons and get prior approval from the University. The candidate shall pay a penalty for the excess number of pages as decided by the Deans Committee. The thesis should be in A4 size.

16.11.2 The specification for the preparation of the thesis is given in Appendix II. A model cover page for a thesis is given in Appendix IV.

16.11.3 The thesis shall be typed on both sides of the page in order to save paper and postage. The thesis shall contain a Certificate from the guide (Annexure) specifying that the thesis submitted is a record of research work done by the candidate during the period of study under him/her and that the thesis has not previously formed the basis for the award of any Degree, Diploma, Associate ship, Fellowship or similar title.

16.11.4 A statement from the guide indicating the extent to which the thesis represents independent work on the part of the candidate should also be made. (Appendix V)

16. VALUATION OF THE THESIS

17.1 **Panel of Examiners**

17.1.1 The thesis submitted in partial fulfilment of the Ph.D. degree shall be evaluated by two external experts one from within the country and the other from outside the country appointed by the Vice-Chancellor on the recommendation of the Research Supervisor of the RAC, HOD and Dean.

17.1.2 The external experts shall be chosen from a panel of at least five names of specialists separately from within the country and outside the country in the particular field, suggested by the Research Supervisor.

17.1.3 The external experts shall send their evaluation reports on the thesis directly to the Director, DARE along with the copy of the evaluated thesis. The Director, DARE on receipt of the reports from the two examiners will send them to the concerned Research Supervisor who is the convener of viva-voce board.

17.1.4 The Research Supervisor will send the consolidated report with his remarks to the Director, DARE through the Head of the Department. Based on the satisfactory reports of the evaluation, Viva-voce examination will be arranged.

17.1.5 After a student's thesis for Ph.D. degree is evaluated as indicated above, the thesis shall be finally accepted for the award only after the student satisfactorily completes the final Viva-voce examination.

17.1.6 The Viva-Voce board comprises the student's RAC with the addition of the external examiner who valued the thesis, and the HOD. If the HOD happens to be the Research Supervisor, the Dean, Faculty of Agriculture will nominate a senior member of the staff of the concerned Department as a member.

17.1.7 The candidate is expected to defend the thesis at the Viva-voce examination. The degree shall be awarded on the unanimous recommendation of the Viva-Voce board as

satisfactory with regard to the thesis and the performance of the student in the final Viva-voce examination.

17.1.8 The recommendation of the Viva-Voce board shall be forwarded to the Director, DARE by the Research Supervisor through HOD and Dean which shall be signed by all members of the committee and the external examiner.

17.1.9 A candidate who is not successful (unsatisfactory) at the Viva–voce examination will be permitted to undergo the Viva-voce examination again within a period of three months

17.2 **Revision and Resubmission of Thesis**

17.2.1 If an examiner recommends change / further work, the thesis will be referred to the same examiner after compliance for his/her opinion. In case of rejection by any one of the examiners, the thesis will be sent to another examiner and his / her recommendation will be final.

17.2.2 If the thesis is recommended to be revised by one or both examiners, the points of revision will be indicated clearly in the report. The necessary correction should be carried out, and the revised version should be sent to the concerned examiner(s). If the examiner(s) is / are still not satisfied with the revised version, the thesis will be rejected. If the thesis is accepted by the examiners (Evaluation), Viva–Voce examination will be conducted by the viva-voce board.

17.3 **Re-registration and Submission of Thesis**

The minimum of 80% attendance requirement for submitting the thesis after re-registration need not be insisted for those students who have fulfilled the minimum academic and residential requirement of three years.

17.4 **Extension of Time**

17.4.1 Research scholars who do not submit the thesis within the stipulated period should apply for extension of time three months before the completion of three years. Extension of time and the fees to be paid will be considered by the Deans Committee, if the extension is duly recommended by the RAC, Head of the Department, and the Dean of the Faculty, such candidates will be eligible for extension of time for a maximum period of three years.

17.4.2 The scholar will have to enrol as fresh candidates if he/she fails to submit the thesis within the maximum extension period of three years when granted.

17.4.3 If a scholar requires a few more months after the expiry of the maximum extension period of three years for the submission of the thesis as per the evaluation of the RAC, duly recommended by the Head of the Department and the Dean of the Faculty, as an exceptional case, the Deans committee may consider for re-registration to enable the scholar to submit the thesis. In any case, the time granted shall not exceed six / twelve months.

17.5.1 Number of Chances

17.5.1 A candidate will not be permitted to submit a thesis for the degree on more than two occasions. However, it will be open to the Syndicate, if the Board of Examiners so recommend, to permit the candidate to submit a thesis on a third occasion.

17.5.2 Also, he / she will not be permitted to appear for the viva-voce examination on more than two occasions.

18. DISCONTINUANCE AND READMISSION

18.1 Students admitted to the Ph.D. degree who discontinue their studies before completing the degree with written permission from the university may be re-admitted to the degree programme, provided that the student should have completed the course work before such discontinuance. However, the period of such discontinuance should not exceed five years for Ph.D. Degree from date of admission.

18.2 After completion of course work and qualifying examination, a student is eligible to discontinue temporarily his research program only once within 5 years for Ph. D. program. If the discontinuation period exceeds two semesters, the student has to forego the research credits already registered and register afresh with revised program.

18.3 In the case of field experiments or laboratory experiments in which continuity is essential for research and if a student temporarily discontinues in the middle without completing the experiments, then the entire experiment should be repeated, even if the discontinuation period does not exceed two semesters.

18.4 A student joining the studies, after discontinuation should pay the fees of the existing semester.

****

GSSC 21– Ph.D. SOIL SCIENCE

PROGRAMME OUTCOME

PO 1	Scholars will gain advanced knowledge in prime frontiers of Soil Science
PO 2	Scholars will acquire advanced and specialized skills in Soil Science
PO 3	Scholars will learn appropriate methodology to handle instruments essential for carrying out cutting edge research
PO 4	Scholars will gain computing and analytical skills for research data processing
PO 5	Scholars will have a comprehensive understanding of methods and techniques applicable to their specific research, writing and presenting technical documents and will have capacity to philosophically interpret their research results

PO and CO Mapping Matrix

Correlation levels 1, 2 and 3 are as defined below:

1 - Low
2 - Moderate/ Medium
3 - Substantial /High

SEMESTER WISE DISTRIBUTION OF CREDIT

Semester	Major Course	Minor Course	Supporting Course	Seminar	Research	Total credit	Non credit Compulsory course
I	7	4	2	1	2	**15**	-
II	5	2	3	1	10	**22**	-
III	-	-	-	-	16	**16**	Research and Public Ethics
IV	-	-	-	-	16	**16**	**MOOC**
V	-	-	-	-	16	**16**	-
VI	-	-	-	-	15	**15**	-
Total credit	**12**	**6**	**5**	**2**	**75**	**100**	-

Distribution of Courses

Course code	Course Title	Credit hour (Theory + Practical)
	Major Courses (Any five out six)	12
SOL603	Physical chemistry of soil	2 (2 +0)
SOL 604	Soil genesis and micromorphology	2 (2 +0)
SOL 602	Modern concept in soil fertility	2 (2 +0)
SOL 608	Clay Mineralogy	3(2 +1)
SOL 606	Soil resource management	3 (3+0)
SOL 609	Recent trends in soil microbial biodiversity	3(2 +1)
	Minor courses (Any three out of four)	
SOL 601	Recent trends in soil physics	2 (2 + 0)
SOL605	Bio-chemistry of soil organic matter	2 (2 + 0)
SOL 607	Modelling of soil plant system	2 (2 + 0)
SOL 610	Soil and Water Pollution and Remediation	2 (2 + 0)
	Supporting Courses	5
COM 601	Advances in Computer Applications (1+1)	2
STA 601	Advances in Designs of Experiments (2+1)	3
	Seminar	
SOL691	Doctoral Seminar – I (0+1)	1
SOL 692	Doctoral Seminar – II (0+1)	1
	Research	
SOL699	Doctoral Research (0+75)	75
	Noncredit compulsory courses	
NGC611	Research and Publication Ethics (2+0)	-
NGC612	**MOOC** (2+0)	-

SOL 601 RECENT TRENDS IN SOIL PHYSICS (2+0)

Objectives:

1. To understand the soil water interactions and theories of horizontal and vertical infiltration.
2. To understand the movement of salts in soil
3. To understand the movement of air in soil
4. To understand the Soil crust and clod formation; structural management of puddled rice soils.
5. To understand the Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems

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). 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 water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow- Theories of horizontal and vertical infiltration under different boundary conditions.

UNIT II: 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 III: Soil air and aeration, mass flow and diffusion processes. Thermal properties of soil, heat transfer in soils, differential equation of heat flow, and measurement of thermal conductivity of soil. Soil, plant and Water relations. Plant uptake of soil moisture, Water balance and energy balance in the field- irrigation and water use efficiency.

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

UNIT V: 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.

Lecture Schedule

1. Soil-water interactions- soil water potential- types of soil water-soil water movement-soil water retention curves
2. Free energy and thermodynamic basis of potential concept- I & II law of the dynamics chemical potential of soil water and entropy of the system
3. Fundamentals of fluid flow, Poiseuilles law, Laplace's equation
4. Darcy's law in saturated and unsaturated flows; Reynolds number
5. Development of differential equations in saturated and unsaturated water flow
6. Capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow

7. Theories of horizontal and vertical infiltration under different boundary condition-soil moisture measurement
8. Movement of salts in soils – salt distribution-upward/downward movement- Efficiency of water in moving salt
9. Models for miscible-immiscible displacement-column displacement method- pressure membrane approach-monolithic lysimeters-zero-tension lysimeters- porous cup vacuum lysimeters
10. Infiltration models- Physical models -Green and Ampt - Kostiakov Equation - -Horton Equation- Philip Equation
11. Semi-empirical models- Empirical models-soil conservation service model.
12. Diffusion, mass flow and dispersion of solutes and their solutions through differential equations
13. Dispersion of solutes -Advection- Diffusion- Brownian motion of the molecules- mechanical and hydrodynamic dispersion- Adsorption/desorption.
14. Break-through curves- Air-entry suction- Hysteresis.
15. Soil air and aeration, mass flow and diffusion processes-Fick's law-composition of soil air- management strategies to improve soil aeration-measurement of soil aeration
16. Importance of soil thermal properties- Correlations between thermal conductivity and soil density or porosity- Effects of ions, salts and other solutes on soil thermal properties
17. **First Test**
18. Thermal properties of soil, heat transfer in soils, differential equation of heat flow-Fourier law
19. Thermal conductivity of soil-at different moisture levels- Needle probe- Thermal cell
20. Measurement of thermal conductivity of soil- instruments to measure thermal conductivity- guarded hot plate-hot wire- modified hot wire- laser flash diffusivity
21. Soil crust and clod formation-methods of crusting – physical/ chemical/biological soil crusting- impact of soil crust
22. Kinds of Soil Crust- Structural Crusts- Erosion and Depositional Crusts- Control of Soil Crusting-degree of clod development
23. Structural management of puddled rice soils- Effects of puddling on soil properties- Structural management of puddled rice soil
24. Soil conditioning- concept - types- organic / mineral / synthetic soil conditioners
25. Soils conditioners - characteristics, working principles, significance in agriculture
26. Solar radiation - beam and diffuse components- Short-wave / long wave radiation
27. Beneficial & Hazardous Effects of Solar Radiation- solar radiation –soil-plant-human health
28. Solar and terrestrial radiation measurement- Actinometer – Pyrheliometer-Pyranometer-Pyranograph- Albedometer -working principles.
29. Solar and terrestrial radiation measurement -Bolometer –Photometer–Spectroheliograph-Spectrobolometer -Radiometer-working principles

30. Dissipation and distribution in soil-crop systems
31. Evapo-transpiration-units-concepts-reference crop evapo-transpiration-energy Balance-microclimatological method
32. Prediction of evapotranspiration using aerodynamic and canopy temperature-based models- Penman-Monteith equation
33. Canopy temperature and leaf diffusion resistance in relation to plant water deficit-ET &Irrigation- Computation of Water requirement
34. Evaluation of soil and plant water status using infra-red thermometer

Course Outcome

CO1: Students comprehend the various modern concepts of soil physics

CO2: Students learn concepts and laws governing soil air, water temperature and its effect on plant growth.

CO3: Students are exposed to various soil physical constraints and their management

CO4: Students understand the various working principles of solar radiation measurements

CO5: Students gain knowledge on soil conditioning concept and different types of soil conditioners

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2	-	-	2	-
CO2	1	-	-	1	-
CO3	1	-	-	-	-
CO4	1	-	1	1	1
CO5	2	1	-	1	-

References

1. Baver L.D, Gardner W.H & Gardner WR. 1972. Soil Physics. John Wiley & Sons
2. Hanks R.J and Ascheroft G.L. 1980. Applied Soil Physics. Springer Verlag.
3. Ghildyal B.P and Tripathi R.P. 1987. Wiley Eastern Limited.
4. Hillel D. 1980. Applications of Soil Physics. Academic Press.
5. Hillel D. 1980. Environmental Soil Physics. Academic Press.
6. Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
7. Kirkham D and Powers W. L. 1972. Advanced Soil Physics. Wiley Interscience
8. Lal R and Shukla M.K. 2004. Principles of Soil Physics. Marcel Dekker.
9. Oswal M.C.1994. Soil Physics. Oxford & IBH
10. Arun Kumar Saha and Anuradha Saha. 2012. Text Book of soil physics

Websites

1. https://www.nature.com/scitable/knowledge/library/soil-water-dynamics.
2. https://www.vaderstad.com/en/know-how/basic-agronomy/let-nature-do-the-work/soil-water
3. http://lawr.ucdavis.edu.
4. http://digitool.library.mcgill.ca/
5. http://www.soilmanagementindia.com

SOL 602 MODERN CONCEPT IN SOIL FERTILITY (2 +0)

Objectives:

1. The students are expected to gain in-depth and advanced knowledge on modern concepts of soil fertility, nutrient availability, nutrient movement and work on models relating to transformation and movement of nutrients in soil
2. To have a vivid understanding of chemical equilibria involving nutrient ions in submerged soils ad kinetic studies of nutrients in soils
3. To know the modern concepts of fertility evaluation and fertilizer application and SSNM for precision agriculture
4. To recognize changes in soil properties and learn about permanent manurial experiments, long term fertilizer experiments and soil productivity under long term intensive cropping
5. To acquire facts on the importance of carbon sequestration in soil and its effect on soil quality and crop productivity

Theory

Unit I

Nutrient availability-concept and relationships, modern concepts of nutrients availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices. 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 II

Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit III

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting. 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 IV

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit V

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.

Theory Lecture Schedule

1. Nutrient availability- concepts and relationships
2. Modern concepts of nutrient availability
3. Soil colloids and nutrient availability
4. Soil amendments and nutrient availability

5. Maintenance of nutrients, soil solution and plant growth
6. Nutrient response functions and availability indices
7. Nutrient movement in soils
8. Nutrient absorption by plants
9. Mechanistic approach to nutrient supply and uptake by plants
10. Models for transformation and nutrient transport in soil
11. Chemical equilibria involving nutrient ions in submerged soils
12. Kinetic studies of major nutrients in soils
13. Kinetic studies of micro nutrients in soils
14. Modern concepts of fertilizer evaluation- approaches and fertilizer recommendation
15. Nutrient Use Efficiency and nutrient budgeting
16. Modern concepts in fertilizer application
17. **First Test**
18. Soil fertility evaluation techniques
19. Role of soil tests in fertilizer recommendations
20. SSNM for precision agriculture
21. Monitoring Physical changes in soil
22. Monitoring chemical changes in soil
23. Monitoring biological changes in soil
24. Permanent Manurial trials - Impact
25. Long-term fertilizer Experiments- Lessons learnt
26. Soil productivity under long term intensive cropping
27. Direct effect of fertilizer Use
28. Residual and cumulative effect of fertilizer Use
29. Significance of carbon- a nutrient central to soil fertility
30. Carbon cycle- stocks, pools and fluxes
31. Green house effect and climate change
32. Carbon sequestration- Process and types
33. Carbon sequestration- Sustenance of soil quality
34. Carbon sequestration- Improvement in crop productivity

Course Outcome:

CO1: The student will have a clear understanding of nutrient movement and models for transformation and movement of nutrients in soil

CO2: The student will gain understanding of chemical equilibria involving nutrient ions in submerged soils and kinetic studies of nutrients in soils

CO3: The student will know modern concepts of fertility evaluation and fertilizer application and SSNM for precision agriculture

CO4: The students will learn about Permanent manurial experiments, long term fertilizer Experiments and soil productivity under long term intensive cropping

CO5: The student will understand the importance of carbon sequestration in soil and its effect on soil quality and crop productivity

CO-PO mapping matrix

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	1	-	-	-	-
CO2	-	2	1	-	-
CO3	1	2	1	2	1
CO4	1	1	2	2	1
CO5	1	1	1	1	1

References:

1. Barber SA. 1995. Soil Nutrient Bioavailability. John Wiley Publication, New Delhi
2. Barker V Allen and Pilbeam David J. 2007. Handbook of Plant Nutrition. CRC / Taylor & Francis, New Delhi
3. Brady N.C. and Weil R.R. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Educ., Delhi
4. Kabata- Pendias Alina 2001. Trace Elements in Soils and Plants. CRC/ Taylor & Francis, New Delhi
5. Kannaiyan S, Kumar K and Govindarajan K. 2004. Biofertilizers Technology. Scientific Publishing company, New Delhi
6. Mortvedt J.J, Shuman L.M, Cox F.R and Welch R.M. (Eds.). 1991. Micronutrients in Agriculture. 2nd Ed. Soil Science Society of America, Madison.
7. Prasad R and Power J.F. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press, New Delhi
8. Stevenson F.J. and Cole M.A. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley Publication, New Delhi.
9. Tisdale S.L, Nelson W.L, Beaton J.D and Havlin J.L. 1990. Soil Fertility and Fertilizers. 5th Ed. Macmillan Publ. Company, New York.
10. Wild A. (Ed.). 1988. Russell's Soil Conditions and Plant Growth. 11th Ed. Longman, London

Web sites

1. http://www.hillagric.ac.in

SOL 603 PHYSICAL CHEMISTRY OF SOILS (2+0)

Objectives

1. To impart knowledge about modern concepts of physical chemistry
2. To understand the predictive approaches for cation exchange equilibria in soil
3. To enrich the knowledge about the thermodynamics of nutrient transformations in soils
4. To acquire advance knowledge about adsorption/desorption isotherms
5. To update the students about recent advances in solubility equilibria in soil

Theory

Unit I

Colloidal chemistry of inorganic and organic components of soils - their formation, clay- organic interaction.

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Lecture schedule

1. Clay fraction of soil-Classification-Unit cell and crystal lattice,
2. Structure of silicate clays-Kaolinite, Halloysite, Smectite group, Illite, Vermiculite, Chlorite
3. Structure of silicate clays- Mixed layer clays, Iron and Aluminium Hydrous oxide clays, amorphous clays, Allophane
4. Total Surface area, specific surface area, origin of negative charges in soil clays-isomorphous substitution, dissociation of exposed hydroxyl groups
5. Positive charges and zero point of charge- use of Δ pH in the determination of negative or positive charges
6. Soil humus and their properties
7. Clay humus interaction in soil
8. Predictive approaches for cation exchange equilibria – thermodynamics.
9. Surface potential-Electrical double layer theory, Helmholtz double layer theory, Guoy-Chapman double layer theory, Stern Double layer theory

10. Structure and properties of diffuse double layer.- Relationships among different selectivity coefficients
11. Zeta potential-Electrical double layer theory and stability of clays. Effect of Flocculation and dispersion on plant growth
12. Thermodynamics of NPK transformations in soils
13. Thermodynamics of Ca, Mg. S transformations in soils
14. Thermodynamics of micronutrients transformations in soils
15. Ion Exchange - Cation exchange-Adsorption of cations by soil colloids- cation exchange reactions
16. Cation exchange capacity- Types of cation exchange capacity, the Exchanging power of cations - ionic composition of the exchange complex
17. **First test**
18. Empirical equations of cation exchange – The Freundlich equation, The Langmuir-Vageler Equation. Mass action law equations of cation exchange – The Kerr and Gapon equation, Vanselow equation
19. Kinetic equations of cation exchange - thermodynamics equation of cation exchange-The Quantity/Intensity (Q/I) relation
20. Cation exchange equation based on Donnan theory, Eriksson, Diffuse Double layer, Schofield's ratio law-
21. Cationic and anionic exchange and molecular interaction
22. Types of adsorption-positive and negative adsorption-specific and nonspecific adsorption. Adsorption characteristics-forces of adsorption-physical forces, chemical forces, Hydrogen bonding-Hydrophobic bonding-electrostatic bonding-coordination reactions-ligand exchanges
23. Four categories of adsorption Isotherms-Freundlich equation, Langmuir equation, BET, Gibbs equation
24. Langmuir adsorption isotherm
25. Freundlich adsorption isotherm
26. Normalized exchange isotherm
27. BET equation
28. Selective and non-selective adsorption of ions on inorganic surfaces of soil materials
29. organic surfaces of soil materials (citation of utility in agricultural system)
30. Common solubility equilibria of carbonates
31. Common solubility equilibria of iron oxide and hydroxides
32. Common solubility equilibria of Aluminium silicate common solubility equilibria of aluminium phosphate
33. Electrochemical properties of clays
34. Electrochemical properties of clays (citation of examples from agricultural use)

Course Outcomes

CO1: The students get familiarize with modern concepts of physical chemistry

CO2: The scholar gain comprehensive knowledge about predictive approaches for cation exchange equilibria in soil

CO3: The students acquired knowledge on current research in Thermodynamics of nutrient transformations in soils

CO4: The scholar acquaint themselves on recent advances in Adsorption/desorption isotherms

CO5: The students acquired knowledge on common solubility equilibria in soil

CO- PO Mapping

	PO 1	PO 2	PO 3	PO4	PO 5
CO 1	1	1	-	1	-
CO 2	2	-	1	1	1
CO 3	2	1	-	-	1
CO 4	1	1	-	1	-
CO5	-	-	1	-	-

References

1. Tan KH, 2017, Principles of soil chemistry, CRC press, New Delhi
2. McBride MB. 1994. Environmental Chemistry of Soils. Oxford Univ. Press
3. Sparks DL. 1999. Soil Physical Chemistry. 2nd Ed. CRC Press.
4. Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford Univ. Press.
5. Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley.
6. Saroj Kumar Sanyal 2018 Text book of soil chemistry, Daya Publishing house, New Delhi
7. Hinrich , L. Bohn , Brian L. Mcneal , George A. O'Connor 2011 Soil Chemistry, Third edition, Wiley India Pvt Ltd, New Delhi
8. Alfred R. Conklin Jr.(Eds)2014Introduction to Soil Chemistry: Analysis and Instrumentation Jhon Wiley &Sons
9. Donald Sparks 2002 Environmental Soil Chemistry. Elsevier Publisher
10. Van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

Websites

1. https://agroecology.ucsc.edu/about/publications/Teaching-Organic-Farming/PDF-downloads/2.2-soil-chemistry.pdf
2. https://www.dcr.virginia.gov/soil-and-water/document/nmagscbsc.pdf
3. https://www.cambridge.org/core/books/soil-chemistry-and-its-applications/84917BB425356999398D8772F16425ED
4. https://ia803400.us.archive.org/33/items/Agronomy/Soil%20Chemistry.pdf
5. https://www.srs.fs.usda.gov/pubs/ja/2005/ja_2005_knoepp_001.pdf

SOL 604 : SOIL GENESIS AND MICROMORPHOLOGY (2+0)

Objectives

1. To enable students to explain the concept of soil forming rocks and minerals
2. To explain the concept of weathering of rocks and minerals
3. To acquaint students with soil genesis in terms of factors and processes of soil formation,
4. To experience on the morphological characteristics of soil and to gain the knowledge on soil taxonomy
5. To enable students to understand about micro pedological features of soil profile and to make the students expertise in solving field problems

Theory

Unit–I: Pedogenic evolution of soils

Pedogenic evolution of soils – formation of rocks and minerals, their characterization and classification. soil composition and characterization

Unit–II: Weathering and soil formation

Weathering of rocks, minerals and soil formation –weathering sequences and stability of minerals. Factors of soil formation –Active and passive. Pedogenic processes - Fundamental and specific.

Unit–III: Profile development

Basic System of Horizon and Layer Designations -Master Horizons and Layers-Transitional and Combination Horizons-*Vertical Subdivisions-Discontinuities*-Sample Horizons and Sequences - Soil profiling & Mineralogical and chemical analysis

Unit– IV: Micro morphology of soils

Micro-pedological features of soils – their structure, fabric analysis, role of micro morphology in soil genesis and classification.

Unit–V: Recent trends in Soil Taxonomy

Concepts and utility of soil classification – Historical developments, Early, modern systems of soil classification, Newer soil classification systems - USDA system of soil classification

Land evaluation methods –land capability classification, land irrigability classification, storie index rating, productivity rating and fertility capability classification.

Lecture Schedule

1. Pedogenic evolution of rocks in relation to Physico - chemical and mineralogical processes.
2. Classification of rocks and their characterization
3. Pedogenic formation of minerals in relation to Physico - chemical and mineralogical processes
4. Formation of soil minerals with relevance to crop production
5. Classification and characterization of minerals
6. Soil composition and characterization
7. Weathering –Agencies
8. Weathering of rocks and minerals –Physical Processes
9. Weathering of rocks and minerals – Chemical and biological Processes
10. Quantifying approaches of weathering process.

11. Stability and weathering sequences of minerals.
12. Factors of soil formation – active
13. Factors of soil formation – passive
14. Fundamental soil forming processes
15. Specific soil forming processes
16. Soil forming processes responsible for development of different soil orders
17. **First test**
18. Soil profile development and description
19. Basic System of Horizon and Layer Designations
20. Assessment of Soil profile development by chemical analysis
21. Assessment of Soil profile development by Mineralogical analysis
22. Soil micromorphology – principles, terminologies and definitions
23. Techniques used in soil micro morphology
24. Relationship of soil matrix, plasma and voids. Soil fabric analysis
25. Cutans - Definition and classes of cutans
26. Preparation of thin sections of soil -micro morphological characters
27. Concepts and utility of soil classification
28. Soil taxonomy – salient features, recent trends and hierarchy
29. Main characteristics of taxa ,criticism and appreciation of soil taxonomy
30. Recent soil classification systems – USDA
31. Description of different soil orders and their uses
32. Land evaluation- land capability classification ,land irrigability classification
33. Storie index rating, productivity rating ,
34. Fertility capability classification , crop suitability classification

Course outcome

CO1: The course aims to provide the basic knowledge to understand the soil formation processes through the examination of its composition, organization and characteristics, in order to describe and interpret the soils correctly.

CO2: The course provides investigation tools and techniques for the interpretation of the soil as a source of information

CO3: To make students to know the descriptive techniques of a soil profile and interpret the main horizons physico-chemical properties and deduce the formation processes and know how to distinguish the main soil groups

CO4: The course aims to make the students to master on the theoretical concepts on soil properties and features and classification and to have knowledge on the soil morphology and improve ability to classify soil

CO5: To evaluate class of soil capability/suitability and provide recommendations which based on efforts to improve limiting factors of soil characteristics based on current technology

CO-PO Mapping

	PO1	PO 2	PO 3	PO 4	PO 5
CO1	-	1	-	-	-
CO2	-	1	-	-	-
CO3	-	1	2	-	-
CO4	-	1	-	-	-
CO5	-	1	2	1	-

References

1. Buckman H.A., and Nyle C.Brady, 2017., The Nature and Properties of Soils, Andesite Press Publishers
2. Boul, S.W., Hole, F.D. and Mc Cracken, R.J. 1995. Soil Genesis and Classification. Affiliated East West Press Pvt. Ltd. New Delhi
3. Das, P.C. 2002. Soils of India. Kalyani Publishers, Ludhiana
4. Dipak Sarkar. 2003-Fundamentals and applications of Pedology. Kalyani Publishers, New Delhi.
5. Fundamentals of Soil Science. 2002. ISSS Publication, IARI, New Delhi.
6. Grim.R.E.1968.Clay Mineralogy. McGraw Hill **,** New York
7. Kolay.A.K, 2017, Basic Concepts of Soil Science. New Age International Publishers
8. Miller.C.E. and Turk, L.M. 2006. Fundamentals of Soil Science , Biotech Books, Trinagar, New Delhi110035
9. Schertz R.J. and Thompson. M.L.2015. Soils- genesis and geomorphology. Cambridge University Press, New York, USA
10. Soil Survey Manual, 2017.Soil Science Division Staff, United States, Department of Agriculture, Handbook No.18

Websites

1. http://www.ebooks.com /1702291/soil- science/rowell-david-l/
2. https://www.ebooks.com/1307442/soil-components/gieseking-j-e/
3. https://www.ebooks.com/264448/soil-classification/eswaran-hari-ahrens-robert-rice-thomas-j-stewart-b/
4. https://www.ebooks.com/219410/soil-formation/breemen-nico-van-buurman-peter/

SOL 605 BIOCHEMISTRY OF SOIL ORGANIC MATTER (2+0)

Objectives

1. To understand the composition of soil organic matter, its distribution and significance in soil.
2. To develop a vivid knowledge on soil organic matter decomposition and its chemistry.
3. To review different theories on hums synthesis in the soil.
4. To impart knowledge related to chemistry and reactions of organic substances and to understand its role in nutrient transformation and chelation reaction in soil.
5. To analyze the mechanisms of humus - pesticide interactions in soil their significance in the environment

Theory

UNIT I

Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter pools.

UNIT II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

UNIT III

Nutrient transformation – N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.

UNIT IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.

UNIT V

Humus - pesticide interactions in soil, mechanisms- Current thinking in the maintenance of soil organic matter, compost, Vermitechnology. Carbon sequestration-methods and significance

Lecture Schedule

1. Soil organic matter-Introduction
2. Organic matter pools in soil
3. Composition and distribution of organic matter in soil
4. Functions of organic matter in soil
5. Humic substances: structure and concept
6. Environmental significance of humic substances
7. Decomposition of organic residues in soil in relation to organic matter pools.
8. Methods of assessing the age of humic substances
9. Biochemistry of the humus formation
10. Different pathways for humus synthesis in soil – lignin theory
11. Humus synthesis- Polyphenol theory, sugar- amine theory
12. Soil carbohydrates
13. Soil lipids
14. Nutrient transformation of N and interaction with humic substances

15. Nutrient transformation of P and interaction with humic substances
16. Nutrient transformation of S and interaction with humic substances
17. **First test**
18. Significance of chelation reactions in soils
19. Reactive functional groups of humic substances
20. Interaction of trace elements with humic substances
21. Adsorption of organic compounds by clay
22. Role of organic substances in pedogenic soil aggregation processes
23. Clay-organic matter complexes
24. Humus - pesticide interactions in soil and their mechanisms
25. Characterization of clay humus complex and clay pesticide complex
26. Recycling of soil organic matter
27. Criteria for recycling of organic matter
28. Crop residue management
29. Importance of compost in maintenance of soil organic matter
30. Composting techniques
31. Vermitechnology
32. Carbon sequestration-Environmental significance
33. Soil carbon sequestration methods
34. Impact of agriculture on Soil carbon sequestration

Course outcome

CO 1: Understand the major pools of soil organic matter

CO2: Gain thorough knowledge on soil organic matter decomposition and its chemistry.

CO3: Widen their knowledge about the mechanisms of humus formation.

CO4: Examine the reactive functional groups of humic substances and the mechanisms of clay- organic complexes.

CO5: Understand the significance of humic substances and pesticides interaction in the soil.

CO- PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1	-	-	1	-
CO2	2	1	-	1	-
CO3	2	-	1	1	1
CO4	1	1	2	-	1
CO5	1	1	2	1	1

References

1. Beck A.J., Jones K.C., Hayes M.H.B and Mingelgrin U. 1993. Organic Substances in Soil and Water: Natural Constituents and their 104 Influences on Contaminant Behavior. Royal Society of Chemistry, London.
2. Gieseking JE. 1975. Soil Components. Vol. 1. Organic Components. Springer-Verlag.

3. Kristiansen P, Taji A and Reganold J. 2006. Organic Agriculture: A Global Perspective. CSIRO Publ.270
4. Magdoff. F and Weil RR 2004. Soil Organic Matter in Sustainable Agriculture. CRC Press.
5. Mercky R and Mulongoy K. 1991. Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture. John Wiley & Sons.
6. Paul EA. 1996. Soil Microbiology and Biochemistry. Academic Press.
7. Stevenson FJ. 1994. Humus Chemistry – Genesis, Composition and Reactions. John Wiley & Sons.
8. Stotzky and Jean-Marc Bollag (ed.,) 1992 Soil Biochemistry Marcel Decker. Inc. New York
9. Vaughan, D and R. E. Malcolm, (Eds)1985 Soil Organic Matter and Biological Activity Martinus Nijhoff, Dordrecht, The Netherlands
10. Kononova M.M 2013 Soil Organic Matter: Its Nature, Its Role in Soil Formation and in Soil Fertility Pergamon press Publishers, Oxford

Websites

1. https://ecaf.org/wp-content/uploads/2021/02/Soil_Organic_Matter-Brian_Murphy.pdf
2. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/soil-organic-matter
3. https://www.frontiersin.org/articles/10.3389/feart.2021.590103/full
4. https://www.nature.com/articles/nature16069
5. http://eagri.org/eagri50/SSAC121/lec17.pdf

SOL 606 SOIL RESOURCE MANAGEMENT (3 +0)

Objectives

1. To impart the student's basic holistic knowledge on soil resources
2. To gain knowledge to develop technology and solutions that increase efficient use of soil and water resources,
3. Examine types of soil degradation, including erosion, compaction and salinity
4. Learn contribution of soil resources to sustainable development
5. To gain knowledge on protecting, conserving and improving land resources for efficient water resources

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. 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 II

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 arid lands. Management of forest, peat and muck soils

Unit III

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

Unit IV

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 V

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

Lecture schedule

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

4. Concept of sustainable land management (SLM)
5. Spatial variability of soils
6. Soil quality and food security
7. Soil quality indices,
8. Conservation agriculture in relation to soil quality
9. Soil resilience and resistance
10. Types of land degradation and desertification
11. Factors of land degradation and desertification
12. Causes of land degradation and desertification
13. GLASOD classification
14. GIS and remote sensing in monitoring, diagnosis and mapping of land degradation-I
15. GIS and remote sensing in monitoring, diagnosis and mapping land degradation-II
16. History, distribution, identification and description of soil erosion problems in India
17. Forms of soil erosion
18. Impact of soil erosion-on-site and off-site effects
19. Soil conservation in hilly lands
20. Soil conservation in arid and semiarid lands
21. Soil conservation in coastal lands
22. Management of peat soils
23. Management of forest soils
24. Management of muck soils
25. Soil conservation planning
26. Land capability classification
27. **First test**
28. Soil conservation in special problem areas such as hilly lands
29. Soil conservation in special problem areas such as arid and semi-arid regions
30. Soil conservation in special problem areas of waterlogged and wetlands
31. Land restoration and conservation techniques
32. Erosion control
33. Reclamation of salt affected soils-1
34. Reclamation of salt affected soils-II
35. Mine Land reclamation
36. Afforestation
37. Organic products
38. Soil fauna
39. Biodegradation
40. Watershed management-definition, concepts and objectives
41. Watershed management- approaches
42. Water harvesting and recycling
43. Flood control in watershed management
44. Socio-economic aspects of watershed management

45. Case studies for monitoring and evaluation of watersheds
46. Agro-ecological regions of India
47. Potentials and constraints of soils of different regions-1
48. Potentials and constraints of soils of different regions-II
49. Land evaluation and rationalizing land use
50. Decision support system with relation to land management
51. National and international soil policy considerations

Course Outcome

CO1: Understand terminology used in soil and water conservation and management.
CO2: Understand the processes of soil erosion and degradation.
CO3: Understand the problems caused by poor management and subsequent soil degradation.
CO4: Gain practical experience in utilizing tools for soil resource management.
CO5: Understand the societal implications of soil and land use management

CO- PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1	-	-	-	-
CO2	1	-	-	-	-
CO3	2	1	1	1	-
CO4	-	2	1	1	-
CO5	-	1	1	-	-

References

1. Abrol I.P and Dhruvanarayana VV. 1990. Technology for Wasteland Development. ICAR, New Delhi.
2. Blackwell, Dent D and Young A. 1981. Soil Survey and Land Evaluation. George Allen and Unwin, London.
3. Dan Binkley D and Fisher R. 2012. Ecology and Management of Forest Soils,4th Edition, Wiley.
4. FAO. 1996. Land Quality Indicators and their Use in Sustainable Agriculture and Rural Development. FAO Land and Water Bulletin.5. FAO, Rome.
5. Faroq M and Siddique K. (Ed.). 2015. Conservation Agriculture, Springer Nature, Chennai, India.
6. Lal R, Blum W.E.H., Valentine C and Stewart BA. (Editors). 1988. Methods for Assessment of Soil Degradation. CRC Press, Boca Raton.
7. Sehgal J. 2014. A Text Book of Pedology- Concepts and Application. Kalyani publishers, New Delhi.
8. SSSA 1996. Methods for Assessing Soil Quality. SSSA Publication Number 49, Madison, Wisconsin, USA.

9. Ademola K. Braimoh Paul L. G. Vlek. 2008. Land use and soil resources. Springer Nature. Switzerland
10. Obi Reddy, N.G. Patil, Arun Chaturvedi.2018.Sustainable Management of Land Resources An Indian Perspective. Rs 250

Web sites

1. https://www.nal.usda.gov › legacy › topics › soil-resources
2. Soil Resource Management for Sustainable Development https://core.ac.uk › download › pdf.
3. Natural resource management - Website - Local Land Services https://www.lls.nsw.gov.au

SOL 607 MODELLING OF SOIL PLANT SYSTEM (2 +0)

Objectives

1. Integrate different steps of crop models designing
2. Understand formalisms used to model different mechanisms occurring in the soil/plant/atmosphere system
3. Use crop models to simulate functioning of agro- ecosystems
4. Discover some instances of the use of modeling in farmers
5. To gain knowledge on nutrient uptake model to assess soil and crop productivity

Theory

Unit I

Introduction, terms and definitions; classification of models; Taylor series; numerical methods of differentiation and integration.

Unit II

High level computer language: FORTRAN-its commands and usage; testing and evaluation of model.

Unit III

Description of spatially homogeneous models; K transformation model; nitrogen and phosphorus dynamics in soil.

Unit IV

Spatially heterogeneous models; equation of continuity; Simulation of water flow through soil; Explicit and Explicit-Implicit method; simulation of solute movement through soil with variable moisture flux by explicit-implicit method.

Unit V

Nutrient uptake model: Integration of nutrient movement in soil (mass flow and diffusion) and uptake by plants (Michaelis-Menten kinetics); Nutrient uptake model: Solubility and free ion activity model

Theory schedule

1. Introduction- what is modelling
2. What is Simulation model? How to develop a simulation Model?
3. Basic concepts in modelling and simulation
4. Classification of models- concrete models, mathematical models, and computational models.
5. Introduction to Taylor Series
6. What is a Power Series?
7. What is a Taylor Series?
8. Function approximation using Taylor polynomials
9. Application of Taylor series
10. Numerical differentiation- Computation of derivatives- A direct approach
11. Numerical differentiation - Partial Derivatives
12. Numerical Integration- Newton-Cotes Integration Formulas
13. High-Level Programming Language- introduction
14. Advantages of high-level programming language and high level versus low level language

15. Introduction to FORTAN
16. FORTRAN Layout, Basic Data Types and commands
17. **First test**
18. FORTAN usage in soil science- soil bulk density, soil moisture, carbon input in soil
19. Model evaluation - Qualitative Criteria and Quantitative Criteria
20. Model testing – Criteria
21. K transformation model- importance, process and application
22. Modelling P dynamics in the soil plant system – introduction, modelling case studies on chemistry and P uptake -1
23. Modelling P dynamics in the soil plant system – introduction, modelling case studies on chemistry and P uptake-II
24. Modelling N dynamics in the soil plant system - introduction, different model studies-I
25. Modelling N dynamics in the soil plant system -introduction, different model studies-II
26. Spatially heterogeneous models; equation of continuity
27. Simulation of water flow through soil- introduction and different model case studies
28. Explicit and Explicit-Implicit method – definition, differences and choosing the method
29. Simulation of solute movement through soil with variable moisture flux by explicit-implicit method.
30. Nutrient uptake model- different types
31. Nutrient movement in soil (mass flow and diffusion)
32. Uptake of nutrients by plants (Michaelis-Menten kinetics)
33. Solubility model - Prediction of free metal ion activity
34. Free ion activity model- description

Course Outcome

CO1: Gained knowledge on various processes involved in soil plant system

CO2: How simulation modeling can be used to understand and forecast multiple interactions among various processes and predict their environmental impact.

CO3: Help to develop an effective decision support system

CO4: Student gained knowledge on methodology of using different models

CO5: Student learnt to understand the basics of simulation

CO- PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2	-	1	-	-
CO2	1	-	-	1	1
CO3	2	1	-	2	1
CO4	2	1	1	1	1
CO5	-	1	1	-	-

References

1. Datta S.C. 2008. Theory and Principles of Simulation Modelling in Soil-Plant System. Capital Publishing Company, New Delhi.
2. Frame J and Thornley J.H.M. 1984. Mathematical Models in Agriculture—A Quantitative approach to problems in agriculture and related science. Butterworth and Co. Ltd.
3. Freud P.J. and Minton P.D. 1979. Regression Methods—A tool for data Analysis. Marcel Dekker Inc., New York.
4. Frissel M.J. and Reinger P. 1974. Simulation of Accumulation and Leaching in Sils. Oxford and IBM Pub. Co., New Delhi.
5. Hanks J and Richie J.T. (Eds.). 1991. Modeling Plant and Soil System. Agronomy Bulletin No. 31, ASA, SSSA Madison, Wisconsin, USA.
6. Lipschutz S and Poe A. 1978. Schaum's Outline Series–Theory and Problems of programming with FORTRAN. McGraw-Hill Book Co., Singapore.
7. Penning de Vries F.W.T, Jansen D.M, Ten Berge H.F.M. and Baker A. 1989. Simulation of ecophysiological processes of growth in several annual crops. PUDOC, Wageningen.
8. Shaffer M.J., Ma L. and Hansen S. 2001. Modelling Carbon and Nitrogen Dynamics for Soil Management. Lewis Publishers, Boca Raton
9. Plentinger, M.C. and Penning de Vries, F.W.T. (Editors) 1996. CAMASE Register of Agro-ecosystems Models. DLO-Research Institute for Agrobiology and Soil Fertility (AB-DLO) Agricultural Systems - at http://www.elsevier.com/wps/product/cws_home /
10. Rolf Nieder and Benbi. D. (Eds). Handbook of Processes and Modeling in the Soil-Plant System. CRC press, London

Web sites

1. Documentation of the respective models. (http://www.simulistics.com/ for Simile; http:// www.iseesystems.com for Stella; and http://www.vensim.com/software.html for vensim PLE)
2. http://www.icasa.net/dssat/index.html for DSSAT; http://www.brc.tamus.edu/epic/ for EPIC
3. http://www.nrel.colostate.edu/projects/century/ for Century
4. http://www.alterra.wur.nl/NL/for WOFOST
5. http://www.apsru.gov.au/ apsru/Default.htm for APSIM

SOL 608 CLAY MINERALOGY (2 +1)

Objectives

1. Learning the mineralogy of soil minerals and clay.
2. Be able to apply the principles learned in the class to solve mineralogy-related problems
3. To develop applications in environmental, agricultural, engineering, and geological areas
4. Understand the principles of common soil mineral analysis methods and instruments
5. Be able to design mineralogy experiments- tailored to your specific research objectives

Theory

Unit I

Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations, crystal systems. Structures and classification of silicate minerals, basics of phyllosilicates, laws governing structural characteristics of phyllosilicates, Goldschmidt's laws – Law I and Law II, Classification of Phyllosilicates. Kaolinite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins

Unit II

Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann-Marshal-Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils. Micas: occurrence and origin in soils, polytypes of micas, structure and formation of muscovites and illite. Vermiculites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite

Unit III.

Chlorite – occurrence, structure, formation, "swelling chlorites". Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties. Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

Unit IV

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

Unit V

Surface chemistry of clay minerals, clay-organic complexes, nano clay mineralogy. Clay minerals in different soil orders, role of clay minerals in soil fertility management

Theory schedule

1. Definition and concepts of clays and clay minerals
2. Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations
3. Crystal systems
4. Structures and classification of silicate minerals
5. Basics of phyllosilicates
6. Laws governing structural characteristics of phyllosilicates- Goldschmidt's laws – Law I and Law II

7. Classification of Phyllosilicates.
8. Kaolinite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins
9. Smectites; properties of smectites
10. Reference models of structure
11. Principal types based on Hofmann-Marshal-Hendricks (H-M-H) models,
12. Occurrence of smectites
13. Transformation and formation in soils.
14. Micas: occurrence and origin in soils
15. Polytypes of micas, structure and formation of muscovites and
16. Structure and formation of illite.
17. **First test**
18. Vermiculites: structure, occurrence in soils, formation
19. Relation between vermiculites and montmorillonite
20. Chlorite – occurrence, structure, formation, "swelling chlorites"
21. Non-crystalline clays (amorphous materials),
22. Subgroups and chemical composition, morphology and structure,
23. Physico-chemical properties
24. Influence of non-crystalline clays on soil properties.
25. Interstratified clay minerals, occurrence and formation in soils
26. Regularly interstratified and partially random interstratified minerals.
27. Genesis and transformation of clay minerals-I
28. Genesis and transformation of clay minerals- II
29. Generalized conditions for formation and persistence of common clay-size minerals in soils.
30. Surface chemistry of clay minerals
31. Clay-organic complexes
32. Nano clay mineralogy
33. Clay minerals in different soil orders,
34. Role of clay minerals in soil fertility management

Practical Schedule

1. Sample preparation and removal soluble salts, carbonates, organic matter, iron and aluminium oxides
2. Dispersion and fraction of sand , silt, clay and fine clay
3. Cation saturation and preservation of clay
4. X ray diffraction techniques- sample preparation
5. Thermal and infrared spectroscope – sample preparation
6. Scanning and transmission microscopes- sample preparation
7. Estimation of vermiculite and montmorillonite by CEC hysteresis
8. Estimation of non-crystalline iron and aluminium oxides by citrate bicarbonate, dithionite dissolution

9 Estimation of amorphous minerals by acidic ammonium

10 Estimation of quarts, feldspar and mica by sodium pyrophosphate selective dissolution

11 Estimation of kaolinite and chlorite by heat destruction
12 Determination of clay CEC
13 Determination of clay surface area by EGMA technique
14 Determination of heat of wetting of clay minerals
15 Sample analysis by X- ray diffraction, DTA and scanning electron microscopy
16 Interpretation of X-ray diffratogram and quantification of clay minerals
17 **Practical examination**

Course Outcome

CO1 Impart knowledge on genesis, structure, classification of clay minerals
CO2 In depth knowledge on chemistry and importance of clay minerals in soil fertility
CO3 Acquaint with crystal chemistry and crystallography
CO4 In depth knowledge on surface chemistry and ion exchange equilibria of clay minerals.
CO5 Clear understanding of influence of clay minerals on soil properties and availability of nutrients

CO- PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2	1	1	-	-
CO2	2	1	1	1	1
CO3	-	-	1	-	-
CO4	1	1	1	1	-
CO5	-	1	1	1	1

References

1. Richard C. Dixon, J.B.; Weed and S.B.; Dinauer.1977. Minerals in Soil Environment. Soil Science Society of America
2. Gieseking J.E (Eds) 2011. Soil Component, Vol. 2. Inorganic Components. Springer
3. Grim R.E. 1968. Clay Mineralogy. McGraw-Hill Inc., US
4. Mukherjee S.K and Biswas T.D. (Editors).1974. Mineralogy of Soil Clays and Clay Minerals.
5. Read H.H. 2005 Rutley's Elements of Mineralogy. CBS publications
6. Wilding L.P. and Smeck N.E. 1983. Pedogenesis and Soil Taxonomy Part II – Soil Orders Elsevier Science Ltd
7. Velde, B. 1992. Introduction to Clay Minerals- Chemistry, origins, uses and environmental significance. Springer- Verlag
8. Wilson, M. J., Ed. Clay Mineralogy: Spectroscopic and Chemical Determinative Methods. Chapman & Hall, London
9. Ford W.E.2006. Danas Textbook Of Mineralogy 4Ed (Pb 2006): With An Extended Treatise On Crystallography & Physical Mineralogy. CBS publishers
10. Duane M. Moore, Robert C. Reynolds Jr. 1997. X-Ray Diffraction and the identification and Analysis of Clay Minerals. 2nd Edition. Oxford University Press

Web sites

1. www.clays and minerals.com
2. http://clay.uga.edu › courses
3. https://geologyscience.com

SOL 609 RECENT TRENDS IN SOIL MICROBIAL BIO-DIVERSITY (2+1)

Objectives

1. To learn and understand the microbial diversity in soils in the living world.
2. To know various physical and chemical growth requirements of microbes
3. To get equipped with various methods of microbial growth measurement.
4. To understand, learn and gain skills of isolation, culturing and maintenance of pure culture.
5. To know various Culture media and their applications

Theory

Unit I

Microbial evaluation and biodiversity, Microbial communities in ecosystems, new insights 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 xerobiotic pollutants and bacterial fertilizers.

Theory Lecture Schedule

1. Soil Biota and Evaluation
2. Microbial communities in ecosystems
3. Microbial diversity in the sub-soil
4. New insights in the diversity of microorganisms and plant performance
5. Molecular diversity of Microbes, Plant and their interactions.
6. Qualitative ecology of microorganisms
7. Environmental factors influencing the activities of microbes in soil.
8. Biomass and activities of microorganisms
9. Microbial transformation of N in soil, nitrogen cycle.
10. Nitrogen fixing microorganisms
11. Diversity of N fixing organisms
12. Microbiology and biochemistry of Nitrogen fixation, root soil interface.
13. Rhizosphere and its importance to crop plants and R : S ratio.
14. Molecular approaches in characterising N fixing organisms.
15. Serology and molecular characterization
16. Ecological aspects of bio determination
17. **First test**
18. Biochemical composition of soil organic matter and crop residues.
19. Biodegradation of soil organic matter and crop residues.
20. Organic wastes and its degradation.

21. Organic wastes as manures.
22. Biotic factors in soil development.
23. Microbial interactions in soil – Positive interactions.
24. Microbial interactions in soil – Negative interactions.
25. Microbial interactions in water – Positive interactions.
26. Microbial interactions in water – Negative interactions
27. Bacterial Bio fertilizer – Rhizobium, Azospirillum and Azotobacter
28. Fungal Biofertilizers and Phosphobacteria.
29. Algal Biofertilizers – BGA, Azolla. Method of Biofertilizers production.
30. Quality control of Biofertilizers. Method of Biofertilizers applications.
31. Soil Enzyme activities and their importance.
32. Biodegradation of Pesticides – Insecticides.
33. Biodegradation of Pesticides – Herbicides.
34. Biodegradation of Pesticides – Fungicides.

Practical Schedule

1. Conn's Direct microscopic count for estimating soil microbial population.
2. Standard plate count of estimating soil microbial population.
3. Most probable number method for estimating soil microbial population.
4. Buried slide techniques.
5. Determination of soil microbial biomass using molecular techniques- I
6. Determination of soil microbial biomass using molecular techniques- II
7. Amylase production test (Demonstration of starch hydrolysis).
8. Cellulase production test (Degradation of cellulose).
9. Production of pectinolytic enzymes (Degradation of pectin).
10. Isolation of root nodule bacterium Rhizobium.
11. Isolation and purification of Azotobacter.
12. Estimation of Soil microbial biomass carbon
13. Estimation of Soil microbial biomass nitrogen
14. Estimation of Soil microbial biomass Phosphorus
15. Community level Physiological profiling of bacteria
16. Community level Physiological profiling of fungi and Rhizosphere study
17. **Practical examination**

Course Outcome:

CO1: The student will have a clear understanding of bacteria, fungal and algal classifications, culturing, reproduction and significance.

CO2: The student will learn techniques of studying bacterial growth curve and factors affecting growth curve

CO3: The student will know microbial techniques for isolation of pure cultures of bacteria, fungi and algae

CO4: The students will gain knowledge about role of macronutrients and micronutrients in growth of microbes.

CO5: The student will gain competence to understand anaerobic cultivation of microorganisms.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	**2**	2	1	-	1
CO2	2	2	1	2	-
CO3	2	2	2	2	2
CO4	1	1	1	1	1
CO5	1	-	2	-1	1

References:

1. Aneja K.R.2007. Experiments in Microbiology, plant pathology, Tissue culture and Mushroom Cultivation , New Age International, New Delhi
2. Atlas R.M. 1988. Microbiology – Fundamentals and Applications, Macmillan Publishing Company, New York.
3. Benson Harold J. 2002.Microbiological Applications, WCB McGraw – Hill, New York
4. Brock T.D. and Madigan M.T.2006. Biology of Microorganisms, Prentice Hall of India Private Limited
5. Martin Alexander. 1977. Introduction to Soil Microbiology. John Wiley Publication New Delhi.
6. Paul, EA. 2007. Soil Microbiology, Ecology and Biochemistry. 3rd Ed. Academic Press, New Delhi
7. Pelczar .J. Chan E.C.S. and Krieg N.R.2001. Microbiology, McGraw Hill Book Company, New York
8. Ravindra Nath, Fundamentals of Biology Courses for Biotechnology, - Vol.1, Special Bangalore University edition, Kalyani Publishers
9. Salle A.J. 2007. Fundamental Principles of Bacteriology, Tata McGraw – Hill Publishing Company Limited, New Delhi
10. Stanier R.Y., Ingraham J.L., 1999. General Microbiology, Prentice Hall of India Private Limited, New Delhi

Websites

1. https://www.biologydiscussion.com
2. https://www.veryshortintroductions.com
3. https://www.slideshare.net › biodiversity-and-microbial

SOL 610 : SOIL AND WATER POLLUTION AND REMEDIATION (2+0)

Objectives

- To understand the problems of soil and water pollution associated with crop production

Theory

Unit–I

Soil pollution- major types. Agrochemicals- Insecticides, herbicides, fungicides, Fuel spill in farms. Greenhouse effect and global warming. Urban sources- Emission from power source-transport- Waste and sewage sludge. Chemical warfare, chemicals weapons- military activities. Biological Warfare's- Bacteria, Virus, Chlamydia fungi and toxins.

Unit–II

Heavy metal pollution and their salts- soil ecosystem- transport of heavy metal- Bioavailability and biochemical effects- Major environmental accidents. Other inorganic pollutants- radio nuclides- separation, behaviour and uptake. e-wastes and organic pollutants. Water pollution-major types and causes.

Unit–III

Physical process-Adsorptive retention and non-adsorptive retention. Contaminant transport-micro and macroscopic dispersion, behavior of non-aqueous phase liquid- lighter them water-denser than water. Processes related to chemical mobility- immiscible phase separation – Acid base equilibria. Dissolution and precipitation reactions. Hydrolysis. Biodegradation, Enzymic transformation, Bacterial transformation.

Unit–IV

Site characterization-data acquisition - sampling. Field and laboratory investigation. Monitoring of ground water flows- different zones. Flow direction and Hydraulic head. Remote sensing applications in monitoring and management of soil and water pollution. Biological monitoring- planning and implementation- Foliage sampling. Sampling and investigation of foliage and litter. Modeling soil pollution- Space Analogue model and modeling of fluid flow in soil.

Unit–V

Categories of pollutants- Scale of pollution Risk level. Remediation techniques- chemical and physical techniques- Biological treatments (Bioremediation). Solidification/ stabilization methods. Thermal treatment.

Theory Lecture Schedule

1. Soil pollution- definition, major types.
2. Sources of soil pollution – Agro chemicals – Insecticides, fungicides and Herbicides, Persistence and degradation of agro chemicals.
3. Green house effect and global warming
4. Soil pollutants of urban sources- Emission from power generation and transport activities.
5. Soil pollution by waste and sewage sludge
6. Soil pollution through chemical warfare – toxic chemicals, chemical weapons and military activities during cold war.
7. Soil pollution through biological warfare- Bacteria, viruses, Rickettesiae, Chlamydia, Fungi and toxins.

8. Heavy metal pollution – heavy metals and their interaction within soil system.
9. Bioavailability of heavy metals and biochemical effects.
10. Major environmental accidents involving pollution by heavy metals.
11. Other inorganic pollutants- Radio nuclides- specification, behaviour and uptake by plants.
12. E-wastes and organic pollutants.
13. Water pollution-major types, sources-pollution due to sewage, industrial effluents and sludges.
14. Pollution mechanisms- physical processes- Adsorptive and non- adsorptive retention.
15. contaminants treatment- micro and macroscopic dispersion
16. Behavior of non-aqueous phase liquids in soils.
17. **First test**
18. Pollutants transformation- processes related to chemical mobility- immiscible phase separation, Acid –base equilibria and dissolution – precipitation reactions.
19. Chemical transformation processes- Hydrolysis.
20. Biodegradation and biologically supported transformations.
21. Transformations assisted by bacterial action.
22. Monitoring soil pollution- site characterization and data acquisition.
23. Field and laboratory investigations for soil solution and solid waste and their proper disposal methods.
24. Monitoring of ground water flow - different zones, flow directions and hydraulic heads.
25. Planning and implementation of biological monitoring.
26. Foliage sampling and their investigation.
27. Sampling litter fall and their investigation.
28. Modeling soil pollution- Space Analogue model.
29. Mathematical modeling of fluid flow in soil.
30. Use remote sensing for soil and water pollution monitoring
31. Scale and risk level of soil pollution.
32. Remediation techniques- physical and chemical techniques.
33. Bio-remediation/ phytoremediation for soil and water pollution.
34. Solidification / Stabilization methods, Thermal treatments

Course Outcome

CO1**:** Demonstrate the basic concepts of pollution, the effects of environmental contamination and the various remediation technologies which may be employed;

CO2: Categorize and differentiate between contamination and degradation caused by various types of urban, industrial and agricultural development

CO3: Explain the nature and types of water pollutants and understand the parameters required for evaluation of water quality

CO4: Use different types of bioremediation techniques for removal of pollutants.

CO5**:** classify sources and types of pollutant in soil; causes, effect and control of soil pollutants.

CO PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	**2**	2	1	-	1
CO2	2	2	1	2	-
CO3	2	2	2	2	2
CO4	1	1	1	1	1
CO5	1	-	2	-1	1

References

1. Clapp C.E, Hayes M.H.B, Senesi N Bloom P.R and Jardine P.M (Eds.) 2008 Humic substances and chemical contaminants. SSSA,ISBN 0-89118-837-1 Item No.B60904
2. FAO 2008. Assessing soil contamination, Jain Books and periodicals, New Delhi
3. Lal R, Kimble J Levine E and B.A. Stewart.1995. Soil management and Green house effect. CRC Press ,New Delhi
4. Mishra S.G 2009. Soil pollution. Agro science book center, New Delhi
5. Mirsal, I. 2008. Soil pollution, Origin, Monitoring and Remediation. Springer http:// www. Springer.Com /978-3.540-70775-2.
6. Singh Ajay, Ward .P. Owen. (Eds). 2004. Biodegradation and Bioremediation. Springer http: // www. Springer. Com/978-3.-540-21101-3.
7. Purohit, S.S, and A.K . Agrawal.2004. Environmental pollution-causes, effects and control.Agrobios,Jodhpur-342002
8. Maliwal G.L 2006. Handbook of environmental management. Agrotech publishing Academy, Udaipur-313002
9. Purohit S.S and Q.J. Shammi and A.K. Agrawal. 2004. A text book of environmental sciences. Student Edition, Jodhpur
10. Singh.K,Jawahar.K,Asha singh A.K and Jomer Alka 2008. Air,soil and water pollution. Kalyani publishers,New Delhi
11. Zhang P.C Brady B.V (Eds.)2008. Geo chemistry of soil radio nucleotides. SSSA Spl. Publication.59. ISBN:978-0-89118-840-1Item No.B60906

SUPPORTING COURSES

COM 611 ADVANCES IN COMPUTER APPLICATIONS (1+1)

Objectives

1. After completion of this unit of module, candidate will be able to
2. Gain the knowledge about documentation on open source tool.
3. To understand the Working knowledge of Latex typesetting language
4. Understand features of Python that make it one the most popular languages in the industry.
5. Understand the areas where Python is used.

THEORY

Unit I Introduction to Latex:

Introduction to Latex – What is Latex – Document Structure, Start Text works, Title, Section, Table of content – Typesetting Text, Font Effects, Colored Text, Font Size, List, Comments & Spacing, Special Characters.

Unit II Packages and Classes in Latex:

Inserting Equations – Mathematical Symbols – Table of Content – Generating New Command – Figure handling numbering, List of figures, List of Tables.

Packages – Geometry, Hyperref, amsmath, amssymbol – Classes – Article, Book, and Report - The BibTex file – Inserting Bibliography – Citing – References.

Unit III MS Access:

MSACCESS: Database, concepts and types - Uses of DBMS in Agriculture; creating database.

Unit IV Introduction to Python:

Python Introduction, Technical Strength of Python, Introduction to Python Interpreter and program execution, Using Comments, Literals, Constants, Python's Built-in Data types, Numbers (Integers, Floats, Complex Numbers, Real, Sets), Strings (Slicing, Indexing, Concatenation, other operations on Strings), Accepting input from Console, printing statements, Simple 'Python' programs.

Unit V Using Databases in Python:

Database Programming: Connecting to a database, Creating Tables, INSERT, UPDATE, DELETE and READ operations, Transaction Control, Disconnecting from a database.

LECTURE SCHEDULE

1. Introduction to Latex.
2. Document Structure.
3. Classes.
4. Typesetting Text.
5. Inserting Equations
6. Packages and Mathematical Symbols.
7. List of figure.
8. List of Tables.
9. Bibliography and References.
10. **Mid Semester Examination**

11. MS Access Concepts of Database, Creating Database.
12. DBMS in Agriculture.
13. Introduction to Python.
14. Built-in Data types.
15. Strings.
16. Python Console.
17. Database in Python.

PRACTICALS SCHEDULE

1. Installation of Latex, Basic Latex commands.
2. Latex Compilation, Page Layout.
3. Building a Latex document, previewing first.tex.
4. Addition of some text in the.tex file, Finding the error and fixing it.
5. Type setting of mathematics, writing equations, matrix.
6. Two figure next to each other, Formation of table
7. Typesetting with a new chapter heading, List of figures, List of tables.
8. Citation, Bibliography, printing your document
9. MSACCESS: Creating Database, preparing queries and reports.
10. MSACCESS: Demonstration of Agri-information system.
11. Introduction to Python, Working with Data.
12. Program Organization, Functions, and Modules, Classes and Objects.
13. Inside the Python Object System.
14. Testing, Debugging, and Software Development Practice.
15. Packages.

COURSE OUTCOMES

CO 1: Problem solving and programming capability.
CO 2: Analyse common problems using Latex.
CO 3: Learn categories of programs.
CO 4: Construct and execute basic programs in Python..
CO 5: Use external libraries and packages with Python.

CO-PO MAPPING MATRIX

	PO 1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	-	1	3	1	2	2
CO3	-	3	2	3	2	2
CO4	3	-	-	-	3	-
CO 5	-	3	2	-	1	3

REFERENCES

1. Introduction to Latex by Tobias Oetiker
2. LaTeX: A Document Preparation System, 2nd Edition By Leslie Lamport
3. Charles Dierbach, “Introduction to Computer Science using Python”, Wiley, 2015
4. Python Programming- A modular Approach (with Graphics, database, Mobile and Web

Applications by Sheetal Taneja and Naveen Kumar, Pearson.
5. Head First Python by Paul Berry, O'Reilly

E-RESOURCES

1. https://www.overleaf.com/learn/latex/Bibliography_management_with_bibtex
2. https://en.wikibooks.org/wiki/LaTeX/Bibliography_Management.
3. https://wiki.python.org/moin/PythonBooks.
4. https://devfreebooks.github.io/python/
5. https://www.digitalocean.com/community/books/digitalocean-ebook-how-to-code-in-python.

STA 601 ADVANCES IN DESIGN OF EXPERIMENTS (2+1)

Objectives

1. The students will acquire sufficient basics of Statistical methods.
2. To help them in understanding the concepts involved in data collection, presentation analysis and interpretation of results.
3. To enhance the knowledge of students pertaining to testing Statistical Hypothesis.
4. To acquire Multivariate Statistical Analysis skills.
5. The students would be exposed to concepts of design of experiments.

Theory

Unit–I: Sampling Techniques

Concept of sampling: Sampling vs complete enumeration. Planning of sample survey. Sampling from a finite population. Simple random sampling. Inverse sampling. Stratified sampling. Cluster sampling. Systematic sampling. Multistage sampling. Double sampling. Ratio and regression method of estimation. Non-sampling errors. Concept and levels of measurement. Non-parametric tests - Sign, Wilcoxon, Mann- Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

Unit–II: Statistical Methods

Classification, tabulation and graphical representation of data. Descriptive statistics. Theory of probability. Random variable and mathematical expectation. Box- plot. Probability distributions: Binomial, Poisson, Negative binomial, Normal distributions and their applications. Concept of sampling distribution: t, chi-square and F distributions. Tests of significance based on normal, t, chi-square and F distributions.

Unit–III: Correlation and Regression Analysis

Correlation, Rank correlation, Correlation ratio, Intra-class correlation. Test of significance of correlation coefficient. Coefficient of determination.- Path analysis - Regression analysis, Partial and multiple correlation and regression. Estimation of parameters. Predicted values and residuals. Introduction to multivariate analytical tools. Test of hypothesis on means, Multivariate analysis of variance and covariance, Cluster analysis, Classification by linear discriminant function, Canonical correlations, Principal components, Factor analysis, multi- dimensional scaling and Correspondence Analysis. Hierarchical clustering. Principal component analysis.

Unit–IV: Experimental Designs

Need for design of experiments, characteristics of a good design. Basic principles of designs - randomization, replication and local control.

Uniformity trials, size and shape of plots and blocks; Analysis of variance and covariance; partitioning of degrees of freedom - Completely randomized design, randomized block design and Latin square design.

Unit–V: Factorial Experiments

Factorial experiments: Layout and analysis of factorial experiments – complete block design–split–plot design: strip-plot design: split split–plot design. Resolvable block designs and their applications. Randomization procedure, analysis and interpretation of results. Analysis of covariance. Missing plot technique and its application to RBD, LSD. Factorial experiments (symmetrical as well as asymmetrical). Factorial experiments with control treatment. Groups of experiments. Transformation of data.

Practicals

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution. Correlation and regression analysis. Fitting of orthogonal polynomial regression. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests. Analysis of data obtained from CRD, RBD, LSD. Analysis of Covariance, Analysis of factorial experiments without and with confounding, Analysis with missing data. Split plot and strip plot designs. Groups of experiments, Transformation of data. Exercises on various Non-parametric tests; Random sampling, Use of random number tables, Simple random sampling, Determination of sample size, Exercises on Inverse sampling, Stratified sampling, Cluster sampling and Systematic sampling, Estimation using Ratio and regression estimators, Estimation using Multistage design and Double sampling.

Theory Lecture Schedule

1. Classification, tabulation and graphical representation of data.
2. Descriptive statistics.
3. Theory of probability. Random variable and mathematical expectation.
4. Box-plot. Probability distributions: Binomial, Poisson, Negative binomial.
5. Normal distributions and their applications.
6. Concept of sampling distribution: t, chi-square and F distributions.
7. Tests of significance based on normal, t, chi-square and F distributions.
8. Correlation, Rank correlation, Correlation ratio.
9. Intra-class correlation. Test of significance of correlation coefficient.
10. Coefficient of determination.
11. Path analysis.
12. Regression analysis.

13. Partial and multiple correlation and regression.
14. Estimation of parameters. Predicted values and residuals.
15. Introduction to multivariate analytical tools.
16. Test of hypothesis on means, Multivariate analysis of variance and covariance.
17. **First test**
18. Cluster analysis, Classification by linear discriminant function.
19. Canonical correlations, Principal components.
20. Factor analysis, multi- dimensional scaling and Correspondence Analysis.
21. Hierarchical clustering.
22. Principal component analysis.
23. Need for design of experiments, characteristics of a good design.
24. Basic principles of designs - randomization, replication and local control.
25. Uniformity trials, size and shape of plots and blocks; Analysis of variance and covariance; partitioning of degrees of freedom.
26. Completely randomized design, randomized block design and Latin square design.
27. Factorial experiments: Layout and analysis of factorial experiments.
28. Complete block design – split – plot design.
29. Strip-plot design: split split –plot design.
30. Resolvable block designs and their applications.
31. Randomization procedure, analysis and interpretation of results.
32. Analysis of covariance. Missing plot technique and its application to RBD, LSD.
33. Factorial experiments (symmetrical as well as asymmetrical).
34. Factorial experiments with control treatment. Groups of experiments. Transformation of data.

Practical Schedule

1. Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests.
2. Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval.
3. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution.
4. Correlation and regression analysis.
5. Fitting of orthogonal polynomial regression.
6. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests.
7. Analysis of data obtained from CRD, RBD, LSD.
8. Analysis of Covariance.
9. Analysis of factorial experiments without and with confounding, Analysis with missing data.

10. Split plot and strip plot designs, Groups of experiments, Transformation of data
11. Exercises on various non-parametric tests.
12. Random sampling, Use of random number tables, Simple random sampling, Determination of sample size.
13. Exercises on Inverse sampling, Stratified sampling.
14. Cluster sampling and Systematic sampling.
15. Estimation using Ratio and regression estimators.
16. Estimation using multistage design and Double sampling.
17. Practical Examination.

Course Outcome

CO1: The course outcome will reveal the knowledge of basic statistical methods.

CO2: The course outcome will ensure the understanding the concept involved in data Collection, presentation, analysis and interpretation of results of Agricultural Sciences.

CO3: The course outcome will support students to test Statistical Hypothesis.

CO4: The course outcome will help students to do Multivariate Statistical Analysis.

CO5: The course outcome will assist students to design experiments in Agricultural field and collect experimental data for analysis.

CO-PO-Mapping Matrix

	PO 1	PO 2	PO 3	PO 4
CO 1	2	-	-	-
CO 2	-	-	-	3
CO 3	-	-	-	3
CO 4	-	-	-	2
CO 5	-	-	-	3

References

1. Agarwal, B. L. 2003, Basic Statistics, New Age International. New Delhi.
2. Anderson, T.W. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley, New Delhi.
3. Bansil, P.C. 2002. Agrl. Statistics. CBS Publishers. New Delhi.
4. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. 1994. Time Series Analysis: Forecasting and Control. Pearson Education, Delhi.
5. Brockwell, P.J. and Davis, R.A. 1996. Introduction to time series and forecasting. Springer Verlag, New York.
6. Campbell, R.A. 1974. Statistics for Biologists. Cambridge University Press. New York.
7. Cochran, W.G. and Cox, G.M. 1957. Experimental Design. John Wiley and Sons Inc. New York.
8. Das, M. N. and Giri, N.C. 1986. Design and Analysis of Experiments.

New Age International. New Delhi

9. Dillon, W.R. and Goldstein, M. 1984. Multivariate Analysis - Methods and Applications. John Wiley. New York
10. Dutta, N.K. 2002. Fundamentals of Biostatistics, Kanishka Publishers, New Delhi.
11. Federer, W.T. 2002. Statistical Design and Analysis of Intercropping Experiments. Springer-Verlag. New York
12. Gomez and Gomez.1984. Statistical procedure for Agrl. Research. Wiley-interscience. New York
13. Gupta, S.P. 2004, Statistical Methods, S. Chand and Sons. New Delhi.
14. Singh R. and Mangat N.S.1996.Elements of Survey Sampling. Kluwer Academic Publishers.

NGC611-RESEARCH AND PUBLICATION ETHICS (2 +0)

Objectives:

1. To impart knowledge on research ethics, academic conduct and Integrity.
2. To sensitize the scholars about their responsibilities to science, society and eco-system.
3. To equip the scholars with techniques and skills to avoid ethical misconduct.
4. To provide hands on experience in the use various software tools in research and publication process.
5. To acquaint participants with tools and techniques popularly utilized for ensuring academic standards, avoiding plagiarism, and promoting high impact publication.

Unit 1 Philosophy, Ethics & Scientific Conduct

Introduction to philosophy: definition, nature and scope, concept, branches - Ethics**:** definition, moral philosophy, nature of moral judgments and reactions - Ethics with respect to science and research - Intellectual honesty and research integrity - Scientific misconducts**:** Falsification, Fabrication, and Plagiarism (FFP) - Redundant Publications**:** duplicate and overlapping publications, salami slicing - Selective reporting and misrepresentation of data

Unit 2 Publication Ethics

Publication ethics: definition, introduction and importance - Best practices/ standard setting initiatives and guidelines: COPE, WAME, etc. - Conflict of Interest - Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types - Violation of publication ethics, complaints and appeals - Identification of publication misconduct, complaints and appeals - Predatory publication and journals

Unit 3 Open Access Publishing

Open access publication and initiatives - SHERPA/RoMEO Online resource to check publisher copyright & self-archiving policies - Software tool to identify predatory publications developed by SPPU - Journal finder / journal suggestion tool viz. JANE, Elsevier Journal Finder, Springer Journal Suggestion, etc.

Unit 4 Publication Misconduct

Group Discussions - Subject specific ethical issues, FFP, authorship - Conflicts of interest - Complaints and appeals: examples and fraud from India and abroad - Software tools - Use of plagiarism software like Turnitin, Urkund and other open-source software tools.

Unit 5 Databases and Research Metrics

Databases - Indexing databases - Citation databases: Web of Science, Scopus, etc., - Research Metrics (Journal) - Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score - Research Metrics (Author) - Metrics: h- Index, i10 index, altimetric.

Lecture schedule

1. Introduction to the philosophy: definition, nature and scope,
2. Concept, branches of Philosophy
3. Ethics: definition, moral philosophy, rational and non-rational approaches to ethical issues
4. Nature of moral judgments and reactions

5. Research Process-Research ethics and Guiding principles-Research Ethics Committee-Animal Ethics Committee-Approval
6. Intellectual honesty and research integrity
7. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)-
8. Factors facilitating scientific misconducts
9. Ethics and Trust: Anonymity, Confidentiality, Conflicts of interest/role/values/ ownership and Competing interest
10. Literature search- Print, Online, key words- boolean search- Inflibnet-E-databases
11. Fundamentals of manuscript preparation
12. Technical writing skills
13. Publication ethics: definition, introduction and importance
14. Best practices/ standard setting initiatives and guidelines: COPE, WAME, etc
15. Publication misconduct: definition, Authorship-Redundant publications:
16. Duplicate and overlapping publication, Salami slicing
17. **First test**
18. Selective reporting and misrepresentation of data
19. Violation of publication ethics, authorship and contributor ship
20. Identification of publication misconduct, complaints and appeals: examples and fraud from India and abroad-
21. UGC and University guidelines and Punishment
22. Software tools - Use of Reference Management Tools to avoid plagiarism and automation of bibiliography
23. Software tools - Use of plagiarism software like Turnitin, and Urkund
24. Other open source software tools
25. How to publish in scholarly journals?- Open access publication and initiatives-
26. UGC- CARE List-Predatory publication journals
27. Databases -Indexing databases
28. Citation databases: Web of Science, Scopus, etc
29. Journal Metrics- (c) Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
30. SHERPA/RoMEO Online resource to check publisher copyright & self-archiving policies
31. Software tool to identify predatory publications developed by SPPU
32. Journal finder / journal suggestion tool viz. JANE, Elsevier Journal Finder, Springer Journal Suggestion, etc.
33. How to share the publications and know the impact?
34. Author Metrics: Author ID-OrcidID- h- Index, i10 index, altmetrics

Course Outcomes:

CO 1: Will be able to identify the ethical issues in research process based on the concept of philosophy and ethics.

CO 2: Will be able to avoid scientific misconduct like fabrication, falsification and fraud in

the research process by following the recommended guidelines.

CO3: Will be able to use tools like Reference Management, Journal Identification, Open Access, Plagiarism Checker and avoid misconduct.

CO4: Will be able to communicate the research findings in approved journals with high journal metrics and also improve the author metrics.

References

1. Barbara H. Stanley, Joan E. Sieber and Gary B. Melton.1996. Research Ethics: A Psychological Approach. University of Nebraska Press
2. Jeffrey A. Gliner, George A. Morgan and Nancy L. Leech.2009. Research Methods in Applied Settings: An Integrated Approach to Design and Analysis. Routledge; 2nd edition
3. Joel Lefkowitz. 2017. Ethics and Values in Industrial-Organizational Psychology. Routledge
4. Sidney Hook, Paul Kurtz, and Miro Todorovich.1977. The Ethics of Teaching and Scientific Research. Prometheus Books