Bangladesh Agricultural University, Mymensingh
Department of Department of Soil Science
Curriculum for MS in Soil Science

April-September (Summer) Semester	
Compulsory courses (8 credits)	
Course Code and Title	**Course Credit**
SS 502: Soil, Plant and Water Analysis	2
SS 507: Soil Fertility and Plant Nutrition	2
SS 509: Soil Microbiology	2
SS 511: Research Methodology	2
Elective courses (4 credits)	
Course Code and Title	**Course Credit**
SS 523: Soil Water	2
SS 525: Soil Resilience and Climate Change	2
SS 527: Micronutrients in Soils and Plants	2
SS 529: Soil Health and Risk Reduction	2
SS504: Research Work	**3 (S/U)**
Total Credits	**15**
October-March (Winter) Semester	
Compulsory courses (8 credits)	
Course Code and Title	**Course Credit**
SS 501: Soil Physics	2
SS 503: Soil Chemistry	2
SS 505: Soil Degradation and Conservation	2
SS 513: Soil Survey and Classification	2
Elective courses (4 credits)	
Course Code and Title	**Course Credit**
SS 515: Waste Management and Biofertilizer	2
SS 517: Soils of Bangladesh	2
SS 519: Soil, Water and Air Pollution	2
SS 521: Soil, Water and Fertilizer Management using Nuclear Techniques	2
SS504: Research Work	**3 (S/U)**
Total Credits	**15**
Thesis Semester	
SS504: Research Work	**2 (S/U)**
Dissertation evaluation	5
Dissertation defense	3
Total Credits	**10**
GRAND TOTAL	40

S=Satisfactory	U=Unsatisfactory

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Syllabus for M.S. in Soil Science
SS 501: Soil Physics
Credit: 2

Soil density
Mass-volume relationship, penetration resistance, importance and management of soil density, aeration, and porosity.

Soil temperature
Soil temperature fluctuation and plant growth, regulation of soil temperature.

Soil water
Soil Water Characteristics Curve (SWCC) and hysteresis. Water flow in soil – saturated flow. Darcy's law. Soil water potential: components, principle and methods of measurement.

Evapotranspiration (ET)
Measurement of ET- water balance and soil water depletion method; Irrigation scheduling-approaches, application of ET values in irrigation scheduling, water use efficiency, critical soil moisture deficits.

Irrigation and Drainage
Irrigation –Irrigation in relation to soil properties, importance of supplemental irrigation for different crops, water requirement of crops.
Drainage-importance and methods of draining agricultural lands

Books Recommended:

1. Hanks R.J. 1992. Applied Soil Physics- Soil Water and Temperature Applications. Springer Nature. 2nd Edition. Heidelberg Germany.
2. Hillel, D. 1998. Environmental Soil Physics. 1st Edition, Academic Press, New York.
3. Baver, L.D., Gardner, W.H. and Gardner, W.R. 1972. Soil Physics. 4th edition. John Wiley & Sons. Ins., New York.
4. Ghildyal, B.P. and Tripathi, R.P. 1987. Soil Physics. Wiley Eastern Ltd., New Delhi.
5. Hanks, R.J. and Ashcroft, F.L. 1980. Applied Soil Physics. Springer-Verlag, Berlin, Heidelberg.
6. Hillel, D. 1980. Applications of Soil Physics. Acad. Press, New York, USA.
7. Hiller, D. 1980. Fundamentals of Soil Physics. Acad. Press, New York, USA.
8. Lambert, K.S. and Rhcroft, D.W. 1983. Land Drainage-Planning & Design of Agric. Drain. System. Batsf. Acad. &Edn. Ltd.
9. Michael, A.M. 1978. Irrigation- Theory and Practice, Vikas Publishing House Pvt. Ltd. New Delhi.

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SS 502: Soil, Plant and Water Analysis
Credit: 2

Introduction
Concept of soil, plant, and water analysis. laboratory facilities; errors in analysis; quality control (QC) and quality assurance (QA); standardization of analytical procedures; preparation of standard solutions; standard series; buffer solutions; limit of detection (LOD), standard reference materials (SRM), precision and accuracy, dilution factor; data handling/processing; interpretation of analytical data.

Collection of soil, plant, water and gas samples
Sampling techniques and itsimportance; time and frequency of sampling, preparation of samples for laboratory analysis; preservation.

Analytical techniques and equipment used in soil, plant, and water analysis
Titrimetric, colorimetric, turbidimetric, chromatography, spectrophotometric, flame emission spectroscopy, atomic absorption spectroscopy (AAS) and inductively coupled plasma mass spectroscopy (ICP-MS), Gas Chromatography (GC).

Soil Analysis
Total nutrient analysis-acid digestion and fusion; fractionation and speciation of plant nutrients and heavy metals in soil; available nutrient analysis-concepts, selection of extractant for determining available nutrients, analysis of trace nutrients and heavy metals.

Plant Analysis
Plant tissue test, leaf analysis, total nutrient analysis; critical nutrient analysis.

Water Analysis
Analysis for irrigation water quality – criteria, parameters, sampling techniques and analysis of waste water.

Gas analysis
Gas sample analysis for CH_4, N_2O, CO_2.

Books Recommended:

1. Estefen, G., Sommer, R. and Ryan, J. 2013. Methods of soil, plant, and water analysis: A manual for West Asia and African Region. International Center for Agricultural Research in the Dry Areas (ICARDA).
2. Hesse, P. R. 1994. A Textbook of Soil Chemical Analysis. CBS Publishers & Distributors, Shadara, New Delhi, India.
3. Joes Jr. J.B. 2001. Laboratory guide for conducting soil tests and plant analysis. CRC Press, USA
4. Sparks, D. L., Page, A. L., Helmke, P. A., Loeppert, R. H. 2005. Methods of Soil Analysis Part 3: Chemical Methods. Soil Science Society of America, Inc. American Society of Agronomy, Inc. Madison, Wisconsin, USA

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SS 503: Soil Chemistry
Credit: 2

Ion sorption and ion exchange
Types and nature of soil colloids, adsorption and desorption phenomena, adsorption isotherm, ion exchange phenomena, principles of cation exchange, cation exchange equations, double layer theories, anion exchange.

Clay minerals
Classification of silicate clays, Physico-chemical and mineralogical properties of silicate clays, identification of clay minerals- X-ray diffraction technique, differential thermal analysis, clay mineral distribution in Bangladesh soils.

Soil-humus complex
Complex formation and chelation, metal-organic complex reactions, clay-humus complexes, binding of biomolecules to clay and humus.

Chemistry of submerged soils
Chemical behaviour of submerged soils, electrochemical changes – pH, redox potential, transformation of N, P, S, Fe and Mn in submerged soils.

Books Recommended:

1. Tan K.H. 1982. Principles of Soil Chemistry, CRC Press, Taylor & Francis, Boca Raton.
2. Bear, F.E. 1967. Chemistry of the Soil. Reinhold Pub. Crop. Inc., USA.
3. Bohn, H.L., Mc Neal, B.L. and O'Connor, G.A. 1974. Soil Chemistry, John Wiley & Sons, New York.
4. Greenland, D.J. and Hayes, M.H.B. 1981. The Chemistry of Soil Processes. John Wiley & Sons Ltd., New York.
5. Grim, R.E. 1953. Clay Mineralogy. McGraw Hill Book Co., Inc., New York..
6. Mengel, K. and Kirkby , E.A. 1987. Principles of Plant Nutrition. Int. Potash Inst. Pub., Switzerland.
7. Ponnamperuma, F.N. 1972. Advances in Agronomy, Vol. 24. Amer. Soc. Agron., Inc. Pub., Wis., USA.
8. Saleque, M.A. 2004. Review of Soil Chemistry. Anik Printers, Dhaka, Bangladesh.
9. Sposito, G. 1989. The Chemistry of Soils. Oxford University Press, New York.

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SS 505: Soil Degradation and Conservation
Credit: 2

Soil quality

Concept of soil quality, indicators of soil quality, soil resistance and soil resilience, factors affecting soil quality and agricultural productivity.

Soil degradation

Concept and causes of soil degradation; soil degradation classes; types of soil degradation-physical, chemical and biological; agents and processes of soil degradation; soil erosion - water and wind erosion, harmful effects of soil erosion, universal soil loss equation; losses due to degradation - soil, nutrients, vegetation; properties of degraded soils - degraded rice soils, saline soils, acid soils, hill soils, charlands, soils polluted with heavy metals; wetland degradation.

Soil conservation

Concept of soil conservation; principles of erosion control; soil conservation measures: agronomical - cover crops, crop rotation, companion crops, strip cropping, crop residue utilization & mulching; engineering - structures their design and layout; soil conservation planning; land capability classification; soil conservation in special problem areas - hilly, drought prone, saline, riverbank, charlands, saline regions, waterlogged and wet lands; modification of soil properties - soil structure, infiltration and drainage.

Books Recommended:

1. BARC. 2018. Fertilizer Recommendation Guide. BARC, Dhaka.
2. Brady, N.C. and Weil, R.R. 2015 (15^{th}Eds). The Nature and Properties of Soils. Pearson Education Pvt. Ltd. New Delhi, India.
3. FAO. 2013. Land Degradation in The Philippines. Food and Agriculture Organization of the United Nations.
4. FAO 2001. The economics of conservation agriculture. FAO Y2781/E.
5. Khuda, Z.R.M.M. 2001. Environmental Degradation: Challenges of the 21^{st} Century. Environmental Survey and Research Unit, Dhaka.
6. Lal, R. and Sanchez, P.A. (Eds) 1992. Myths and of Soils of the Tropics. SSA Special Publication No.29. Soil Science Society of America, Madison.

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SS 507: Soil Fertility and Plant Nutrition
Credit: 2

Soil fertility

Soil fertility and plant growth; plant growth equations; soil fertility assessment - soil analysis, crop response to fertilizers, plant analysis, diagnosis and recommendation integrated system and nuclear techniques; soil fertility management - use of manures, and fertilizers &biofertilizers, soil management. Integrated Plant Nutrition System; Conservation agriculture; fertilizer management - mixed, compound & slow release fertilizers, nano-fertilizers, soil amendment, strategies for fertilizer application for crops and cropping patterns, nutrient balance, fertilizer use efficiency.

Plant Nutrition

Macro and micronutrients; mechanisms of nutrient absorption - mass flow & diffusion, contact exchange & soil solution theories; nutrient mobility; nutrient interactions; nutritional disorders - deficiency & toxicity symptoms; nutrient concentration - normal, deficiency & toxic levels; Biofortification of seeds - methods of biofortification& micronutrients biofortification.

Books Recommended:

1. BARC, 2018. Fertilizer Recommendation Guide. Soils Publication no. 41. Bangladesh Agricultural Research Council, Farm-gate, Dhaka.
2. Brady, N.C. and Weil, R.R. 2002. The Nature and Properties of Soils. Pearson Education Pte. Ltd. New Delhi, India.
3. Bennelt, W.F. 1996. Nutrient Deficiencies and Toxicities in Crop Plants. Amer. Phytopath. Soc., St. Paul, Minnesota, USA
4. Havlin, J.L, Beaton, J.D., Nelson, W.L., and Tisdale, S.L. 1999. Soil Fertility and Fertilizers. Prentice Hall, Upper Saddle River, New Jersey
5. Mengel, K. and Kirkby, E.A. 2001. Principles of Plant Nutrition.5th Edition Dordrecht: Kluwer Academic Publishers
6. Miller, R.W. and Donahue, R.L. 1990. Soils An Introduction to Soils and Plant Growth. Prentice Hall Inc., USA.
7. Mortvedt, J.J., Cox, F.R., Shuman, L.M. and Welch, R.M. 1991.Micronutrients in Agriculture. 2nd ed. Soil Sci. Soc. Amer. Inc., Madison, Wis., USA
8. Stevension, F.J. 1985. Cycles of Soils-Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons Inc., New York.
9. Thomson, L.M. and Troeh, F.R. 1978. Soils and Soil Fertility. McGraw Hill, New York.

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SS 509: Soil Microbiology
Credit: 2

Soil Microbes

Soil microorganisms and their nutrition; microbial community structure and soil biodiversity, soil enzymes and their significance; biochemical activities of soil microbes; microbial biomass; rhizosphere - its biology and impact on crop productivity, crop micro biome study.

Biological Nitrogen Fixation

Symbiotic, non-symbiotic and associated nitrogen fixation systems; biochemistry of nitrogen fixation; nitrogenase enzyme – its oxygen protection mechanisms and regulation; Nif genes; methods for measuring nitrogen fixation.

Bioremediation

Bioremediation – approaches, metabolism & catabolism; bioremediation through enzyme technology; microbial response & resistance to heavy metals– As, Cd & Hg; methanogenesis; biovolatilization, plant growth promoting rhizobacteria (PGPR).

Books Recommended:

1. Alexander, M. 1977. Introduction to Soil Microbiology. John Wiley & Sons Inc., New York.
2. Brady, N.C. and Weil, R.C. 2012. The Nature and Properties of Soils. Pearson Education Pvt. Ltd. New Delhi, India.
3. Coyne, M.S. 1999. Soil Microbiology: An Exploratory Approach. Delmar Publishers.
4. Keister, D.L. and P.B. Cregan 1991. The Rhizosphere and Plant Growth. Kluwer Academic Publishers, Dordrecht, The Netherlands.
5. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M. and Stahl, D.A. 2017. Brock Biology of Microorganisms, 15thEdn. Pearson Education.
6. Paul E.A. (Ed.). 2015. Soil Microbiology, Ecology and Biochemistry. 4thEdn. Academic Press.
7. Rangaswami, G. and Bagyaraj, D.J. 2004. Agricultural Microbiology, Prentice Hall of India (Pvt) New Delhi.
8. Roger, L.J. and Gallon, J.R. 1988. Biochemistry of algae and cyanobacteria. Oxford University Press, London.
9. Subba Rao, N.S. 2001. Soil Microorganisms and Plant Growth. Oxford and IBH Publishing Co. Pvt. Ltd.
10. Sylvia, D.M., Fuhrmann, J.J., Hartel, P.J. and Zuberer, D.A. 2005. Principles and Applications of Soil Microbiology. 2ndEdn. Pearson, Prentice Hall.

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SS 511: Research Methodology
Credit: 2

Basic Statistics
Basic descriptive and inferential statistics. A few measures of central tendency. An overview of univariate and multivariate analyses and test of significance. Step-by-step procedure of conducting these statistical analyses using Minitab/SPSS, reading the output, and summarizing the results.

Data processing
Collection and analysis of data, Spreadsheet handling in Excel, normalization methods, Transformation of data - square root and logarithmic transformation, Tabular and graphical forms of data presentation, Step-by-step demonstration of producing graphs and tables using Excel/Sigma plot, reading the output, and summarizing the results.

Simple & Multiple Regression
Fundamental concepts underlying regression analysis, including regression equation, regression coefficients, and other indices. Multicollinearity and a means of testing interaction effects in regression analysis. Step-by-step demonstration of conducting a multiple regression analysis using Minitab/SPSS, reading the output, and summarizing the results.

Field Experimentation
Basic principles of experimental designs-layout, plot size and shape, number of replications, sampling, data collection; Selection of experiment site, experimental designs -Completely Randomized Design, Randomized completely Block Design, Latin Square Design and Split-Plot Design. Different utilities of and variables used in one-way vs. two-way ANOVA, between-group vs. within-group ANOVA, and ANCOVA. Mean separation test- Duncan's multiple range test; least significant difference. Step-by-step demonstration of conducting these statistical analyses using Minitab/SPSS, reading the output, and summarizing the results.

Scientific paper writing
Writing a scientific paper, Plagiarism testing, Procedure to submit a paper, Peer reviewing an actual example on responses to reviewers.

MS thesis writing
Developing research questions and claims/hypotheses, Developing critical reading skills and managing reading/note-taking, Structuring a doctoral thesis, Developing oral presentation skills

Books Recommended:

1. Anonymous, 2004. A Handbook of Scientific Report Writing. Graduate Training Institute (GTI), Bangladesh Agricultural University (BAU), Mymensingh.

2. Cargill, M. and O'Connor, P. 2009. Writing Scientific Research Articles: Strategy and Steps. Blackwell Publishing, West Sussex, UK.
3. Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. Second Ed. John Wiley & Sons, New York.
4. Mertler, C. A., & Vannatta, R. A. 2010. Advanced and multivariate statistical methods (5th ed.). Glendale, CA:
5. Pyrczak Publishing. Pallant, J. 2011. SPSS survival manual: A step-by-step guide to data analysis using SPSS (4th ed.). Crows Nest, N.S.W., Australia: Allen & Unwin. [eBook available on Course Reserves on Sakai]
6. Winner, L. 2004. Introduction to Biostatistics, Department of Statistics, University of Florida.

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SS 513: Soil Survey and Classification
Credit: 2

Soil Survey

Principles and methods of soil survey; use of soil surveys, application of soil survey in land use planning and development. Planning of a soil survey, orders of soil survey, base maps, generalized soil maps and schematic soil maps, plan metric and topographic maps, aerial photographs and mosaics, photo interpretation, mapping units in soil survey, map legends, soil survey reports. Remote sensing, GIS and sterio imagery in soil survey, collection, display of information and interpretation. Field observations, examination and description of soils, Use of land utilization guides. Soil survey in Bangladesh.

Soil Classification

Principle of soil classification; Types of soil classification, FAO-UNESCO World/Legends, USDA Soil Taxonomy; diagnostic horizons, moisture regimes, thermal Soil Map of the regimes. Categories: Order, Suborder, Great group, Subgroup, Family and Series. Classification of Bangladesh soils according to soil taxonomy.

Books Recommended:

1. Brady, N.C. and Weil, R.R. 2015 (15^{th}Eds). The Nature and Properties of Soils. Pearson Education Pvt. Ltd. New Delhi, India.
2. Dent, D. and Yong, A. 1981. Soil Survey and Land Evaluation. George Allen and Unwin Pub. Ltd., London.
3. Hussain, M.S. 1992. Soil Classification with Special Reference to the Soils of Bangladesh. Univ. Dhaka.
4. Lillesand, T.M. and Kiefer, R.W. 1994. Remote Sensing and Image Interpretation. 3^{rd} edition. Wiley, New York.
5. Soil Survey Staff, 1992. Keys to Soil Taxonomy. SMSS Technical monograph no. 19, Pocahontas Press, Inc., Blacksburg, Virginia
6. Soil Survey Staff. 1993. Soil Survey Manual. Hand Book No. 18. Washington, D.C. USDA
7. Star, J. and Estes, J. 1990. Geographical Information Systems: An Introduction. Prentice Hall, Englewood Cliffs, N.J.
8. USDA, 1951. Soil Survey Manual. Agriculture Hand Book No. 18.
9. USDA, 1978. Soil Taxonomy-A Basic System of Soil Classification for making and Interpreting Soil Surveys. National Bureau of Soil Survey and Land Use Planning (ICAR), New Delhi.
10. SRDI, 1987-date. Land and Soil Resources Utilization Guide (in Bengali). Upazila Nirdeshika series. Soil Resource Development Institute, Dhaka.

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SS 515: Waste Management and Biofertilizer
Credit: 2

Waste
Concept, types and availability of wastes, scope and importance of waste utilization in Bangladesh

Waste management
Municipal solid waste management: process and practice, incineration of waste, land filling, implication in agriculture

Organic recycling of waste
Composting of waste, methods of composting, maturity of compost, enrichment of compost, composing scenario in Bangladesh, challenges and opportunity of composting
Quick composting, vermicompost, Trichocompost

Biofertilizers
Definition, scopes, types, quality control and use of Biofertilizers
Rhizobium: Classification, characterization, mass production of inoculums and use.
Azotobacter: Classification, physiology, amount of N fixation and use as biofertilizer
Cyanobacteria: Classification, nitrogen fixation, fate of fixed N in rice field ecosystem,
Azolla: Species, biomass production and N fixation; benefits and limitations of Azolla culture in rice field.
Mycorrhiza: Types, physiology, inocula maintenance; use in seedling nursery beds for vegetable crops and fruit trees
Plant Growth Promoting Rhizobacteria (PGPR): Types and effects on plant growth

Books Recommended:

1. Diaz, L.F., Savage, G.M., Eggerth, L.L. and Goluke, C.G. 1993. Composting and Recycling Municipal Soild wastes. Lewis Publishers, Boca raton,
2. Hamdi, Y.A. 1982. Application of Nitrogen Fixing Systems in Soil Improvement and Management. FAO Soils Bulletin 49. Rome, Italy.
3. Krishna Murthi, R. 1978. A Manual on Compost and Other Organic Manures. Today and Tomorrows Printers and Publishers, New Delhi-110005
4. Malik, K.A. Naqvi, S.H.M. and Aleem, M.I.H. 1985. Nitrogen and the Environment, NIAB, Faisalabad, Pakistan.
5. Subba Rao, N.S. 1984. Biofertilizers in Agriculture. Oxford and IBH Pub. Co. Pvt. New Delhi.
6. Subba Rao, N.S. 1987. Advances in Agricultural Microbiology. Oxford and IBH Pub. Co., New Delhi.
7. Vincent, J.M. 1982. Nitrogen Fixation in Legumes. Academic Press, Paris, San Diego, Tokyo, Toronto.
8. Xinthian. D.1993. Current Development in Soybean Rhizobium Symbiotic Nitrogen Fixation. Heilongjiang Sci. & Tech. Pub. House.

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SS 517: Soils of Bangladesh
Credit: 2

Environment of soil formation in Bangladesh
Location and climate; Geology; Geomorphology; Hydrology; Biological agents; Physiography.

Soil Forming Processes
Soil formation on seasonally flooded and non-flooded land. The Soil Forming Processes in Bangladesh: Ripening, Homogenization, Reduction, Ferrolysis, Decalcification, Formation of gleyans, Clay Eluviation and illuviation, Acidification, Formation of mottles, Formation of lime nodules, Alkalization, Formation of peat.

Soil Classification
Classification of Bangladesh Soils based on USDA Soil taxonomy and FAO-UNESCO Soil Map of the World/Legends
Agroecological Zones of Bangladesh (AEZ): concept and a brief description of different AEZs for potential crop production suitability. Description of soils: Morphological description of representative soil series of Bangladesh viz. Baliadangi, Gangachara, Sonatala, Shilmondi, Sara, Ajmiriganj, Tejgaon, Nijhuri, Pirojpur, and Rangamati series.

Books Recommended:

1. FAO report. 1971. Soil Survey, Project, Bangladesh Soil Resources. Rome. Tech. Rep..
2. FAO report. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development, Agroecological Regions of Bangladesh. Report-2.
3. H. Brammer, 1996. The Geography of the Soils of Bangladesh. University Press Ltd., Dhaka, Bangladesh.
4. Huq, S. M. I. and Shoaib, J. U. M. 2013. The Soils of Bangladesh, World Soils Book Series 1, Springer Science+Business Media Dordrecht, Germany.
5. Hussain, M.S. 1992. Soil Classification with Special Reference to the Soils of Bangladesh. Univ. Dhaka.

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SS 519: Soil, Water and Air Pollution
Credit: 2

Introduction
Pollutants in the environment, source and consequences; organic, inorganic & biological pollutants; transport of pollutants. Phytoremediation/bioremediation: concept and application.

Soil pollution
Pesticides and fertilizer as soil pollutant: residues, degradation, hazards, and their impacts on soil properties.
Heavy metals (As, Cd, Pb & Cr) as soil pollutants: sources; hazards and their impacts on soil properties and potential remediation measures.

Water pollution
Sources-heavy metals, fertilizers, pesticides, sewage sludge, industrial effluents; eutrophication of natural bodies of water; biochemical aspects of water pollution.

Air pollution
Emission of CH_4, NOx, CO_2; Ozone depletion; acid rain; global warming; urban air pollution and impacts on environment.

Health risk & control measure
Risk assessment and pricing measures to control pollution; safe limits of heavy metals; water and air quality index; control of pollution; remediation measure.

Books Recommended:

1. Agrawal, S.B. and Agrawal, M. 2000. Environmental Pollution and Plant Responses. Cat. No. L. 1341, CRC Press, UK.
2. ASA. 1993. Agricultural Ecosystem Effects on Traces Gases and Global Climate Change. ASA Special Pub. No. 55, USA.
3. de Haan, F.A. and Visser-Reyneveld, M.I., 1996. Soil pollution and soil protection. International Training Centre (PHLO), Wageningen Agricultural University.
4. Minkina, T.M., Motuzova, G.V., Nazarenko, O.G. and Mandzhieva, S.S., 2010. Heavy metal compounds in soils: transformation upon soil pollution and ecological significance. Nova Science Publishers, Inc.
5. Mirsal, I.A., 2008. Soil pollution. New York, NY: Springer.
6. Rodríguez-Eugenio, N., McLaughlin, M. and Pennock, D., 2018. Soil pollution: a hidden reality. FAO.
7. Saha, J.K., Selladurai, R., Coumar, M.V., Dotaniya, M.L., Kundu, S. and Patra, A.K., 2017. Soil pollution-an emerging threat to agriculture (Vol. 10). Springer.
8. Yaron, B., Calvet, R., Prost, R. and Prost, R., 1996. Soil pollution: processes and dynamics. Springer Science & Business Media.
9. Yunus, I.S., Harwin, Kurniawan, A., Adityawarman, D. and Indarto, A., 2012. Nanotechnologies in water and air pollution treatment. Environmental Technology Reviews, 1(1), pp.136-148.

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SS 521: Soil, Water and Fertilizer Management using Nuclear Techniques
Credit: 2

Stable and Radioisotopes

Stable and radioactive isotopes, Applications of stable isotopes in crop production
Principles and application of isotopes in fertilizer management and tracking soil degradation. Predicting heavy metal contamination using isotope dilution technique.

^{15}N

Fertilizer N use efficiency, biological nitrogen fixation, N balance, Gross N transformation in soils, N availability from organic-materials, animal nutrition studies

^{32}P

Fertilizer P use efficiency, residual P fertilizer studies, exchangeable P in soils, root activity patterns of crops, root distribution in soils, agronomic evaluation of rock phosphates, residual P fertilizer availability

^{18}O

Source identification of nutrients and contaminants, ecological studies, hydrology, and irrigation

^{13}C

Carbon source and balance, soil organic matter dynamics in agro-ecosystems

References/Books Recommended:

1. Mohammad Zaman, Lee Heng, Christoph Müller (Editors). 2021. Measuring Emission of Agricultural Greenhouse Gases and Developing Mitigation Options using Nuclear and Related Techniques. Springer Nature Switzerland AG.
2. B. Singh, J. Singh and A. Kaur, "Applications of Radioisotopes in Agriculture," Int. J. Biotechnol. Bioeng. Res. 4, 167 (2013).
3. Bhat, M. I., Faisul-ur-Rasool, and Bhat M. A. 2010. Applications of Stable and Radioactive Isotopes in Soil Science. Current Science, vol. 98, no. 11, 2010, pp. 1458–1471.
4. IAEA (International Atomic Energy Agency) 2001. Use of isotope and radiation methods in soil and water management and crop nutrition.
5. Rakshit A., Ghosh S., Chakraborty S., Philip V., Datta A. 2020. Soil Analysis: Recent Trends and Applications. Springer, Singapore.
6. Zaman M., Shahid S.A., Heng L. (2018). The Role of Nuclear Techniques in Biosaline Agriculture. In: Guideline for Salinity Assessment, Mitigation and Adaptation Using Nuclear and Related Techniques. Springer, Cham.
7. Sood, D.D., Reddy, A.V.R. and Ramamoorthy, N. (2010). Applications of radioisotopes in agriculture and Industry. In: Fundamentals of Radiochemistry, IANCAS (4th Eds), Perfect Prints, India, pp 296-310.

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SS 523: Soil Water
Credit: 2

Water in soil
Sources, structure and properties of water, water losses and balance, capillary rise, forces affecting free energy of soil water, percolation and groundwater, Enhancing soil drainage, Septic tank drain fields.

Soil water stress
Drought tolerance of plant, ionic uptake, turgidity, osmotic adjustment, protein and hormone imbalance, growth and yield.

Soil moisture and nutrient
Soil air- water interaction, nutrient uptake at different moisture levels; Water uptake by plants due to water potential gradient; components of soil water potential and plant water potential.

Salty water
Salt affected soils of Bangladesh, plant response to saline and alkaline soil, reclamation and management of salt affected soil. Soil dispersion by sodium.

Soil water conservation
Methods of soil water conservation: mulching, tillage, no tillage and crop varieties.

Books Recommended:

1. Ghildyal, B.P. and Tripathi, R.P. 1987. Soil Physics. Wiley Eastern Ltd., New Delhi.
2. Hillel, D. 1980. Fundamentals of Soil Physics. Academic Press, New York.
3. James, D.W., Hanks, R.J. and Jurinak, J.J. 1982. Modern Irrigated Soils, John Wiley & Sons. New York.
4. Kramer, P.J. 1983. Water Relations of Plants. Academic Press, New York.
5. Lambert, K.S. and Rycroft, D.W. 1983. Land Drainage-Planning and Design of Agricultural Drainage System. Cornell University Press. New York
6. Levitt, J. 1972. Responses of Plants to Environmental Stress. Academic Press. New York.
7. Mengel, K. and Kirkby, E.A. 2001. Principles of Plant Nutrition. Kluwer Academic Publishers.
8. Michael, A.M. 1978. Irrigation - Theory and Practices. Vikas Publishing House Pvt. Ltd. New Delhi.
9. Nilsen, E.T. and Orcutt, D. M. 1996. The Physiology of Plants Under Stress: Abiotic factors. John Wiley and Sons, Inc. New York.
10. Turner, N.C and Kramer, P.J. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley and Sons, Inc., New York.

Department of Soil Science
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Syllabus for M.S. in Soil Science
SS 525: Soil Resilience and Climate Change
Credit: 2

Balancing climate and food security through resilient cropping systems
Conservation agriculture, carbon sequestration, low input water and fertilizer, INSFM

Nutrient balance sheet for diversified and intensive cropping systems
Holistic approach, input-output, volatilization, leaching, denitrification and crop uptake

Greenhouse gas and NH_3emissions and mitigation
GHG and NH_3production, transport and emissions in diversified cropping systems, Nutrient biogeochemistry in a changing climate, methods of GHG measurement, and sources/pathways of GHGs, management impacts of reducing gaseous loss of plant nutrients.

GHG emissions during manure management and compost preparation
Composts, manures and urine management vs gaseous emissions

Biochar, biocompost and organic amendment for C sequestration and GHG mitigation
Production, characterization and filed impacts in diversified crops and soils

Soil and climate interactions
Effects of soil properties and cropping on global warming potential and vice versa

Books Recommended:

1) M.N.V. Prasad and Marcin Pietrzykowski.(Editors) 2020. Climate Change and Soil Interactions-1st Edition. Elsevier
2) Rattan Lal, and B.A. Stewart. 2019. Soil and Climate. Published September 20, 2018 by CRC Press. Taylor and Francis.
3) Walter Leal Filho.2020. Handbook of Climate Change Resilience. Springer, Cham.
4) Lipper**, L.,** McCarthy**, N.,** Zilberman**, D.,** Asfaw**, S.,** Branca**, G**.(Editors).2018. Climate Smart Agriculture: Building Resilience to Climate Change (Natural Resource Management and Policy Book 52) Springer International Publishing.

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SS 527: Micronutrients in Soils and Plants
Credit: 2

Geochemistry of Micronutrients, Different Forms of Micronutrients in Soils, Micronutrient Reactions in Soils – Adsorption & Desorptions, Inorganic Equilibria Affecting Micronutrients in Soils, Geographic Distribution of Trace Element Problems.

Micronutrient - Organic Matter complex in soil, Metal Chelates in Soils and Nutrient Solutions, Mechanisms of Micronutrient Uptake and Translocation in Plants, Functions of Micronutrients in Plants, Critical limits of micronutrients in soils and plants, Environmental and Soil Factors Affecting Micronutrient Deficiencies and Toxicities, Micronutrients and Disease Resistance and Tolerance in Plants

Micronutrient Fertilizer Technology, Fertilizer Applications for Correcting Micronutrient Deficiencies, Trace Elements in Animal Nutrition, Trace Elements in Human Nutrition.

Books Recommended:

1. Alloway, B.J (ed). 2008. Micronutrient Deficiencies in Global Crop Production. Springer, Dordrecht, The Netherlands.
2. Barker, A.V., Pilbeam, D.J. (Eds.). 2007. Handbook of Plant Nutrition, CRC Press, Taylor & Francis, Boca Raton, FL
3. Brady, N.C, Weil, R.R. 2017. The Nature and Properties of Soils. 15th edn., Pearson Education, South Asia.
4. Fageria, N.K., Baligar, V.C., Jones, C.A. 2010. Growth and Mineral Nutrition of Field Crops. 3rd ed., Marcel Dekker, Inc., New York.
5. Havlin, J.L., Tisdale, S.L., Nelson, W.L., Beaton, J.D. 2013. Soil Fertility and Fertilizers, 8th ed., Prentice-Hall Inc., New Jersey, USA.
6. Marschner, H. 2012. Mineral Nutrition of Higher Plants. 3rd ed., Academic Press. Harcourt Brace & Company, Publishers.

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SS 529: Soil Health and Risk Reduction
Credit: 2

Soil health

Concept of soil health and soil quality; components of soil health; characteristics and functions of a healthy soil; effects of soil health on human health; present status of soil health in Bangladesh, challenges of climate change to soil health; causes of soil health deterioration; indicators for assessing soil health - physical, chemical and biological; impact of major soil health indicators on sustainable crop production; calculation of soil health index for crop productivity; principles to improve soil health; management of soil health revitalization-strategies and practices, impacts of vastly increased ratios of people to land, intensified agriculture-the Green Revolution, Biochar: Hype or Hope for soil quality, Organic farming system, sustainable agricultural system for resource poor farmers.

Disaster risk reduction

Concept of disaster and hazards; relationship among soil, disaster, and hazards; climate change and disasters - impact on soil health and land use; planning for resilience against multiple risks; soil and land use related adaptation and coping measures for disaster and climate change risk reduction; global climate change adaptation policies regarding soil health and its current status in Bangladesh.

Books Recommended:

1. Brady, N.C. and Weil, R.C. 2012. The Nature and Properties of Soils. Pearson Education Pvt. Ltd. New Delhi, India.
2. Climate Change Adaptation Actions in Bangladesh. *Rajib Shaw, Fuad Mallick, Aminul Islam (eds.)*, Springer, Japan
3. Disaster Risk Reduction Approaches in Bangladesh. *Rajib Shaw, Fuad Mallick, Aminul Islam (eds.)*, Springer, Japan
4. FAO. 2013. Climate-Smart Agriculture: Sourcebook. Food and Agriculture Organization of the United Nations, Rome, Italy.
5. Food security and risk reduction in Bangladesh. *U Habiba, M A Abedin, A W R Hassan and R Shaw (Eds.)*, Springer, Japan, Pp 273. ISBN: 978-4-431-55410-3 (Print) 978-4-431-55411-0 (Online). DOI 10.1007/978-4-431-55411-0.
6. Singh, V.P., Cowie, A.L. and Chan, K.Y. 2011. Soil Health and Climate Change. Springer.