Biofertilizers

The science of agriculture, though amongst the oldest have engaged the attention and is still subject to developments for consideration by the modern farmers whose endeavours are always towards maximum economic production per acre of land. The recent advances in knowledge of agriculture science have been developed by research, experimental demonstrations and field trials.

The biofertilizers were devised to develop methods of crop production, mixed cropping patterns and domestication of economically important plants. This was later diversified to study genetic variations in crops and cultivated varieties to relate with the biological mechanisms and soil residing microbial communities.

In the present agriculture practices biofertilizers have emerged as a very important alternative to chemical fertilizers due to their eco-friendly, non toxigenic and cost effective features. The biofertilizers are defined as biological products containing living strains of microorganisms or ecotypes and any biological component added to seeds, plant surfaces or inside the soil to promote plant growth and crop yield. Biofertilizers provide nutrients in a form which can be readily taken up by the plant system and increases the productivity.

The nutrients in soil are increased by biofertilizers through biological processes like nitrogen fixation, phosphorous solubilization, plant growth promoting rhizobacterial mechanisms, associative symbiosis, Fe^{3+} chelation, carbon sequestration and restoration of chemical recycling, nutrient acquisition by rhizosphere and activation of microbial biochemical networks, precisely by two component signal transduction cascades.

Microorganisms are descriptive in terms of strain differentiation and genetic recombination models specifically the horizontal gene transfer and plasmid mediated gene clusters gives a significant delineated picture of a microbial genome and its decisive adaptability. These microbial genomic features are important for defining the functions as biofertilizers.

The basic examples of microbes for biofertilizers are the Rhizobacteria, *Azotobacter*, *Azospirillium*, *Clostridium*, *Cyanobacteria* like *Anabaena*, *Nostoc* and *Tolypothrix*. The study of *Azolla-Anabaena* symbiotic association in rice fields is significant for enhancing the rice production by increasing the fixed Nitrogen. The Proteobacteria are primitive forms of microbes which determined the phylogenetic evolution of transient microbial species with exquisite form and structure. The Actinomycetes *Frankia* colonizes the roots of Pine, Spruce , Cedar and Rose species to form actinorhizal symbiotic association for N_2 fixation. The microbial diversity is to be studied in detail for biofertilizer paper.

The mycorrhiza is a symbiotic association of fungi and the roots of higher plants. Arbuscular Mycorrhizal Fungi are considered as the biofertilizer as they provide the host with water and minerals

in exchange of photosynthates formed by the plants. The mycorrhization helper bacteria *Pseudomonas* and *Streptomyces* are associated with the roots to promote mycorrhizal symbiosis by enhancing nutrient uptake and soil conductance. This paper includes the comprehensive information of mycorrhizal symbiotic association.

This paper presents the detailed comparative study of microbial species to create sustainable and best technologies for the improvement of agriculture and regenerative farming. The students will study basic microbiology methods, microbial cultures, dilution plating and strain development by mutations and replica plating techniques. Students will also acquire knowledge about the various composting methods, soil analysis and organic farming.

The plant growth promoting rhizobacteria like *Pseudomonas* isolates, *Bacillus* species PSB10, Micromonospora and Pseudonocardia are widely used as biofertilizers. Phosphate solubilizing bacteria *Pantoea agglomerans* strain P5 and Pseudomonas mediate phosphate immobilization in plants. Commercial applications of *Streptomyces griseus, Rhizobium* and allied strains *Azorhizobium, Sinorhizobium,* nonsymbiotic microbial species *Azotobacter, Rhodospirillium, Chromatium* and *Beijerinckia* are to be studied as biofertilizers for legumes and the millets.

The study of siderophore producing microbes *Bacillus, Klebsiella , Methylobacterium* and *Serratia* is important to understand soil - microbe interactions. Siderophores are the low molecular weight iron-chelating compounds secreted by the microorganisms for iron uptake from the soil. These high affinity Fe^{3+} binding proteins are required for biochemical characterization of microbes and are important for the cereal crops.

The significance of biocontrol agents is another important concept to be studied in this paper through the isolation of soil fungi. They are important to control pests and pathogens in crops.

The students will learn recent research trends in biofertilizers based on PCR mediated detection of microorganisms and bacterial symbionts specifically *Burkholderia* species, detection of N_2 fixers by immunofluorescence, antibiotic resistance markers and metagenomics. They will make a project based on research work as the practical assessment.

The paper will facilitate in developing the basic aptitude and advances in the field of agriculture biotechnology and precision farming to pursue higher studies and research in applied life sciences.

Department of Botany

Ramjas College, University of Delhi

Course Descriptions of UGCF-NEP GE and SEC papers Sem. II and IV (2023-2024)

GE Semester II

GE 1. Ethnobotany (UPC: 2164001204)

Learning Objective:

● To acquire knowledge of the plants used by the local communities, tribals, ethnic groups, their nutritive and medicinal value.

Learning Outcomes:

• After studying this course, the student will have an understanding of the value and usefulness of the natural products and their efficient use by the local communities as food and medicine and their conservation practices.

Course Description

Ethnobotany is an interdisciplinary field, combining the aspects of botany and ethnology. It is a branch of science that aims to document, describe and explain complex relationships between cultures and plants, focusing primarily on how plants are used, managed and perceived across human societies. Traditionally, indigenous communities worldwide are extremely knowledgeable about local plants and other natural resources, on which they are immediately and intimately dependent for food, clothing, medicines, timber, dyes, construction etc. Ethnobotany, therefore is an important area of research for documentation and preservation of traditional knowledge. Unfortunately, much of this wealth of knowledge is currently becoming lost as traditional cultures become eroded. Ethnobotanists can play very important roles in rescuing disappearing knowledge and returning it to local communities, by making them understand their medicinal and other practical applicability, helping to maintain a sense of pride in local cultural knowledge and practices, and reinforcing links between various ethnic communities, researchers and pharmaceutical companies.

The paper aims to provide the students a comprehensive account of the methodology of Ethnobotanical studies including field work, role of herbarium, sacred places and archaeological findings. The students will learn the role of ethnobotany in modern medicine and also the legal aspects of ethnobotany including Biopiracy and Intellectual Property Rights (IPR) to protect the interests and knowledge of ethnic groups. The course will certainly provide skills to the students for higher studies, particularly in the area of exploration of medicinal plants for pharmacological and clinical research.

SEC Semester II

SEC 1. Mushroom Culture and Technology I (UPC: 2166000008)

Learning Objectives:

- To make students aware about Mushroom growing techniques
- Medicinal and nutritive value of Mushrooms

Learning Outcomes:

After successful completion of the course, the students will be able to

- Practice the techniques of cultivation of various edible mushrooms.
- Setup entrepreneurial small-scale units for self-employment
- Apply the skills as Mushroom grower in large-scale industries.

Course Description

The SEC Course on ***Mushroom Culture and Technology*** is aimed at imparting knowledge about the different types of mushrooms, including edible mushrooms, poisonous mushrooms and medicinal mushrooms. The students will learn about the nutritional, medicinal and market value of mushrooms; mushroom cultivation techniques, as well as post-harvest technologies like packaging and preservation. They will also study the common fungal, bacterial, viral and insect borne diseases of mushrooms. After successful completion of the course, students will be able to practice the techniques for cultivation of various edible mushrooms, set up entrepreneurial small-scale units for self- employment and apply the skills as Mushroom Grower in large- scale industries.

SEC 2. Biofertilizers (UPC: 216401002)

Learning objectives:

To help the students understand:

● the concept of biofertilizers and develop the skills for handling microbial inoculants.

● the growth and multiplication conditions of useful microbes and their role in mineral cycling and nutrition to plants.

● various methods of decomposition of biodegradable waste and their conversion to compost.

Learning outcomes:

After completion of this course, the learners will be able to:

• describe the different methods of composting.

• assess quality of compost and its role in soil nutrition.

• apply methods of bio-control

• develop a composting unit for production of biofertilizers (generate employment)

Course Description

Biofertilizers include preparations of efficient strains of microorganisms which when applied to plants help in acquisition of nutrients from the rhizosphere. Bio-fertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth promoting substances. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants. Biofertilizers are eco-friendly, organic agro-inputs and more cost effective than chemical fertilizers. Today, biofertilizers have emerged as a highly potent alternative to chemical fertilizers due to their eco-friendly, easy to apply, non-toxic and cost-effective nature. Also, they make nutrients that are naturally abundant in soil or atmosphere, usable for plants and act as supplements to agrochemicals.

The SEC course on ***Biofertilizers*** will provide a comparative account of various microorganisms used as biofertilizers and their role in agriculture and soil fertility. Students will also acquire knowledge about the practical aspects of various bio-composting methods, included in organic farming, using microbes and earthworms. They will also study the applications of various bio-control methods/ agents including Pheromone trap, *Trichoderma viridae* (fungal biopesticide), *Pseudomonas fluorescens* (bacterial biopesticide) and Neem (botanical pesticide) for pest management. The paper will facilitate increasing basic aptitude in the field of agricultural biotechnology to pursue higher studies and research and the skills to develop a composting unit for production of biofertilizers.

GE Semester IV

BOT-GE 1. Plant Health and Disease Diagnostics

Learning Objectives:

● understand the challenges and importance of plant pathogen diagnosis

● understand methods for reducing/minimizing risk of the spread of pathogens and pests.

● understand principles and tools for early warning systems to protect plant health.

Learning Outcomes:

At the end of this course, students will be able to:

● diagnose the cause of a plant disease and identify the causal agent

●select appropriate methods and strategy for control and mitigate spread.

Course Description

Plants are the primary source of nutrition for human and animal health. Plant diseases threaten the availability and safety of plants for human and animal consumption. The study of plant health and disease triangle (interaction of a susceptible host, a virulent pathogen and an environment favourable for disease development) is a pre-requisite to reduce the virulence of diseases and their detrimental impacts on crops. The course is, thus designed to understand the significance of plant health and the concepts and components of plant diseases, including history of plant pathology; causes and classification of diseases; the disease cycle; types and symptoms of viral, bacterial and fungal plant diseases, as well as the methods of diagnosis of plant disease (Histochemical, Serological and PCR techniques). The students will learn to identify the causal agents of plant disease, isolate the pathogen from an infected plant sample, and apply appropriate methods or strategies for control and mitigation of spread of disease caused by Tobacco Mosaic virus, Yellow Vein mosaic of Bhinde, Citrus Canker, Angular leaf spot of Cotton, White rust of crucifers, Late & early blight of potato, Rust of wheat and Smut of Cereals. They will also understand the concept of Plant disease epidemics; the factors affecting the development of epidemics; Epidemic assessment and Disease forecasting; and the tools of epidemiology geographic information system (GIS), Global Positioning System (GPS), Geostatistics and Remote sensing. The applications of integrated disease management (IDM) to prevent and manage diseases in crops, and strategies for IDM-regulatory, cultural, physical, chemical and biological, constitutes an important component of the course.

BOT-GE 2. Environmental Monitoring and Ecosystem Restoration

Learning Objectives:

● The course will train students on methods for conducting environmental monitoring protocols.

● It will provide experiential learning in conducting quality check experiments on soil, water and air.

● The course will develop understanding on different aspects of ecosystem restoration and processes through monitoring system.

Learning Outcomes:

At the end of this course, students will be able to:

● understand the problem of environmental degradation

● assessment of quantitative and qualitative parameters used in environmental monitoring of air, soil and water.

● understand the strategies and methods for ecosystem restoration, including physicochemical and biological indicators.

● understand degraded and restored sites through field visits.

Course Description

The undesirable changes in the physical, chemical and biological properties of various components of the environment, land, water and air have affected the environment, human life and other living organisms of the biosphere. Ecosystem restoration is the process of assisting the recovery of ecosystems that have been degraded and damaged and restoration is required when degraded ecosystems are unable to self-repair. Ecosystem restoration is especially important in agricultural and other intensive use landscapes. The paper will enable students to understand the problems of ecosystem and environmental degradation, the factors responsible for degradation of soil, water and air, climatic factors like flood, storm and drought, natural and anthropogenic activities responsible for forest fire, deforestation, causes of destruction of forests and landslides. Anthropogenic activities like industrialization, nuclear tests, fossil fuels, organic solvents, pesticides and herbicides, automobile industry, are collectively responsible for the degradation of environmental ecosystems. Particulate air pollutants such as aerosol, dust, smoke, fumes, compound of nitrogen, oxides of sulphur and hydrocarbons present in the air in the form of suspended particles matter constitute one of the most dangerous factors responsible for severe environmental pollution. The paper on Environmental Monitoring and Ecosystem Restoration, would equip the students to utilize various strategies and methods of ecosystem restoration, such as monitoring and measuring the air quality index, methods to control air, water and land pollution, restoration and preventive measures for loss of biodiversity, restoration of degraded land ecosystems by joint forest management system and adaptation of different sustainable development goals for ecosystem restoration. Students will also learn the impact of various heavy metals like lead, mercury and cadmium content present in the air, responsible for many acute as well as chronic effects on human health. Use of plants and microbes have become necessary to check the environmental pollution without harming environment and thus many methods like Bioremediation and Phytoremediation, Phytoaccumulation, Rhizodegradation, Rhizofiltration, Phytovolatilization, Phytostabilization, Phytodesalination and dissipation have been developed to solve the problem and clean the contaminated sites. The role of Arbuscular Mycorrhizal Fungi (AMF) as a bio-fertilizer which can potentially strengthen plants adaptability to changing environment and their influence on host plants at various growth stages is essentially needed to recover the degraded ecosystem. The urban green spaces are open areas in cities that have a significant amount of vegetation, including parks, gardens, cemeteries, allotment gardens and woodlands which play an integral part in determining health of humans and environment. They lower regional pollution by lowering particulate matter and moderate climate extremes. The sustainable development goals (SDGs) and their role to remove poverty and inequality, protect the planet, aim to ensure that all people enjoy health, justice and prosperity. Thus, this course will encourage students to develop an understanding on different aspects of ecosystem restoration and provide experiential learning through environmental monitoring systems.

SEC Semester IV

BOT- SEC 1. Exploring Medicinal Plants: from cultivation to applications

Learning Objectives:

• To learn various methods of propagating medicinal plants, such as seed germination, stem cuttings, and division.

• To develop the ability to observe and document macroscopic characteristics of herbal materials.

• To learn the microscopic techniques for examination of plant materials.

• To learn the different methods used in extracting bioactive compounds from medicinal plants and the factors to be considered in choosing the appropriate method.

• To conduct phytochemical screening tests to detect the presence of various compounds in medicinal plant extracts.

• To analyze the separated compounds from medicinal plant extracts using Thin Layer Chromatography (TLC).

Learning Outcomes:

By studying this course, students will be able to:

• acquire knowledge of proper care and maintenance of medicinal plants during cultivation.

• learn to identify and describe variations in size, color, odor, and surface texture among different plant specimens.

• acquire the skills to observe and count stomata, the tiny openings on leaf surfaces.

• perform commonly used phytochemical screening methods such as the alkaloid test, glycoside test, steroid and triterpenoid test, tannin test, flavonoid test, and phenol test and interpret the results

• use Thin Layer Chromatography (TLC) to separate compounds from a medicinal plant extract and analyze the separated compounds.

• evaluate the current research and developments in the field of medicinal plants.

Course Description

Medicinal plants have long been used in traditional cultures all over the world and are increasingly becoming popular as natural alternatives to synthetic medicines. The high cost and side-effects of modern drugs, multiple drug- resistance and lack of curative treatment for chronic diseases has rekindled global interest in traditional herbal medicine. The SEC Course on 'Exploring Medicinal Plants: from cultivation to applications' aims to impart knowledge about the rich diversity of medicinal plants and their potential in prevention and treatment of various diseases. The students will learn and practice various methods of cultivation, propagation and maintenance of medicinal plants. Adulteration and substitution is common in herbal drugs, affecting the quality and purity of drug. The students will acquire the skills to identify medicinal plants and document macroscopic characteristics, as well as learn microscopic techniques for examination of herbal material. They will also learn different methods used in extracting bioactive compounds from medicinal plants and perform phytochemical screening tests to detect the presence of various compounds in medicinal plant extracts. The course will equip the students for understanding current research and developments in the field of medicinal plants from cultivation to extraction and applications. The students will acquire the skills to work in pharmaceutical industries, herbal products companies, as research scientists in various national and international laboratories, and medicinal plants farmer or cultivator.

BOT- SEC 2. Basics of Food Science and Nutrition

Learning Objectives

1**.**The primary objective of this course is to provide an understanding to the students of the types and biological importance of macro and micronutrients found in the dietary sources.

2. The students will get an opportunity to understand the integrated learning between the areas of Food science and Nutrition.

3. The course will also provide hands-on experience of different methods used to estimate different types of nutrients that will help the students learn the concept nutrition and health.

Learning Outcomes

Learners will be able to:

1. Analyse and evaluate concepts in human nutrition and its relation with food and health

2. Understand the concept of food exchange and meal planning

3. Understand the essentiality of macro and micronutrients in food items

4. Assess the quality and nutritive value of food.

Course Description

The SEC paper "Basics of Food Science and Nutrition" offered by the Department of Botany is designed to provide an understanding of food and nutrition as an integrated science to maintain good health. The students will be taught the nutritional classification of dietary food based on chemical composition and calorie intake. The dietary sources, roles and Recommended Dietary Allowances (RDA) of various macro and micronutrients will be discussed to recognize the components of a balanced diet. The concept of food energy and energy balance would help the learners understand the changes in energy intake and expenditure.

Further, hands-on learning experience of different methods viz. estimation of macronutrients (total carbohydrate content by Molisch's test/ Hanes method/Folin-Wu method, total protein content by modified Lowry's method and total fat content by Soxhlet extraction/ Bligh and Dyer method) and quantitative estimation of micronutrients by titration (determination of Vitamin C) and spectrophotometric methods (Vitamin A/E in oils) in addition to the analysis of the mineral content in food- Ca, P/Na/K and Fe) would equip the students to assess the quality and nutritive value of food from diverse dietary sources. Practical training experience in designing a meal plan for healthy adult men and women and food exchange would serve as a valuable asset to students for personal growth and to acquire skills for jobs in food processing, packaging and production in home care facilities, schools, hostels, business establishments and old age homes.

Skill development and job opportunities:

Students will be able to take up jobs in public and community health schemes where food assessment is done. They can also as serve as assistants in program where meal planning is done like home care facilities, schools, hostels, old age homes. It will provide them the training to apply for jobs in any business establishments concerning food processing, packaging and production. After completion of the entire series, students will be able to take up job opportunities in any business involved with advanced food processing. They would also be eligible to get placements in food and drug assessment centres. The course will also enable students to apply to advance food science and tech courses.

Abstracts for GE and SEC Papers offered by Dept of Chemistry 2023-24 (Even Semester)

SEC COURSES

For Semester VI (CBCS-LOCF): BSc (P) Physical Sciences

SEC 6: Intellectual property Rights; UPC: 42173910

Total Credits: 4 (Lecture: 4, Practical: 0)

'Intellectual Property Rights' offers a comprehensive and authoritative exploration of this rapidly evolving field. The Indian patent law, structured with the primary aim of advancing scientific research and technology for the public good, grants inventors exclusive rights over their creations for a limited duration. This course delves into the significance of safeguarding scientific discoveries with commercial potential, emphasizing the discourse on intellectual property rights across statutory, administrative, and judicial spheres.

The objectives of the course encompass a historical perspective and the types and importance of protecting intellectual property, including copyright and trademarks. It covers the basics of patents and associated rights, the WIPO and PCT system, geographical indications, rules for registration, prevention of illegal exploitation, industrial and international design registration, trade secrets, and protection. The course also navigates the complexities of international agreements such as GATT, TRIPS, GATS, Madrid Protocol, Berne Convention, and Budapest Treaty. It addresses the Paris Convention under WIPO, TRIPS, IPR, plant breeders' rights, and the intersection of IPR with biodiversity.

With a focus on infringement and enforcement, this paper provides a fresh perspective and a comprehensive understanding of intellectual property rights, encompassing copyright, trademarks, and patents. It explores the diverse aspects of patent law, offering insights into chemistry, pharmaceuticals, biotechnology, software, electronics, manufacturing, and other fields, making it an invaluable resource for those considering a career in this dynamic and crucial area.

Detailed Syllabus:
https://drive.google.com/file/d/1IeXurOrhEAZrjYVMbHXNrJ0R8r5o2Y_T/view?usp=sharing

BSc. (P) Life Sciences

SEC 3: Chemical Technology & Society; UPC: 32173903

Total Credits: 4 (Lecture: 4, Practical: 0)

This paper serves as a comprehensive introduction to the extensive array of equipment essential in chemical technology, spanning reactors, distillation columns, extruders, pumps, mills, and emulgators. Going beyond equipment, it explores the pivotal aspect of scaling up operations within the chemical industry while introducing the principles of clean technology. The curriculum delves into the foundational principles of distillation, solvent extraction, solid-liquid leaching, liquid-liquid extraction, absorption, and adsorption. Beyond

technicalities, the course extends its scope to address the societal dimension by examining contemporary issues through a chemical lens. Students are guided to develop chemical and scientific literacy to grasp topics like air and water, emphasizing pollutants, and exploring energy sources encompassing solar, renewables, fossil fuels, and nuclear fission. Material exploration includes the study of materials such as plastics, polymers, proteins, and nucleic acids, shedding light on their natural analogues. Moreover, the course navigates through the intricacies of molecular reactivity and interconversions, ranging from fundamental processes like combustion to more complex applications such as genetic engineering and pharmaceutical manufacturing. This holistic approach positions students to not only comprehend the technical nuances of chemical technology but also to critically engage with the societal and ethical dimensions of the field.

Detailed Syllabus:
https://drive.google.com/file/d/1hLiVsYICPN8IFOtIykxzz3MmhC7e7Bar/view?usp=sharing

Sem IV (UGCF-NEP):

SEC – Green Methods in Chemistry; UPC – 2176000007

Total Credits: 2 (Lecture: 0, Practical: 2)

This transformative course has been meticulously designed to instil a profound understanding of the dynamic intersections between chemistry, human health, and environmental sustainability. With primary objectives centred on fostering awareness about chemistries that contribute to both human well-being and ecological balance, the curriculum provides in-depth insights into the principles of green chemistry. Through this course **based on hands-on training**, the students will be equipped with expertise to employ innovative remediation technologies for the cleanup of hazardous substances. By the end of the course, they will develop the ability to design and implement materials and processes that effectively minimize the use and generation of harmful substances in industrial contexts. Graduates emerge with a skill set that includes proposing inventive solutions to environmental challenges, critically analysing traditional chemical pathways, and applying green technologies practically. This comprehensive approach ensures students are well-prepared for roles that demand a visionary commitment to responsible and innovative chemistry, making them sought-after professionals in today's sustainability-focused landscape.

Detailed Syllabus:
https://drive.google.com/file/d/1H5skSBN8ACHOgEJA89ZO7VOdq77nS3mz/view?usp=sharing

Sem II (UGCF-NEP):

SEC - Lab Testing and Quality Assurance. UPC: 2176000003

Total Credits: 2 (Lecture: 1, Practical: 1)

Studying this paper on quality check and control in chemical industries offers students practical knowledge and skills crucial for academic and professional growth. The objectives

focus on providing a comprehensive understanding of quality control practices, and the outcomes ensure practical application. Upon completing the course, students will proficiently articulate the role of a quality control chemist, adeptly demonstrate analytical techniques, competently carry out sample preparation, articulate the fundamentals of quality check, and proficiently implement safety procedures.

The syllabus is thoughtfully structured, commencing with an exploration of industry sectors, standards in life sciences manufacturing, and the pivotal role played by quality control chemists. Subsequently, the course delves into modern analytical methods, separation techniques, the rudiments of sample preparation, and guidelines for proper handling. The section on quality check encompasses diverse aspects such as lab testing, productivity concepts, statistical analysis, calibrations, validation, and government regulations in sectors like pharmaceuticals and cosmetics.

This paper offers both theoretical and practical aspect of the topic and strategically prepares students for roles in chemical industries, augmenting their employability and efficacy in ensuring the quality and safety of chemical processes and products.

Detailed Syllabus:
https://drive.google.com/file/d/1wNGhKtoQsi1H6gsv2Sbu6qJmuYtRUZy-/view?usp=sharing

GE COURSES

For Sem IV (UGCF-NEP):

GE-17 - Energy and Environment; UPC: 2174001211

Total Credits: 4 (Lecture: 3, Practical: 1)

The Energy and the Environment paper provides students with a comprehensive understanding of the interplay between energy-related issues and their environmental ramifications. Covering a range of energy sources and distinguishing between renewable and non-renewable options, the course underscores the significance of eco-friendly fuels. Students delve into the complexities of pollution, exploring both its adverse effects and potential remediation strategies. The curriculum promotes contemplation on energy costs, resource efficiency, and the integration of renewable solutions like solar power. Additionally, it addresses pollution reduction measures, advocating for practices such as re-use, recycling, and ethical material utilization.

The syllabus, structured into four units, explores key topics such as the chemistry of energy, the carbon cycle, greenhouse gases, and global warming. It delves into electric power production methods, encompassing non-renewable sources like fossil fuels and renewables like solar, wind, and biomass. Furthermore, the course examines pollution, air quality, and remediation measures, shedding light on pollution's impact on health and the economy.

In summary, this course equips students with a holistic understanding of the intricate connections between energy, the environment, and societal well-being. It prepares them to

critically evaluate energy technologies and actively contribute to sustainable practices, fostering a comprehensive perspective on these interconnected issues.

Detailed Syllabus:
https://drive.google.com/file/d/19EInakgx48srxeprqb6hjhedxh96r8Rx/view?usp=sharing

For SEM II (UGCF-NEP):

GE-20 - Green Chemistry; UPC: 2174001201

Total Credits: 4 (Lecture: 2, Practical: 2)

Over the past 150 years, most chemicals have been developed with a focus on effectiveness and little regard for their toxicity and impact on human health or the environment. The field of
chemistry has fostered almost no formal training in toxicity or eco-toxicity. But growing awareness of the detrimental effects of many chemicals has led to a new movement known as 'green chemistry'. It is the science of creating safe, energy efficient and non-toxic products and
processes and offers a concrete path towards solving the environmental problems our society faces today.

In this paper, the students will be made to understand the notion of sustainability and how it applies to chemistry. They will explore the principles of green chemistry along with real world cases in green chemistry. The connection between chemical toxicity and human health and how
it influences material and product decision making will be emphasized. It will provide students with the opportunity to make connections among the discipline of chemistry, other disciplinary subject matters, and aspects of their lives. The paper offers both **theoretical** and **practical** aspect of Green Chemistry and overall, it prepares students (future chemists) for safe and sustainable practices in laboratories and industries, fostering a mindset for a greener and more responsible approach to chemistry.

Detailed Syllabus:
https://drive.google.com/file/d/1PI0m4fHbiELS3_6NbwdSQ9Ue9olbAC-4/view?usp=sharing