Uttarakhand Residential University
Almora

B.Sc.(Biofuels)

About the Programme

Bio-fuel Technologies: Towards Cost Effective Eco-friendly and Renewable Energy

- The global energy demand is steadily increasing with the economic growth combined with the population explosion. The fossil fuels are depleting at faster rate with the economic development. Thus, the continued use of fossil-based fuels is not sustainable owing to its limited availability and emission of the green house gases and other air contaminants upon combustion. Therefore, development of an alternate renewable and clean energy source has gained serious attention worldwide.
- According to the feedstock and technology used, the biofuel technologies have been categorized as the first, second, third and fourth generation biofuels.

First generation bio-fuel technologies

First generation bio-fuels are the fuels derived from sugar, starches or vegetable oils. Bio-diesel and bio-ethanol are widely known as first generation or conventional biofuels. The use of vegetable oil as a fuel dates back to more than a century when Rudolph Diesel invented the compression-ignition (CI) engine. In order to lower the viscosity and improve volatility, the triglyceride oils require some chemical modifications such as transesterification or emulsification. The fatty acid methyl esters (FAME) obtained by transesterification of oil with methanol is popularly known as bio-diesel. The physical properties of fatty acid methyl esters resemble to petroleum derived diesel fuel. Presently, bio-diesel is derived from food grade edible oils in many developed and developing countries *i.e.* Soyabean oil in USA, Canola in Canada, Rapeseed in Europe, Palm in Malaysia and Indonesia, etc. India being one of the largest edible oil importers, it can't divert these edible sources for fuel purpose. The non-edible oilseeds *i.e.* Karanja (*Pongamia pinnata*) and Jatropha (*Jatropha curcas*) are suitable feed stock for bio-diesel in India.

Second generation bio-fuel technologies

The first generation biofuels compete with inputs for food, so the alternative may be the advanced or second generation biofuels which uses cellulosic products such as wood, straw, long grass or wood waste for biofuel production. The advantage of second generation biofuels is the ability to use the whole plant and not just its parts (for example grains), as is the raw material for the first generation. All plants contain lignin, hemicellulose and cellulose. Lignocellulosic ethanol is made by freeing the sugar molecules from cellulose using enzymes, steam heating, or other pre-treatments. These sugars can then be fermented to produce ethanol in the same way as first generation bioethanol production.

Second generation biofuels from lignocellulosic biomass can be broadly obtained through biochemical and thermo-chemical processes. Biochemical processes typically employ pre-treatment to accelerate the hydrolysis process, which separates out the lignin, hemicellulose and cellulose. Once these ingredients are separated, the cellulose fractions can be fermented into alcohols. Liquid

biofuels from biomass can be obtained through thermo-chemical processing or by chemical treatment. Thermo-chemical treatment comprises thermal decomposition and chemical transformation of substrates by the action of the temperature in the presence of various concentrations of oxygen. The advantage of thermal treatment in relation to the biochemical is able to convert all organic ingredients, not just the polysaccharides, as is the case with chemical treatment. Carbon-based materials can be heated at high temperatures in the absence (pyrolysis) or presence of oxygen, air and/or steam (gasification). These thermo-chemical processes yield combustible gas and solid char. The gas can be fermented or chemically synthesized into a range of fuels, including ethanol, synthetic diesel or jet fuel. However, the majority of these processes are still under development phase and trying to secure a market share due to various challenges, right from suitable infrastructure, raw material, technical limitations, government policies, and social acceptance.

Third generation bio-fuel technologies

The Biofuels derived from microalgae, the unicellular algae, are referred as third generation biofuels. Microalgae are a promising feedstock for biofuels owing to their rapid growth rate and higher lipid productivity than the best oil producing terrestrial plants. Further, the higher photosynthetic efficiency and wider adaptability to different environmental conditions are the other reasons for interest in microalgae for biofuels. Microalgae, does not need fertile land and can be grown in sewage water, thus eliminating or minimizing the competition with food crops for resources, consequently avoiding the food vs fuel conflict. In addition to source of different types of biofuels, microalgae are useful as nitrogen fixing bio-fertilizers and in phyto-remediation.

Fourth generation Bio-fuel technologies

Omics advancements contribute to the development of the fourth generation biofuels from genetically engineered species. The omics technological advancement has tremendous future scope to extract deeper biological knowledge and thereby cost effective production of renewable energy. It mainly includes key area of research such as new strain development, improved cultivation, low energy harvesting and high-yield extraction-conversion technology.

In order to advance the economic feasibility of the microalgae or other feed stocks, much attention is being given on genetic and metabolic engineering to increase the yield of biofuel relevant lipids without compromising the growth. Genetic engineering approach has been widely used for improvement in biofuel traits in terrestrial plants as well. Commercial application of genetically engineered species is however subject to strict bio-safety regulations.

Future perspectives

Natural petroleum resources, synthesized over millions of years are likely to be exhausted shortly. Though, a number of alternative fuels have been discovered, none of them is as usable as biofuels are, primarily because we do not need to

change the way we currently use our fuels or energy resources. However, both the cultivation of the raw material for biofuels, as well as the extraction of the yields at present is a challenging task, simply because neither we have been accustomed to cultivate them, nor the nature has destined these resources to be utilized so. Thus, huge amount of investments on Research and Development of these resources are required.

Given the current state of technology, and the uncertainty remaining about the future breakthroughs that would potentially make some advanced-generation biofuels cost competitive, policymakers need to carefully consider what goals are to be pursued in providing support to different biofuels. Biofuels that simultaneously advance multiple policy goals could warrant greater support when designing incentive mechanisms. An integrated approach combining economically sustainable rural development, climate change mitigation, and alternative energy provision provides a good policy framework for advanced-generation biofuels. It is also necessary to consider regional and international developments in policies and trade in order to maximize the potential benefits achievable through the policies implemented.

Uttarakhand Residential University Almora has started B.Sc (Biofuels) course from academic session 2017-18. The objective of this course is to provide students with the basic principles of biofuels and bioenergy systems design. Students in this course will identify biofuels and bioenergy sources; describe biofuels and bioenergy technologies, applications and efficiency; analyze biofuels and bioenergy manufacturing, distribution and integration issues; evaluate biogas and its sources and site location; design a biofuels and bioenergy process and its related components.

Uttarakhand Residential University
Almora, Uttarakhand-263001

Study & Evaluation Scheme

SUMMARY

Programme	:	**B.Sc.(Biofuels)**
Duration	:	**Three Years (Six Semesters)**
Medium	:	**English**
Minimum Required Attendance	:	**75%**
Credit	:	
Maximum Credit	:	**180**
Minimum Credit required for the degree	:	**180**

Assessment :

Internal	External	Total
25	75	100

Evaluation of Practical/Dissertations & Project Reports :

External	Internal	Total
50	50	100

Duration of Examination :

External	Internal
3 hrs	1 ½ hrs

To qualify the course a student is required to secure a minimum of 40 marks in aggregate including the semester end examination and teachers continuous evaluation (i.e. both internal & external).A candidate who secures less than 40% of marks in a course shall be deemed to have in that course. The student should have at least 40 % marks in aggregate to clear the semester

Question Paper Structure:

Semester where Class room teaching is taking place in University

1. *The question paper shall consist question one as compulsory of 15 marks. In addition there will be two questions from each unit of which one question will have to be answered by the student. Each question will carry equal weightage.*

Semester where Class room teaching is taking place in University

1. *The question paper shall consist question of Multiple choice Questions and the same would take place using computer software in a manner that the result would be known to the student at the end of the paper.*

2. **STUDY & EVALUATION SCHEME**

B.Sc.(Biofuels)

SEMESTER I

S. N.	Subject Code	Subject	Periods			Credits	Evaluation Scheme		
			L	T	P		Internal	External	Total
1		Professional &Confident Communication	5	-	-	5	25	75	100
2		Computers Basics	5	-	-	5	25	75	100
3		Biofuels Basics	5	-	-	5	25	75	100
4		Professional	-	-	4	2	25	75	100
5		Computer Lab	-	-	4	2	50	50	100
6		Biofeuls Lab	-	-	4	2	50	50	100
7		Project work				6	50	50	100
Total			**15**	**-**	**12**	**27**	**250**	**450**	**700**

FIRST SEMESTER

TITLE		Object of the course
Paper 1	Professional and confident communication	This course will help students to read, write, think and communicate critically. The goal is simply not to memorize terminology but to learn critically. It will enable students to know how to use concepts and relate the concepts to other subjects and other dimensions of life such as personal life, social life and professional life.
Paper 2	Computer Basics	This course is the simplest and quickest way to be acquainted with basic IT skills and usages of the internet through simple fun filled programs. The programs shall equip students with basic IT skills thereby bridging the digital divide.
Paper 3	Basics of Biofuel	The objectives of this course are to provide students with the basic principles of bio fuels and bio energy system design. Students in this course will identify bio fuel and bio energy sources.
PRACTICAL		
01	Professional communication Lab	It shall comprise of the four skills of learning – Listening, Speaking, Reading and Writing in addition to their theory. The lab training shall be given with the assistance of Networked Computers and specially designed software.
02	Computer lab	After getting introduction of windows, students will have hands on lab for learning the basics of DOS, Word, Operating systems, spread sheet, communication and internet.
03	Biofuel lab	1- Fermentation by yeast 2- Bio fuel yielding plants 3- Algae which produce bio fuel 4- Equipment for microbial culture technique

SECOND SEMESTER

Paper 1 - Introduction to Bio- Energy

Introduction to Bio- Energy ; The need for alternative fuels, composition of fossil fuels; Further definition and introduction to the major bio-energy feed stocks; Potential benefits of replacing fossil fuels with biofuel, Biomass and Biogas; Food verses fuel.

Paper 2 – Bioethanol

Introduction; fermentation of sugars to ethanol, Sucrose; Synthesis of plants; sugarcane; Bioethanol from starch; Bioethanol from wheat; Bioethanol from other grains.
Second generation bio-ethanol from cellulose and other cell wall polysaccharides, plant cell wall.
Bio- ethanol from algal cell wall polysaccharides.

Paper 3 –Biodiesel –I

Introduction, oil synthesis in oil seed crops; Biodiesel manufacturing.
Biodiesel feed stock, soybean oil, oil seeds (canola oil, palm oil), tallow and waste oil.
The potential first generation feed stock, potential second generation biodiesel feedstock.
Biotechnology.

Practical Biofuel

1. Bio- production from maize (corn).
2. Collection and identification of different species of Blouin artifno
3. Collection and identification of different species of Lantana Camarao
4. Bio- diesel production from bukol (blowing artifino) and Lantana camara by burning them with different plastic items and rubber

THIRD SEMESTER

Paper 1- Microbiology

- Introduction to Microbiology.

(History and scope of microbiology, Microscopy, Bio-instrumentation and Bio-safety)

- Microbial nutrition, Growth and control of micro-organisms by physical and chemical agents.
- Microbial metabolism and its correlation to biofuel production.

  (Ethanol production by fermentation with use of different microbes i.e. *S.cerevisiae, E.coli, Zymomonas.*)
- Microbial aspects of biofuel production and industrial microbiology: Current status and future.

  (Alcohol as biofuel, different generation of bio-fuel, Bioprocessing, Bio-diesel, Bio-hydrogen, Biogas, water purification system and sanitary analysis, waste water treatment)
- Engineering of micro algae for biofuel production.
- Bio-degradation and bioremediation by natural communities.

(Bio-augmentation) References:

Paper 2- Biodiesel-II

- Introduction: National policies for biofuel production.
- Oil Synthesis in Oilseed crops.
- Biodiesel Manufacturing.
- Biodiesel Feed stocks. Feedstock pretreatment in biodiesel Production.
- Potential Second Generation Biodiesel Feed Stocks.
- Biotechnology.
- Oilseed crops for biodiesel production
- Oilseed handling for biodiesel Production
- Used and Waste oil and Grease for biodiesel Productions.
- Small Scale biodiesel Production Systems
- Reactors for biodiesel Production
- Fuel sampling procedures.
- Biodiesel Technologies in National Scenerio.
- Biodiesel fuel specifications and fuel property measurements.
- ASTM methods for determining the chemical properties of Biodiesel.

Paper 3– Chemistry of Biofuel and Bioenergy

- Mass Balances
- Energy Balances
- Thermodynamics.
- Organic Compounds
- Chemistry of Plant Materials
- Synthetic Hydro Carbons
- Login Based Products
- Fiber based Products

Practical Biofuel

1. Biofuel production from maize (corn).
2. Biofuel production from sugar cane.
3. Biofuel production from Parthenium hysterophorus
4. Collection and identification of different species of Blouin artifno
5. Collection and identification of different species of Lantana Camara
6. Bio- diesel production from bukol (blowing artifino) and Lantana camara by burning them with different plastic items and rubber

FOURTH SEMESTER

Paper 1– Biowaste to Bioenergy

Bioenergy from biomass as source of alternative energy – Wet milling of grain for alcohol production ,grain dry milling cooking for alcohol production, use of cellulosic feed stocks for alcohol production .

Biogas Technology- Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues and biochemical aspects – operating parameters for biogas production.

Bio power – Introduction, Co –firing, Biomass gasifiers, Bio refineries concept and definition, development status and prospects, Bio refineries platform.

Biomass Pretreatment and upgrading Technologies – Pelletisation, Pyrolysis and hydrothermal upgrading .Biomass for heat application Combution , Gasification.

Introduction on second generation biofuel – From waste biomass. Electrical energy production from municipal solid waste (MSW)using process of Land fill gas (LFG) production ,Mass incineration (MI) and anaerobic digestion (AD).

Paper 2- Bio-Diesel Part- III

Biodiesel analysis methods : Diesel engine fuel requirements, Biodiesel fuel specifications as per ASTM -975. Other important fuel properties not included in ASTM -975, Measurement of fuel properties.

Non edible vegetable oils : Introduction, Resources, Advantages and extraction techniques. Fatty acid composition profile of various non-edible oils. Technique of biodiesel production from non-edible oils: Pyrolysis, Micro-emulsion, Dilution and Tans esterification. Effect of blending on engine performance and emission.

Biodiesel from microalgae : Introduction as second generation feed stocks, Classification of microalgae, Cultivation techniques and culture parameters, Nutrients requirements for growth, harvesting Techniques. Oil extraction and biodiesel production.

Biodiesel from waste cooking oils and animal fats : Introduction, Types of cooking oils, Biodiesel production technique from waste cooking oils and animal fat wastes, Technical challenges in biodiesel production.

Global warming : Introduction, Factors, Geochemical cycles, Carbon, Nitrogen and Hydrogen cycle and role of biofuel in minimization of global warming.

Paper 3– Chemistry of Biofuel and Bioenergy II

Sources of energy : Solar energy ,Hydrogen ,geothermal ,Tidal and hydel etc.

Types of fuels and their calorific values. Coal ,Petrol and natural gas. Nuclear fusion /fission.

Use of coal (fuel and non fuel) in various industries, its composition ,carbonization of coal. Coal gas, producer gas and water gas –composition and uses.

Reforming petroleum and non petroleum fuels (LPG, CNG ,LNG ,biogas, fuel derived from biomass),fuel from waste ,synthetic fuels (gaseous and liquids), clean fuels.

Petrochemicals : Vinyl acetate, propylene oxide ,Isoprene ,Butadiene ,Toluene and its derivatives Xylene.

Solvent Refining : Fractional distillation principle and process. Fractionation of coal tar and uses of coal tar bases chemicals.

Carbohydrates : Occurrence, classification and their biological importance. Monosaccharides, Disaccharides, Polysaccharides.

FIFTH SEMESTER

Paper 1- Chemistry of Biofuel and Bioenergy III

Biomolecules- Biomolecules, Carbohydrate, Lipids, Amino acids and peptides, Nucleic acids.

Enzymology- Nomenclature and classification of enzymes, Enzyme- substrate complex, Enzyme kinetics, Enzyme inhibition, Isozymes, Zymogen, Ribozymes.

Biophysics or Bioanalytical Techniques- Chromatography, Electrophoresis, Spectroscopy, Centrifugation, Microscopy.

Plant Secondary Metabolites – Alkaloids, Terpenes, Phenolics, Glycosides.

Harvesting Energy from Biochemical Reaction- Biological oxygen demand and Chemical oxygen demand, Bioremediation: Strategies and Advantages.

Biochemistry in Daily Life- Prebiotics and probiotics, Nutraceuticals; use of nutraceuticals in traditional health sciences. Role of omega-3 fatty acids, Food additives: Definitions, functions and uses in processed food products. Sweetening agents: Artificial sweeteners, composition, uses.

Biofuel and chemicals from algal feed stocks

By –product utilization (value added products from glycerols/ oil cake etc.)

Effluent treatment system.

Paper 2- Biotechnology

Biotechnology : An overview – origin and definition : old v/s new biotechnology , Scope and importance, Present scenario of Biotechnology in India.

Nucleic acid (DNA and RNA) : Occurrence , Morphology and Functions. Protein synthesis : Mechanism and regulation .

Recombinant DNA and Gene cloning : Restriction enzymes for cloning ,cloning vectors for recombinant DNA (Plasmid ,Phages, Cosmid ,Viruses, Transposons, YAC, MAC etc), Expression vectors , binary and Shuttle vectors .Restriction enzymes for cloning, Techniques of restriction mapping, cloning in bacteria and eukaryotes Molecular probes(production, labelling and uses)Genomics and c DNA libraries Walking and Jumping chromosomes..

Polymerase Chain Reaction and Gene Amplification : Introduction ,Basic PCR and its modifications , application in biotechnology and Bioengineering. DNA polymorphism, RAPD , DNA fingerprinting .

Biotechnology for pollution control : Use of cleaner technologies for reducing impact of industrial efficient, toxic site reclamation ,removal of spilled oil and grease deposits ,impact of chemical herbicides and fertilizers ,Biosensors to detect environmental pollutants.

Energy scenario and challenges.

Types of feedstock and their availability in India.

Potential feed stocks for biodiesel in India.

Paper 3- Microbiology:

Vaccines And Their Production : Introduction ,Traditional vaccines ;Live attenuated vaccines ,Dead ,Inactivated vaccines , Toxoids ,Pathogen –derived antigens. Modern vaccines ; Subunit vaccines , Conjugate vaccines , Recombinant vaccines .

Microbes In Production Of Commodity Chemicals : Introduction ,Commercial production of ethanol ,Industrial production of Acrylamide ,Industrial production of citric acid, Penicillin as a commodity chemicals .

Agricultural Application Of Microbes : Introduction ,Biofertilisers ;Nitrogen fixing microorganism as Biofertilisers. PGPB(Plant Growth Promoting Bacteria),Plant growth promoters, Biopesticides ; Bio-weedicides, Bioinsecticides , Biofungicides , Biorational Pesticides of microbial origin ; Bacterial secondary metabolites as Agrochemicals , Agroactive compounds from Actinomycetes , Fungal secondary metabolites as Agrochemical.

Environment and Microbes : Introduction ,Microbial Bioremediation ; In situ Bioremediation by microbes, Ex situ Bioremediation by microbes, Biodegradiation of Xenobiotic compounds, Bioremediation of heavy metals,Microbially enhanced oil recovery (MEOR)

Molecular Mechanism of Ethanol tolerance in Sacaharomyces Cerevisiae : Introduction , Expression of structure and organelle related gene , Membrane and Cell wall; Vacuole , Mitochondria , Peroxisome , Amino acid encoding genes; Tryptophan, Proline.

Biodiesel process and problem with conventional technologies.

Biodiesel Technologies available in Indian: Few Case studies.

Biodiesel Technologies : International status.