FACULTY OF AGRICULTURE
AGRI 5705: MODULE COURSE
COURSE SYLLABUS

Title: Sustainable Biorefinery Processes, Circular Bioeconomy and Socio-Environmental Impacts

Instructor: Dr. Sonil Nanda

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Dates: Module 1: September 1-30
Module 2: October 1-31
Module 3: November 1-30

Format: 12 hours of contact time per module
(i.e., 4 weeks of 1.5 hours per lecture/meeting in each module)

Module content and learning objectives:

Module 1: Profiling of Bioresources and Industrial Waste for Biorefinery
This module will introduce the first, second, and third generations of feedstocks for biorefinery applications to produce biofuels, biochemicals and bioproducts. It covers definitions, examples and biorefinery potential of various waste streams including agricultural and forestry biomass, energy and oilseed crops, municipal solid waste, food waste, plastic waste and sewage sludge. This module will provide current statistics, availability and composition of bioresources along with analytical characterization methods to assess their suitability for biorefinery applications.

Module 2: Applications of Waste-to-Energy Technologies, Biofuels and Bioproducts
This module will introduce different biological, thermochemical, hydrothermal and mechanical biorefinery processes to produce biofuels and bioproducts. The module will describe several waste-to-energy processes such as anaerobic digestion, fermentation, densification, combustion, torrefaction, pyrolysis, liquefaction, gasification and transesterification. The applications of different biofuel products such as biomethane, biohydrogen, bioethanol, biobutanol, bio-oil, biochar, syngas and biodiesel will be covered.

Module 3: Lifecycle and Techno-economic Analyses, Intellectual Property, Policy Frameworks and Market Opportunities for Biorefineries
This module will cover lifecycle analysis to assess the environmental impacts, energy use, and emissions in feedstock collection, transportation, and conversion at a biorefinery. It will cover intellectual property, Technology Readiness Levels, and policy frameworks for biofuels commercialization. This module will highlight the market potential and key drivers for biorefineries like environmental regulations, clean energy security, techno-economic factors, carbon credits and Canada's Net-Zero Targets.

Overall Learning Outcomes

The Canadian bioeconomy consists of various feedstocks, processes and applications. This sector is multifaceted and rapidly evolving with a high demand for skilled workforce. The specific learning outcomes for students in this three-module course offering include understanding and developing critical thinking and analytical skills to enable them to apply biorefinery concepts as a sustainable approach to address complex issues of waste management, energy security and global warming. By the end of this course, students should be able to:

- Define and describe different renewable feedstocks of importance to biorefineries along with their production, availability and feasibility.
- Describe and discuss biomass and biofuel properties and their commercial feasibility.
- Analyze different biorefinery processes appropriate for specific feedstocks and desired bioproducts.
- Understand supply chain management, energy and mass balances, environmental impacts and policy aspects in circular bioeconomy.

Method of Evaluation and Distribution of Marks

For each module, the following assessment rubrics will be followed:

- Weekly assignments (total of 4): 40%
- Final presentation: 40%
- In-class discussion topics (total of 2): 20%

Restrictions on Enrolment

Enrollment in the graduate program is required.

Textbooks and Additional Materials

- Biomass Gasification, Pyrolysis and Torrefaction: Practical Design, Theory, and Climate Change Mitigation. Authors: P. Basu, P. Kaushal. Academic Press (Elsevier); 2023; pp. 706.
- Bioprocessing of Biofuels. Authors: P.K. Sarangi, S. Nanda. CRC Press. 2021; pp. 98.
- Other recent research and review articles and book chapters relevant to the topics in the module.