Module 2: Waste-to-Resource Strategies in Agri-Food Systems
Student Notes

These notes are designed to help you understand the main ideas, vocabulary, and concepts from Module 2. Each section matches the learning outcomes and activities discussed in class. Use these notes to study for quizzes, complete projects, and participate in discussions.

Note: Vocabulary words marked with an asterisk (*) are required knowledge. Unmarked words are included for personal enrichment.

Lesson A – Beyond the Trash: The Five Pathways of Food Waste

Learning Outcomes:

- **Identify:** Five major waste-valorization pathways—landfill, aerobic composting, anaerobic fermentation / digestion (Bokashi & digesters), biochar pyrolysis, and insect bioconversion
- **Describe:** Inputs, process conditions, and primary outputs of each pathway
- **Compare:** Greenhouse-gas profiles of the five pathways and determine which emit or avoid the most CO_2-equivalent
- **Predict:** Which pathway would deliver the greatest carbon reduction for a given food-waste scenario

  Key Concepts:

  1. **Five major waste-valorization pathways**:
     - Landfill
     - Aerobic composting
     - Anaerobic fermentation/digestion (Bokashi & digesters)
     - Biochar pyrolysis
     - Insect bioconversion
  2. **Inputs, processes, and outputs** of each pathway
  3. **Circular vs. linear systems** in waste management
  4. **Trade-offs**: nutrient recovery, speed, scalability, costs
  5. **Case study**: Bokashi + biochar fertilizer benefits

Think About:

- Which pathway do you think has the greatest benefit for your community? Why?
- How can food waste be diverted from landfills?

Important Vocabulary to understand and use:

a. Landfill*
b. Aerobic Composting*
c. Anaerobic Digestion*
d. Biochar Pyrolysis*
e. Insect Bioconversion*
f. Organic Waste*
g. Methane*
h. CO_2-equivalent*
i. Nutrient Potential
j. Circular Economy*

Vocabulary in Context: Fill in the Blanks using Word Bank

1. ____ is material from plants or animals that will naturally decompose.
2. A __________________________________ breaks down food waste without oxygen, releasing methane.

3. ____ is a gas more harmful than CO_2.
4. Converting waste into valuable products supports a ______________________________________.
5. ____ uses oxygen to break down organic waste into compost.
6. Heating organic matter without oxygen to create a charcoal-like product is called ____.
7. ____ uses insects to convert waste into usable products.
8. The five main pathways are landfill, aerobic composting, anaerobic digestion, biochar pyrolysis, and ____.

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Self-Test:

1. The most common disposal method for food waste is ____.
2. The process that produces biogas and fertilizer without oxygen is ____.
3. ____ produces methane during decomposition without air.
4. A method that creates compost to improve soil health is ____.
5. ____ measures the impact of greenhouse gases.
6. Using insects to process food waste is called ____.
7. The system that keeps materials in use for as long as possible is a ____.
8. A stable form of carbon created by heating organic material without oxygen is ____.

Reflection Questions

- Of the five waste-valorization pathways (landfill, composting, digestion, pyrolysis, insect bioconversion), which do you think would benefit your community the most, and why?
- How can we realistically divert more food waste from landfills and move it into circular pathways?
- If you had to design a waste system for your school, which pathway would you choose first and what trade-off would you accept (speed, cost, or emissions)?

Lesson B – Carbon Math

Learning Outcomes:

- **Understand**: Recognize the ΔCO_2-equivalent for landfilling 1 kg of food waste versus treating it with alternative valorization options, using provided emission factors or data.
- **Create**: Design an optimal valorization route for a specific real-world waste stream (e.g. cafeteria leftovers or farm waste), supporting the recommendation with evidence from carbon calculations and practical considerations.
- **Evaluate**: Assess the trade-offs of each pathway – considering factors like cost, scalability, speed, and nutrient recovery – to justify which option might be preferable in a given context.
- **Rank:** Categorize different waste-to-resource technologies by their net carbon impact (most to least climate-friendly) and also compare their energy requirements and useful co-products.

  Key Concepts:

  1. **Ranking pathways** by net carbon impact (most to least climate-friendly)
  2. **Trade-offs**: climate benefit vs. cost, complexity, energy, and co-products
  3. **No "perfect" pathway** — combining methods for best results
  4. **Emission factors** for different waste treatments
  5. **ΔCO_2-equivalent concept**: comparing emissions between landfill and other pathways
  6. **Scenario analysis**: creating optimal valorization routes for real-world waste streams
  7. **Case study**: 10% Bokashi + 10% Biochar → Half the fertilizer, healthier citrus

Think About:

- Which pathway provides both environmental and economic benefits?
- How might community infrastructure limit or support certain pathways?

Important Vocabulary to understand and use:

a. Renewable Energy*
b. Emissions Avoided
c. Process Conditions
d. Compost*
e. Biogas*
f. Biochar*
g. Fertilizer
h. Protein
i. Methane*
j. Carbon Storage

Vocabulary in Context: Fill in the Blanks using Word Bank

1. ____ is the gas produced by anaerobic digestion and used as an energy source.
2. A product of aerobic composting that enriches soil is ____.
3. ____ occurs when a process prevents greenhouse gases from being released.
4. Insect bioconversion can produce ____ for animal feed.
5. Heating organic matter without oxygen creates ____ that stores carbon.
6. The temperature, oxygen level, and moisture during processing are called ____.
7. Biogas from anaerobic digestion can be used to make ____.

8. Applying compost or biochar to soil can increase ____ availability.

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Self-Test:

1. ____ is a form of energy made from organic waste.
2. ____ can reduce the need for synthetic soil amendments.
3. A method that prevents greenhouse gases from entering the atmosphere has ____.
4. Waste processed by insects can be turned into ____.
5. ____ stores carbon and improves soil health.
6. ____ affect the quality and quantity of outputs.
7. Using anaerobic digestion to make biogas produces ____.
8. Applying compost helps increase ____ in soil.

Reflection Questions

- Which waste-to-resource pathway do you think provides the best balance of environmental and economic benefits? Explain.
- If your town had to process cafeteria leftovers, which method would you recommend (composting, digestion, insect bioconversion, etc.) and why?
- What trade-offs do you think are hardest for communities to overcome: cost, scalability, speed, or nutrient recovery?

Lesson C – Measuring Waste & Calculating CO_2 Impact

Learning Outcomes:

- **Analyze:** Quantify their campus's waste-generation hotspots, estimating weekly amounts of food, yard, and paper waste at key locations and computing the associated CO_2-equivalent emissions for each.
- **Apply:** Utilize the feasibility and projected carbon savings of their proposed solution in a brief presentation or "mini-pitch," using data (emission reductions, etc.) and practical reasoning to persuade peers.
- **Create / Evaluate:** Design a prototype waste-to-resource system for one selected hotspot or waste stream, specifying how the waste could be collected and processed (composted, fermented, fed to insects, etc.) to close the nutrient or energy loop.
- **Reflect:** How can implementing multiple different valorization routes in parallel move the entire campus toward a circular economy, and identify challenges and next steps for making it happen.

  Key Concepts:

  1. **Waste measurement steps**: volume → mass → weekly totals → CO_2-e emissions
  2. **Calculating emissions** for each hotspot using emission factors
  3. **Designing waste-to-resource solutions** for specific hotspots
  4. **Mini-pitch presentations**: feasibility, projected carbon savings, co-products
  5. **Benefits of multiple valorization routes** working together
  6. Case study: calculating CO_2-e emissions from dorm kitchen food waste
  7. **Closing the loop** in campus waste management

Think About:

- How does a circular economy benefit both people and the planet?
- Which waste-to-resource strategy do you think should be prioritized in your area?

Important Vocabulary to understand and use:

a. Circular Economy*
b. Sustainable Development Goals (SDGs)*
c. Waste Reduction*
d. Resource Recovery*
e. Pollution Prevention
f. Food Security
g. Job Creation
h. Responsible Consumption
i. Recycling
j. Reuse

Vocabulary in Context: Fill in the Blanks using Word Bank

1. Keeping materials in use and reducing waste is part of a

   ______________________________________.
2. Converting waste into valuable products is an example of

   ______________________________________.
3. Preventing harmful substances from entering the environment is called

   ______________________________________.
4. Ensuring people have consistent access to nutritious food relates to

   ______________________________________.
5. The ______________________________________ are a global set of goals for a better future.
6. Using products more than once is an example of ______________________________________.

7. Turning old materials into new ones is called ______________________________________.
8. Using resources carefully so they last longer is part of ______________________________________.

Folder/cover paper here and test your knowledge

Self-Test:

1. A system that focuses on eliminating waste and keeping materials in use is a ______________________________________.
2. Creating useful products from waste is an example of ______________________________________.
3. ______________________________________ stops harmful materials from damaging the environment.
4. Access to safe and sufficient food is called ______________________________________.
5. The ______________________________________ guide global efforts for sustainability.
6. Using something again without processing is ______________________________________.
7. ______________________________________ involves converting used materials into new items.
8. Using resources responsibly to ensure their availability is ______________________________________.

Reflection Questions

- What waste stream on your campus (food, yard, paper) do you think is the biggest hotspot, and how would you design a solution to reduce it?
- How can multiple waste-to-resource strategies (like composting + insect bioconversion) work together to create a stronger circular economy?
- In your opinion, should responsibility for reducing food waste fall more on policymakers, innovators, or consumers? Why?