Session 2: Methane Mitigation through Best Practices for Organic Waste Treatment

Training on Best Practices for Landfill and Organic Waste Management

October 29, 2024

Global Methane Initiative

Webinar Panels

- We will use two panels
  - Participants and Question & Answer (Q&A)
  - Use the arrow to expand or collapse the panels

- Adding Panels
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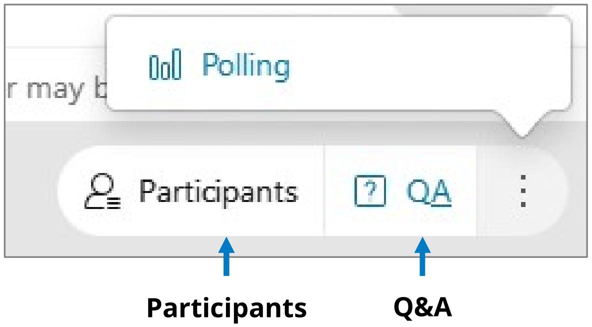

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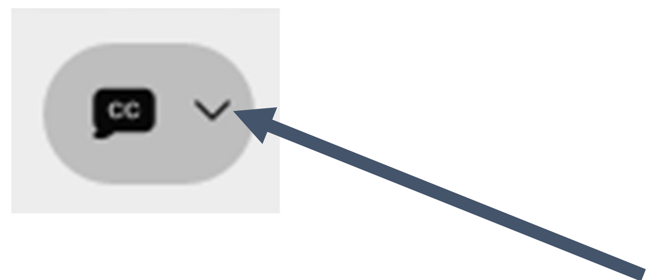

Q&A

- Participants are muted while speakers are presenting
- Please enter your questions in the Q&A box at any time during the training. These questions will be answered during the open discussion
- To ask a question:
  - Select "All Panelists" from the drop-down menu
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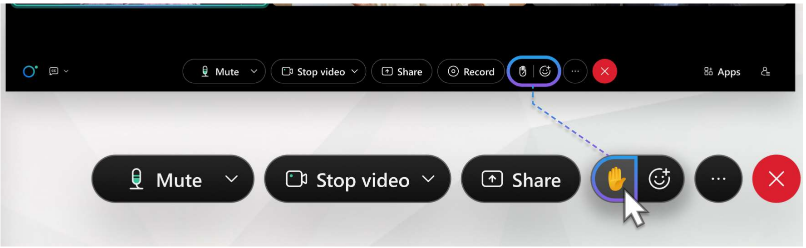

Speakers

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Overview of Session

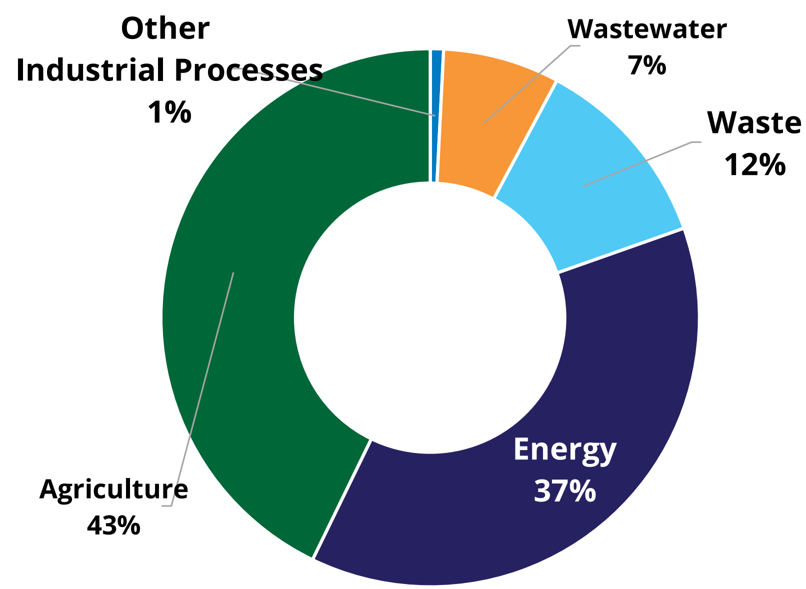
- Introduction to organic waste
- Anaerobic digestion
- Composting
- Emerging trends in organic waste management
- Value added products from organic waste

Introduction to Organic Waste

Presenter: Erik Anderson

Importance of Organic Waste Management

- In the waste sector, methane is produced due to the decomposition of organic (biodegradable) materials in landfills and dumpsites.
- Pakistan generates 68% of its waste from organic materials
  - This provides an opportunity to collect methane and use it for renewable energy
- Management of the organic waste to produce useful byproducts, like biogas, compost etc., instead of its disposal in landfills or dumpsites.



Global Methane Emissions By Sector

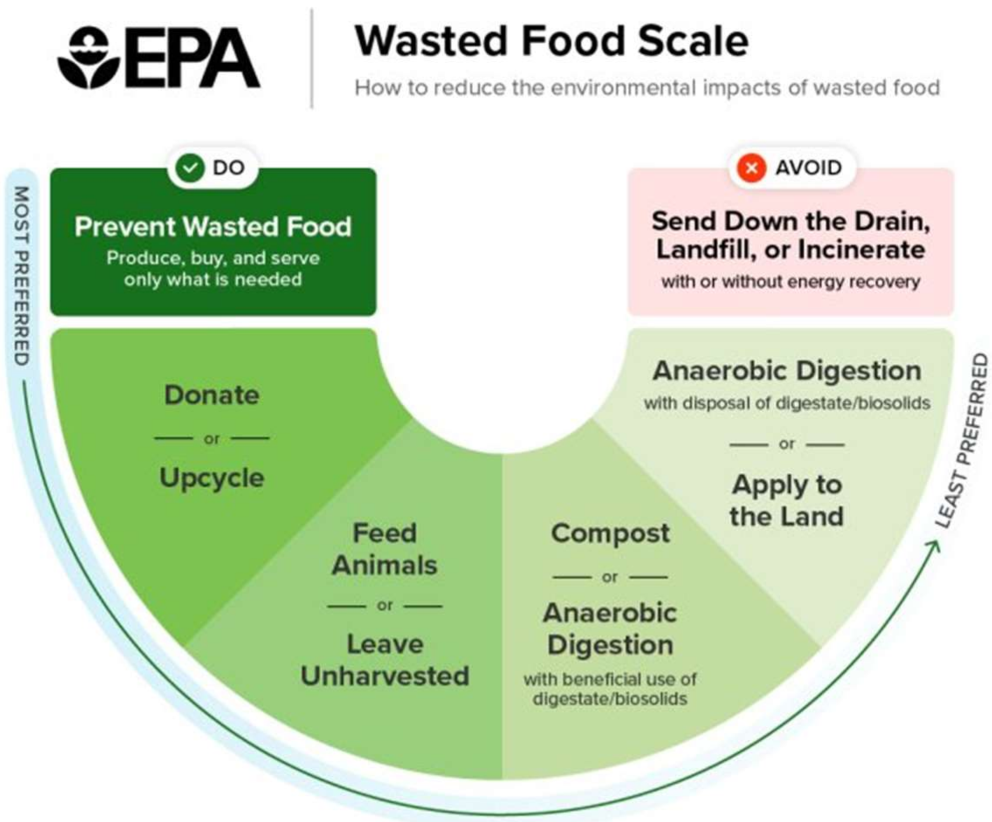
Introduction to Organic Waste

- **Definition:** Organic waste refers to biodegradable material from plant and animal origins.
- **Sources:** Food waste, yard trimming, crop residue, paper and pulp waste, etc.
- **Environmental Impact:** Decomposes and contributes to methane emissions.

Organic Waste Management Challenges

- Collecting and separating at the source
- Preventing contamination with non-organic waste
- Balancing system nutrients
- Controlling odors and managing leachate
- Producing high quality byproducts
- Sourcing of clean feedstock
- Marketing end products

EPA's Wasted Food Scale



Anaerobic Digestion

Presenter: Erik Anderson

Introduction to Anaerobic Digesters (AD)

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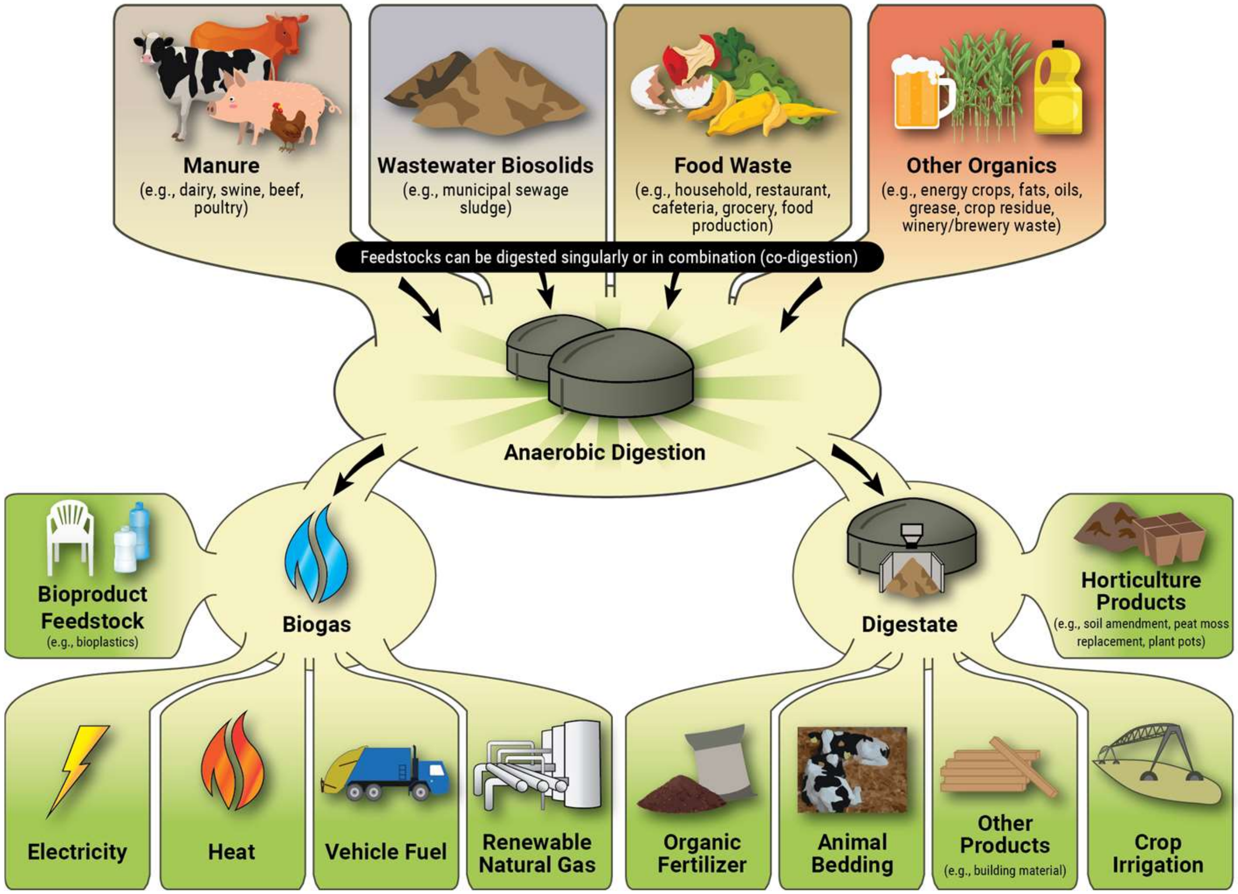
- **Basic Process:** Breakdown of organic materials in the absence of oxygen
- **Role of AD in waste management:** Organic waste is converted into biogas (50% methane, 50% CO2) which is collected to produce energy. Reduces the landfill usage and methane emissions
- Examples of waste that can be degraded anaerobically are:
  - Food waste
  - Yard waste
  - Paper waste
  - Agriculture waste
  - Animal manure
  - Fat, Oil & Grease (FOGs)
  - Wastewater treatment sludges

Environmental Benefits of Anaerobic Digestion

- **Reduction in Methane/GHG Emissions**
  - Organic waste can be separated from MSW and processed in anaerobic digesters
- **Energy Production**
  - Anaerobic digesters produce biogas, which can be converted to electricity and heat, promoting energy sustainability
- **Waste Reduction**
  - The digestion process significantly decreases waste volume, contributing to enhanced waste management and environment preservation
- **Manure Management**
  - Reduce methane emissions from manure lagoons
  - Minimize odors and pathogens
- **Soil Health Benefits**
  - Post-digestion, the nutrient-rich digestate serves as an effective organic fertilizer, enriching soil health for agriculture

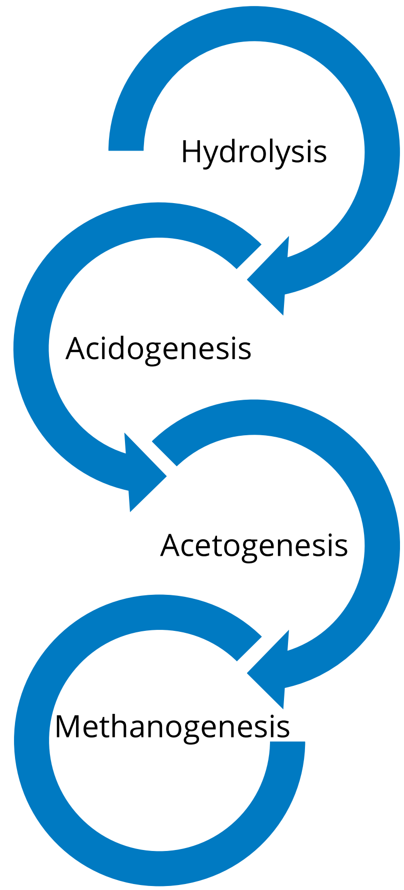
Anaerobic Digesters



Stages of Anaerobic Digestion

Big food pieces, like carbs and proteins, get broken down into smaller bits so the microorganisms can "eat" them

These small bits turn into things like acids, alcohol, and gases (like food getting sour)



The sour parts are further broken down into even simpler substances, including acetic acid (like vinegar)

Finally, special microbes turn these simple substances into biogas, mostly methane, which can be used for energy

Factors affecting production of methane

- Factors affecting amount of methane produced
  - Waste composition/percentage of organic waste
  - Organic loading rate (measure of organic component entering AD)
- Factors affecting rate of methane produced
  - Temperature
  - Grain size

Factors affecting viability of microorganisms (methanogens)

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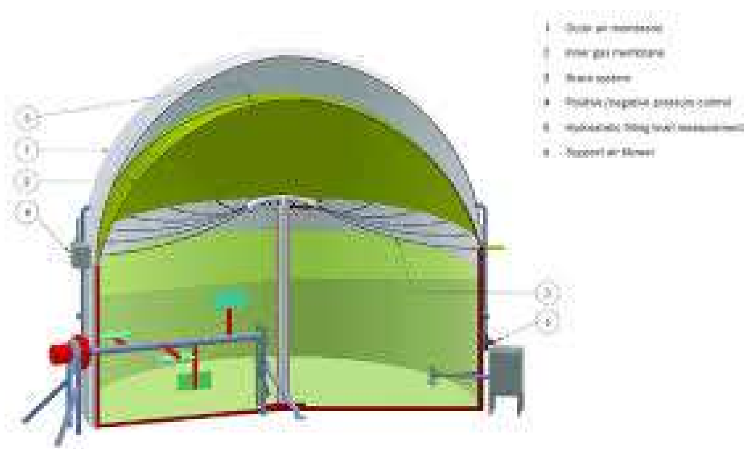
- Temperature
  - Impact on methane production rate:
    - Mesophilic bacteria: 30-40°C
    - Thermophilic bacteria: 50-60°C
- pH
  - Acidogens prefer pH 5.5-6.5; methanogens prefer 7.8-8.2
  - When both cultures coexist, the optimal pH range is 6.8-7.5
- Moisture
  - If too little water is added, acetic acid will accumulate resulting in AD failure
  - If too much water is added, the digester could become diluted, which can reduce biogas yield
  - Methanogens require macronutrients P and N, as well as micronutrients
- Toxics
  - High concentrations of constituents like ammonia, calcium, chromium , copper, cyanide, magnesium, nickel, potassium, sodium, sulfate etc. can be toxic for ADs

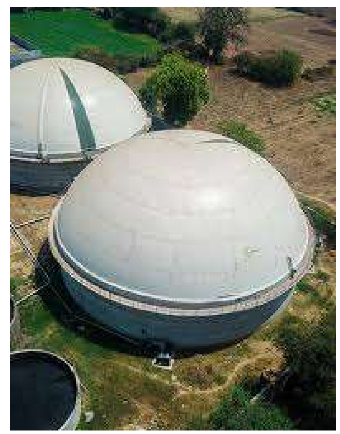
Types of Digesters

- **Continuous Digesters:** Organic material is regularly fed in and digested material is continuously or periodically removed
  - **Wet Digesters:** A wet digester processes feedstock with less than 12 percent solids content.
  - **High-solids loading digesters**: Processes feedstock with 12-20 percent solids content
- **Dry Digesters:** A dry digester processes feedstock with greater than 30 percent solids content.
  - **Batch Digesters**: Organic material is loaded all at once, sealed, and left to digest in a single cycle
  - **Continuous Digesters:** Organic material is regularly fed in and digested material is continuously or periodically removed

Continuous (Wet) Digesters

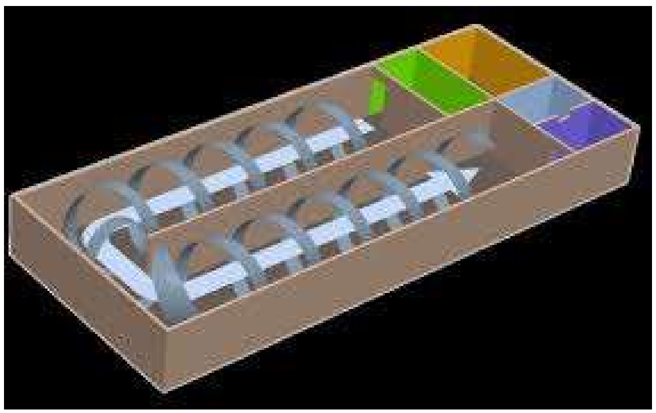
Continuous-stirred
Tank Reactors (CSTR)



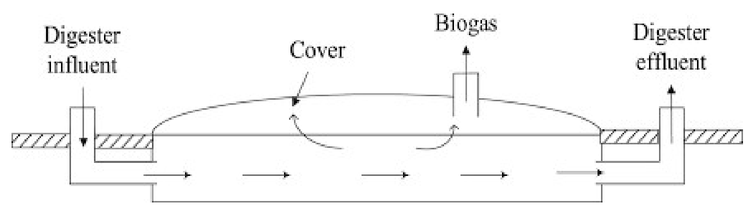


Continuous (Wet) Digesters

High-Solids Loading (HSL)



Plug-flow digesters



Batch Digesters

Dry
Digestion

Application of Digesters

- **Stand-Alone Digesters**
  - Accept and process feedstocks from one or more sources for a tipping fee.
- **On-Farm Digesters**
  - Primarily uses manure from dairy, swine and poultry farms.
- **Digesters at Water Resource Recovery Facilities (WRRF)**
  - Primarily uses to treat wastewater solids.

Design and Components of AD

- **Feedstock Input:** Balance of nitrogen (N) and carbon (C) determine digester efficiency, impacting biogas yield and nutrient composition
  - Methane generation is driven primarily by the organic content of the waste
- **Gas Collection System:** Essential for capturing produced biogas, this system must ensure minimal losses while maintaining pressure stability
- **Retention Time:** Optimal retention time balances digestion and gas production; Insufficient time leads to incomplete digestion and inefficiency

Challenges and Limitations

- **Feedstock Variability:** Variation in feedstock can lead to inconsistent biogas production
  - Fluctuations in feedstock can impact the microorganisms that need a stable environment to thrive
  - Optimal carbon to nitrogen ratio ranges from 20:1 to 30:1
- **Economic Barriers:** High initial investment costs and market volatility hinder widespread adoption of anaerobic digestion technologies and infrastructural development
- **Regulatory Challenges:** Strict regulations and unclear policies can obstruct project development, impacting operational feasibility and financial sustainability

Keys to Digester Success

U.S. EPA considers the following factors as key to success

- Plan for success
- Recruit and secure an experienced team
- Develop a sustainable business model
- Secure suitable feedstock supply
- Use the most appropriate technology
- Analyze options for biogas and digestate use
- Develop off-take agreements
- Evaluate added benefits
- Conduct community outreach
- Plan for operation and maintenance

Questions?

Composting

Presenter: Hussain Ali

Introduction

- A controlled aerobic process that converts organic materials into nutrient-rich soil amendment or mulch through natural decomposition
- Important factors for composting
  - Proper feedstock mix
  - Moisture
  - Oxygen
  - Temperature

Goals/Requirements for Compost Facilities

1

Produce high-quality, consistent compost

2

Comply with regulations

- Odors, air emissions
- Contact water, stormwater

3

Need to be cost-competitive

Composting Basics

There are five main areas that must be "controlled" during composting.

- Feedstock and nutrient balance
- Particle size
- Moisture content
- Oxygen flow
- Temperature

Types of Composting Techniques

- **Windrow Composting**: Organic waste is piled into long, narrow rows (windrows) that are periodically turned with machinery to aerate the pile.

Types of Composting Techniques

- **Aerated Static Pile (ASP) Composting**: Organic material is placed in a pile that is aerated through a system of pipes or channels underneath the pile, providing oxygen without the need for turning.

Types of Composting Techniques

- **In-Vessel Composting**: Composting occurs in a sealed container or drum, which controls temperature, moisture, and aeration.

Types of Composting Techniques

- **Vermicomposting**: Uses worms to break down organic waste in a controlled environment, often in bins or trays.

Challenges

- Contamination of organic waste
- Seasonal limitations
- Managing odor, optimal temperature and moisture content
- Selecting the most suitable composting technology

Best Composting approaches

- Optimal ratio of carbon-rich materials i.e., dry leaves or wood chips to nitrogen-rich materials i.e., food scraps or grass clippings.
- Maintain adequate moisture level, oxygen flow, particle size, and temperature.
- Selection of composting technology and equipment based on scale/size of site, volume and type of feedstock.
- Feedstock should be free of contaminants.

Emerging trends in organic waste management

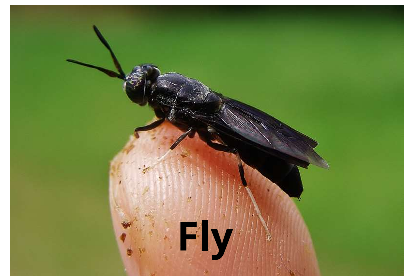
Presenter: Hussain Ali

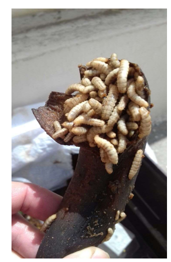
Traditional Methods of Organic Waste Management and the need for Emerging Technologies

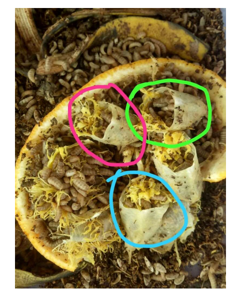
- **Emerging Technologies Necessity:** Rising organic waste volumes necessitate innovative technologies to enhance efficiency and sustainability in management.
- **Emerging Technologies** include Black Solider Fly Larvae (BSFL), termite gut bacteria, hydrothermal carbonization, etc.
- **Insect Farming Advantages:** Utilizing BSFL for organic waste conversion offers rapid decomposition and protein-rich outputs.
  - Black Solider Flies originated in South America but now can be found in countries across Asia, Africa and Europe.
  - BSFL feeds on varying types of organic wastes.
  - Larvae consume waste and turns to animal feed.
  - BSFL does not produce any methane or leachate.

Black Soldier Fly Larvae (BSFL) Organic Waste Treatment & Valorization Technology

- Non-vector; Non-pest
- High waste reductions
- Waste Sanitization
- Biomass productions:
  - Protein & fat rich animal feed
  - Stable residue
  - High value products
- No methane
- No leachate
- CO2 47 times lower than conventional compositing
- Waste management cost savings







Value-added products from organic waste treatment projects

Presenter: Erik Anderson

By-Products of Organic Waste Management

Some of the beneficial by-products of organic waste management are:

- Compost
- Digestate
- Biochar
- Animal feed
- Biofuels
- Pulp and paper products
- Organic acids
- Processed organic fines (POF)

Digestate

- **Definition:** Digestate is the nutrient-rich organic material remaining after the anaerobic digestion process. It comes in two forms: liquid and solid.
- **Types of Digestate:**
  - **Liquid Digestate:** Contains high levels of nitrogen, phosphorus, and potassium, making it ideal for use as a liquid fertilizer.
  - **Solid Digestate:** Can be dried and used as a soil amendment or bio cover material in landfills.

Digestate

- **Production Process:** Digestate is produced in biogas plants where organic waste undergoes anaerobic digestion.
- **Applications:** As a biofertilizer in agriculture or as a bio cover in landfills to suppress odors and enhance soil stability.
- **Environmental Benefits:** Promotes nutrient recycling, reduces the need for chemical fertilizers, and contributes to sustainable landfill management.

Biochar

- **Definition:** Biochar is a stable, carbon-rich material.
- **Production Process:** Biochar is produced by heating organic materials, such as wood, in a controlled environment.
- **Properties:** Biochar has a high surface area, porous structure, and the ability to retain nutrients and water, making it beneficial for soil health.

Biochar

- **Applications in Agriculture:** Used as a soil amendment to improve fertility, enhance water retention, and sequester carbon, thus mitigating climate change.
- **Uses in Landfills:** Biochar can be mixed with soil to create a bio cover, enhancing the stability of the landfill surface and providing long-term carbon sequestration.

Animal Feed

- **Definition:** Organic waste such as food scraps and agricultural residues diverted from food processing and farming can be repurposed as animal feed.
- **Production Process:** Waste is processed, sterilized, and sometimes supplemented with additional nutrients to create safe and nutritious feed for livestock.
- **Nutritional Benefits:** Recycled food waste can provide essential nutrients for animals, reducing the need for commercial feed.
- **Environmental Impact:** Reduces the volume of organic waste sent to landfills, lowers methane emissions from waste decomposition, and supports sustainable agriculture.

Biofuels

- **Definition:** Biofuels are renewable fuels produced from organic materials, including biodiesel, ethanol, and bio-oil.
- **Production Process:**
  - Biodiesel: Produced through the transesterification of vegetable oils or animal fats.
  - Ethanol: Generated by fermenting sugars from crops like corn or sugarcane.
  - Bio-Oil: Created from the pyrolysis of organic waste.
- **Energy Potential:** Biofuels can be used in vehicles, machinery, or blended with traditional fuels to reduce carbon emissions.
- **Environmental Benefits:** Reduces dependence on fossil fuels, lowers greenhouse gas emissions, and promotes the sustainable use of organic resources.
- **By-Product:** Residual biomass from biofuel production can be used as a bio cover in landfills, aiding in moisture control and gas management.

Pulp and Paper Products

- **Definition:** Organic waste, such as agricultural residues, wood chips, and recycled paper, can be processed into pulp and paper products.
- **Production Process:** Waste materials are broken down into fibers, which are then processed into paper or cardboard products.
- **Environmental Benefits:** Minimizes the environmental impact of traditional paper production.
- **By-Product:** Residual fibers from the pulping process can be repurposed as a bio cover material in landfills, aiding in moisture retention and gas management.

Organic Acids

- **Definition:** Organic acids, such as lactic acid, acetic acid, and citric acid, are produced through the fermentation of organic waste.
- **Production Process:** Organic acids originate from fermentation of sugars in organic materials. These organic acids are then purified and used in various industries.
- **Industrial Applications:** Used in food preservation, pharmaceuticals, cosmetics, and biodegradable plastics.
- **Environmental Benefits:** Organic acids offer a renewable alternative to petrochemical-derived acids and support the circular economy.

Processed Organic Fines (POF)

- **Definition:** These particles primarily originate from composting or the mechanical treatment of organic waste, where larger chunks are broken down into finer, manageable particles.
- **Benefits:**
  - **Good Compaction Properties:** POF exhibits excellent compaction characteristics, which helps in creating stable and well-compacted layers when used in landfills. This property is crucial for maintaining the integrity of landfill operations and minimizing settlement.
  - **Reduces Odors:** By covering waste with POF, the exposure of organic waste to the atmosphere is minimized, which helps in reducing the unpleasant odors.

Questions?

Resources

- Anaerobic Digester / Biogas Operator Guidebook (epa.gov)
- Community Composting Done Right: A Guide to Best Management Practices - Institute for Local Self-Reliance (ilsr.org)
- Composting | NC State Extension Publications (ncsu.edu)
- Composting Food Scraps in Your Community: A Social Marketing Toolkit (epa.gov)

Thank You!

Please reach out with any questions to: biogastoolkit@epa.gov

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