ENVE 424
Anaerobic Treatment

Course Outline and Lecture 1

2012 – 2013 Fall

Assist. Prof. A. Evren Tugtas

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Course Content

- Introduction to anaerobic treatment
- The biochemistry of anaerobic treatment
- The microbiology of anaerobic treatment
- Stoichiometry
- Influence of environmental factors
- Toxic substances in anaerobic treatment
- Process monitoring and control in anaerobic treatment
- Low-rate anaerobic reactor technologies
- High-rate anaerobic reactor technologies
- Start-up and operation of anaerobic reactors
- Anaerobic sludge digestion
- Types of anaerobic sludge digesters
- Mixing and heating anaerobic sludge digesters

Grading

Evaluation Tool	Weigh in total (%)
Midterm Exam I	30
Midterm Exam II	30
Final	40

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Lecture 1
Introduction to Anaerobic Treatment

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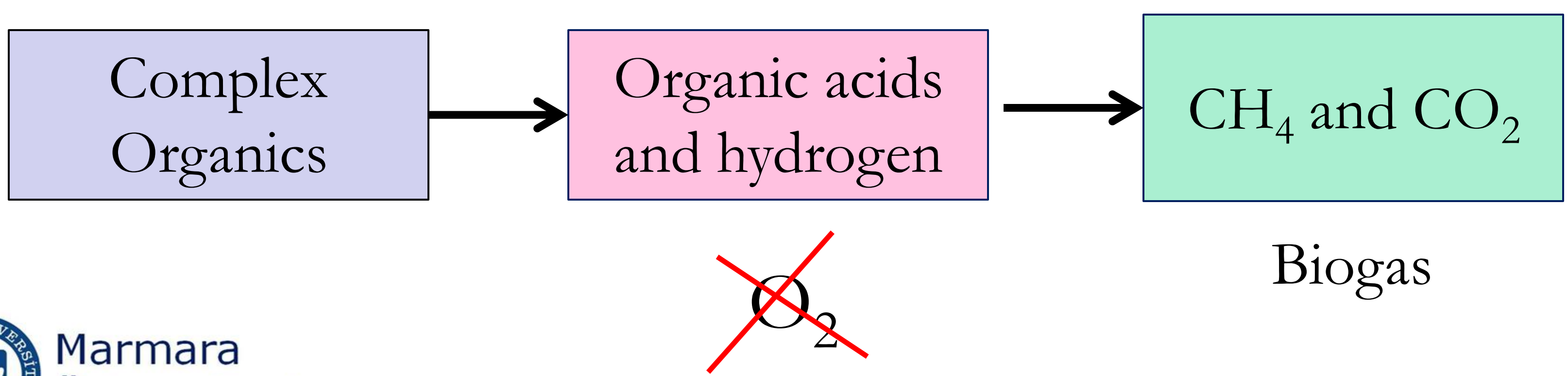
- Lecture notes are prepared by Prof. Dr. B. Callı and Assist. Prof. Dr. A. E. Tugtas

Anaerobic Digestion

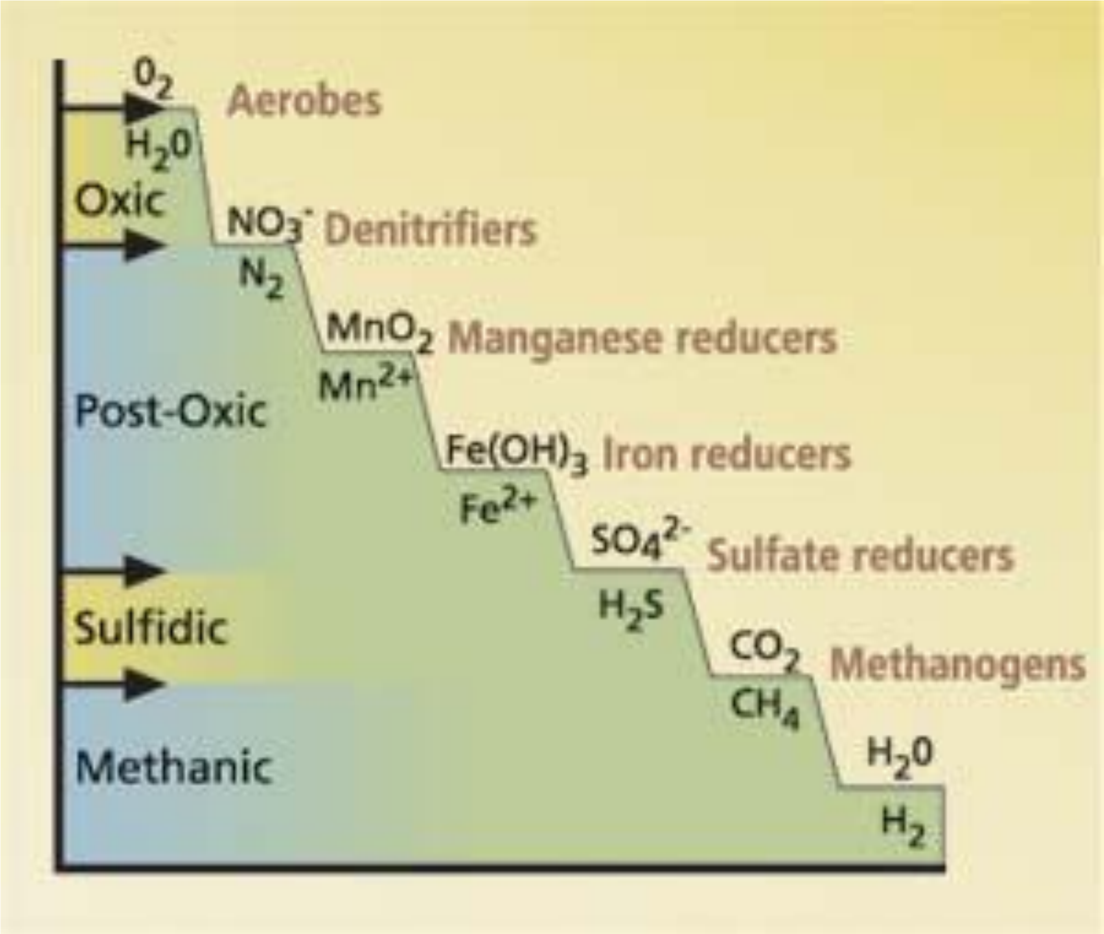
- Anaerobic digestion/treatment is a natural process in which a variety of different species from two entirely different biological kingdoms, Bacteria and Archaea, work together to convert organic wastes through a variety of intermediates into **methane gas**

Anaerobic Digestion (AD)

- Complex organic matters are converted to one-carbon compounds representing the most oxidized (CO_2) and most reduced (CH_4) via anaerobic digestion in the absence of oxygen



Redox Ladder



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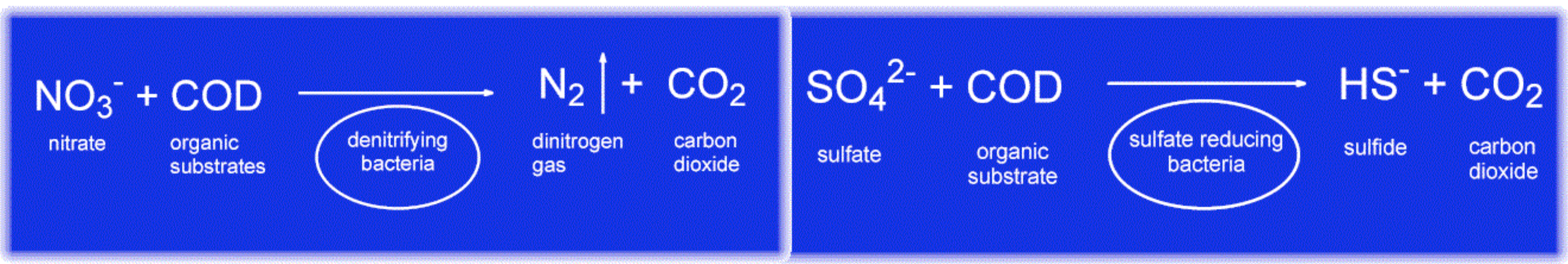
Ref:
http://ucce.ucdavis.edu/files/repository/calag/fig5702p56a.jpg

Anaerobic Digestion (AD)

- For CH_4 formation to occur, there should not be any electron acceptors in the environment (O_2, NO_3^-, SO_4^{2-}) dacceptor.



  - Swamps, soil, river sediments, lakes, seas and digestive tracks of ruminant animals are natural environments of CH_4 production.

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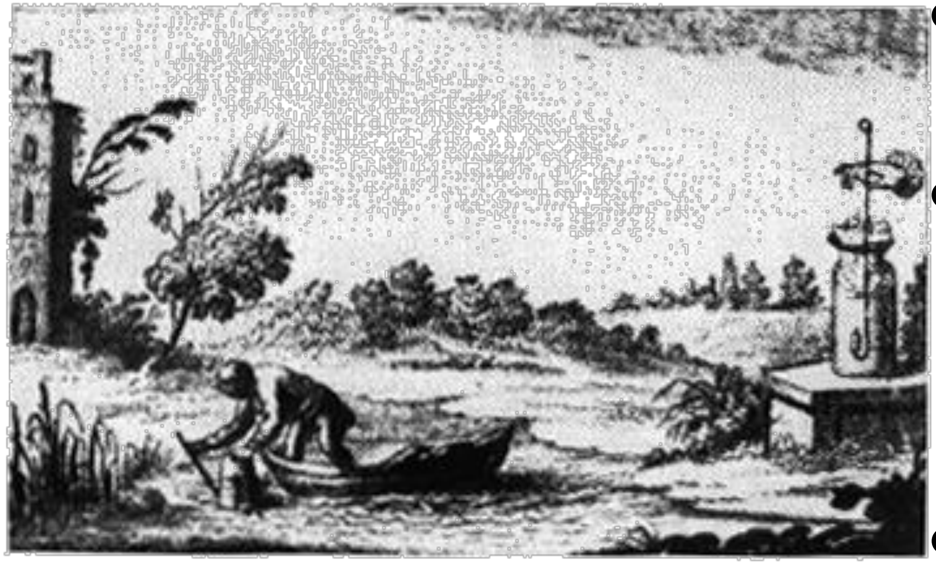
Composition of Biogas

Component	Percentage (%)
Methane (CH_4)	50-80
Carbondioxide (CO_2)	20-40
Nitrogen (N_2)	0-5
Hydrogen (H_2)	<1
Oxygen (O_2)	<0.4
Hydrogen sulfide (H_2S)	0.1-3

History



•Lake Maggiore

- Methane was discovered by Alessandro Volta in **1776**.
- Volta began to poke the muddy bottom of the water with a stick and saw lots of gassy bubbles floating up to burst on the surface.
- He collected some of this gas and discovered it was inflammable. He called it ***inflammable air from marshlands***. It was what we nowadays call methane.

Ref: http://ppp.unipv.it/volta/pages/eavus3.htm

History, cont.

•Biogas street lamp

- In 1808, Sir Humphrey Davy determined that CH_4 was present in the gases produced by cattle manure
- First AD was built in Bombay, India in 1859.
- The technology then moved to England in 1895, when biogas was recovered from a sewage system and used to fuel street lamps.

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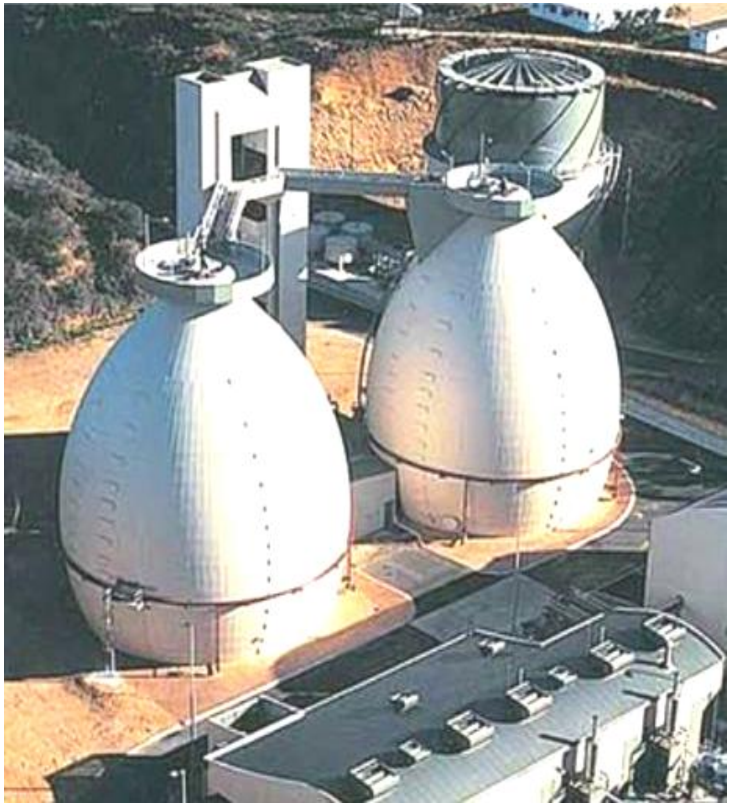
History, cont.



•Anaerobic sludge digesters

- In the 1930's, developments in microbiology identified the anaerobic bacteria and the conditions needed to promote CH_4 production
- In 1970s, the energy crisis renewed interest in AD
- In 1970s - 80s, the lack of understanding and overconfidence resulted in numerous failures in ADs

Currently

- Hundreds of farm-based digesters operating in Europe plus several centralized AD systems
- Danish systems co-digest manure, organic industrial wastes and municipal solid waste
- Large numbers of family-sized, low technology digesters in developing world provide biogas for cooking and lighting
- Renewed interest in U.S. because of high oil & natural gas prices.

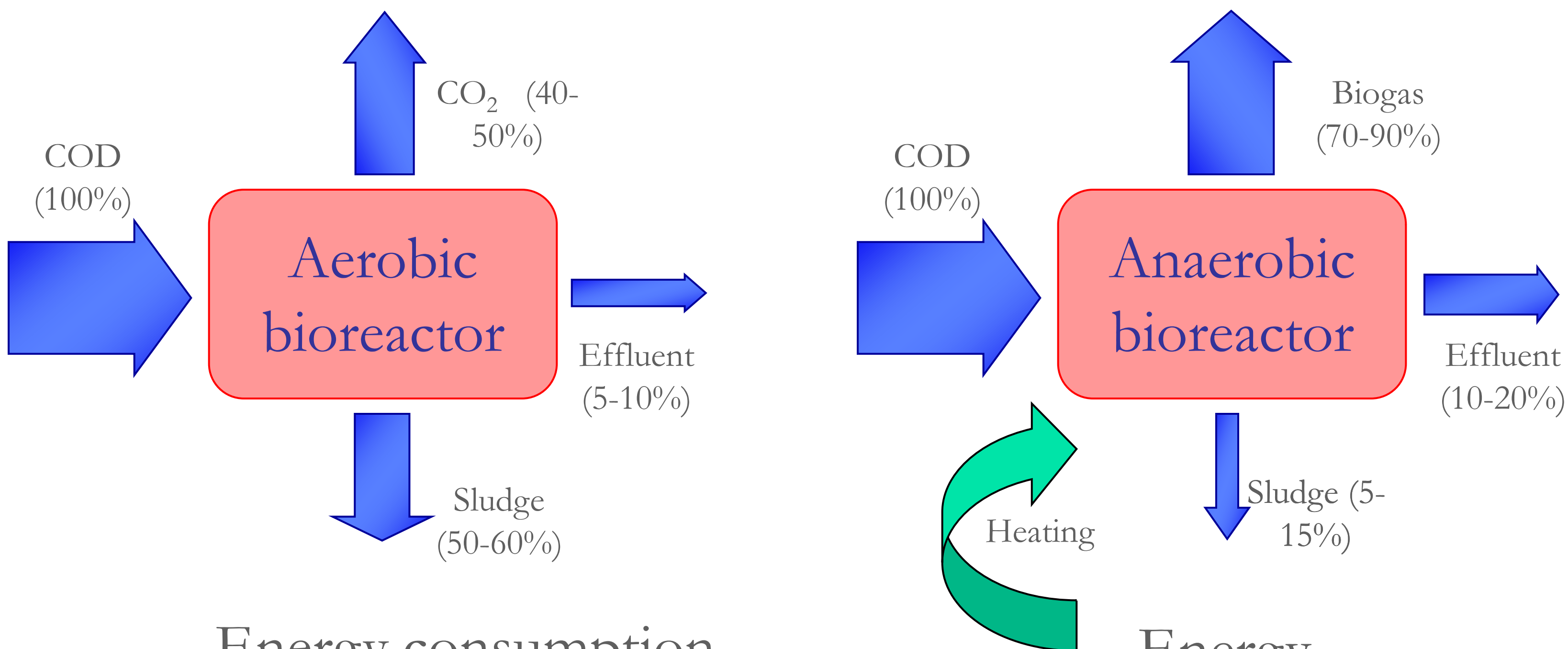
Suitable Wastes

- Domestic wastewaters (black water)
- Industrial wastewaters
  - Bakeries
  - Beverage production
  - Breweries and Wineries
  - Chemical plants
  - Dairies
  - Food processing plants
  - Meat and poultry processing
  - Pharmaceutical plants
  - Pulp and paper mills
  - Rendering plants
  - Textile mills
- Biosolids
  - Household food waste
  - Animal manure
  - Farm wastes
  - Waste paper
  - Green waste
  - Sewage sludges

Carbon and Energy Balance

Aerobic treatment

Anaerobic treatment



Energy consumption for aeration (O_2)

Energy produced from CH_4

Advantages: Anaerobic vs Aerobic

- Less energy required
- Less biological sludge production
- Fewer nutrients required
- CH_4 production, a potential energy source
- Smaller reactor volume required
- Elimination of off-gas air pollution
- Rapid response to substrate addition after long periods w/o feeding

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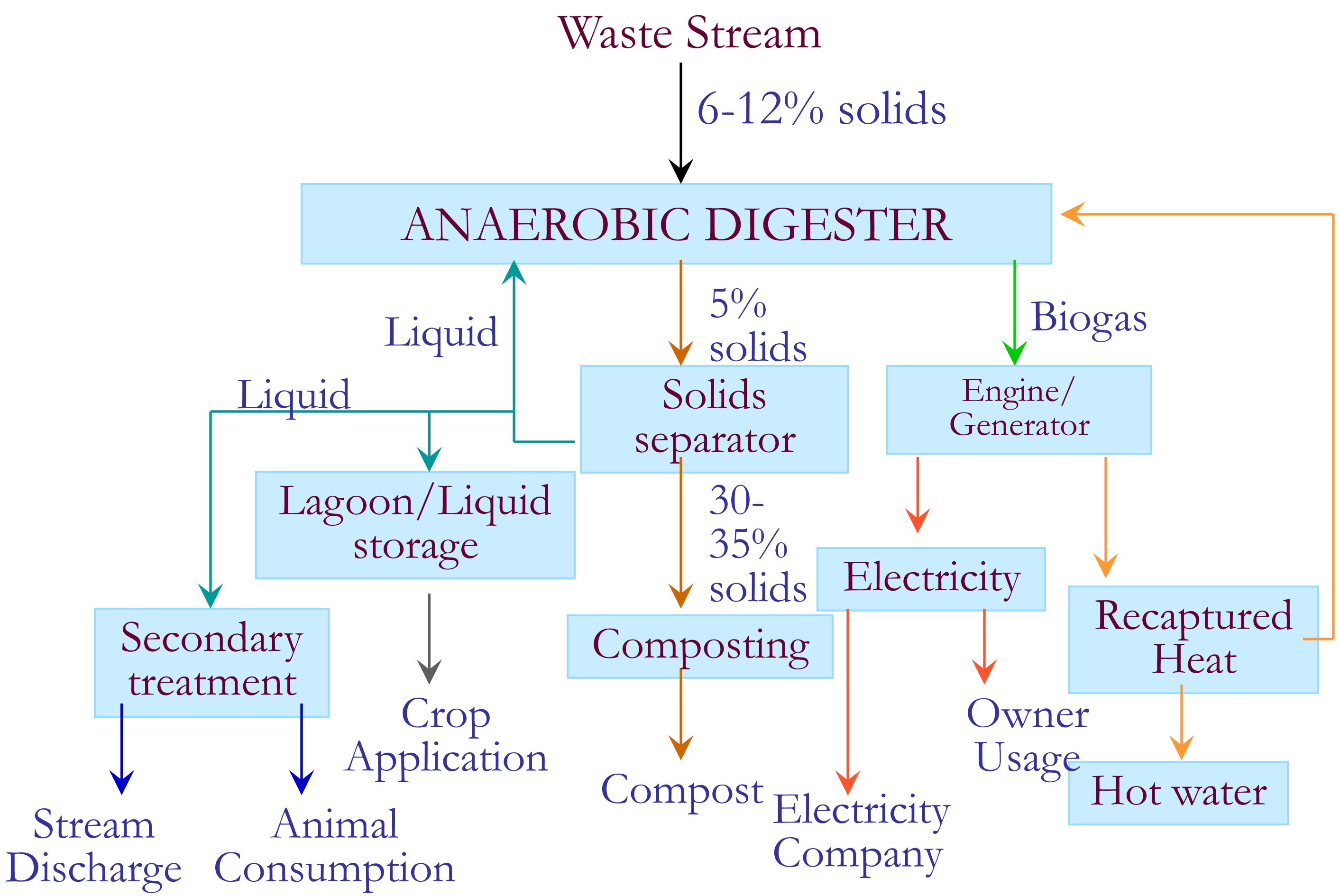
Disadvantages: Anaerobic vs Aerobic

- Longer start-up time
- May require alkalinity addition
- May require further treatment with an aerobic process to meet discharge requirements
- Biological N and P removal is possible to certain extent
- Much more sensitive to the adverse effect of lower temperatures on reaction rates
- May be more susceptible to upsets due to toxic substances
- Potential for production of odor and corrosive gasses

Environmental Benefits

- Reduces odor from land application
- Protects water resources
- Reduces pathogens (High temperatures)
- Weed seed reduction
- Fly control after digestion (stabilized waste)
- Greenhouse gas reduction

Materials flow in AD



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