(Biogas) lagoons

H.-P. Mang

Laggon - Pond

1. Artificial pool for storage and treatment of polluted or excessively hot sewage, liquid waste, etc.
2. Wastewater treatment lagoons are earthen impoundments that are engineered and constructed to treat as well as temporarily store wastewater.
3. In practice, the terms lagoons and ponds are used interchangeably.

Treatment ./. Storage (1/2)

1. Wastewater **treatment** lagoons are different from wastewater **storage or holding** lagoons in that they are designed to function as **biological reactors** that allow **effective degradation of organic compounds** contained in the wastewater by various microorganisms.
2. Therefore, the physical, chemical, and biological environments in the **treatment lagoons are controlled** to achieve the intended purposes of wastewater treatment.

Treatment ./. Storage (2/2)

3. Treatment lagoons are not pumped down below their treatment volume elevation except for maintenance purposes.

4. Storage lagoons are emptied regularly when the wastewater is pumped out for irrigation.

Animal wastewater lagoons (1/2)

1. Animal wastewater lagoons have about 50 years of history.
2. Specific engineering design standards have been developed for animal wastewater lagoons.
3. Due to the high contents of nutrients and organics in the animal wastewater, the treatment capacity of wastewater lagoons is often limited, and effluent from the lagoons is not suitable for direct discharge into surface waters.

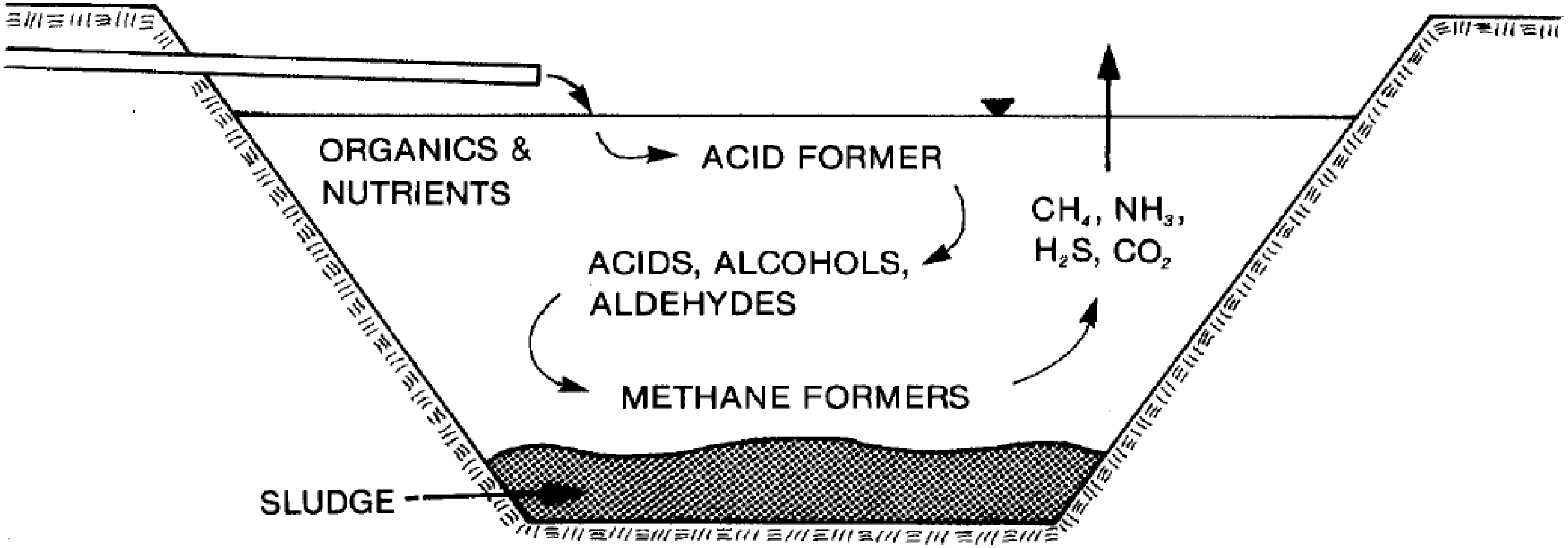
Animal wastewater lagoons (2/2)

4. Due to the high organic content of animal wastewater, all the primary lagoons used for animal wastewater treatment are essentially anaerobic lagoons.
5. Vary in depth from 2.5 to 9 meter and are built as deep as the local geography allows to minimize the surface area and reduce odour emissions.
6. Top layer may contain dissolved oxygen depending on wind, temperature, and organic loading rate. This aerobic layer is very thin, less than 50 cm, and the contribution of aerobic bacteria to the overall waste degradation is insignificant.

Lagoons plus wetlands

1. The use of constructed wetlands for treating concentrated animal wastes is a relatively new idea (since about 20 years).
2. All wetland systems have some form of pre-treatment. The most common form of solids removal as necessary pre-treatment step is a settling pond or a anaerobic lagoon.
3. Wetlands for animal wastewater treatment should always be coupled with additional waste management strategies for the separated solids.

Degradation of organic compounds



1. Stage one (up to 1-5 days RT), hydrolysis of organic compounds and conversion to intermediate organic acids are achieved by acid-forming bacteria called *acidogenic*.

2. Stage two (after 1-5 days RT), the organic acids are converted by methane and carbon dioxide (biogas) by methane-forming bacteria called *methanogenic*.

(simplified)

reaction of anaerobic degradation

Organics (C, H, O, N, S) $\longrightarrow$ $CH_4 + CO_2 + NH_{4+} + H_2S$

1. Ammonium (NH_{4+}) and hydrogen sulphide are the end products of nitrogen and sulphur degradation, respectively.
2. Ammonium (NH_{4+}) exists in equilibrium with ammonia (NH_3) in the wastewater.
3. At high concentrations, ammonia can become inhibitory or toxic to the bacteria in the lagoons. Total ammonia nitrogen in the lagoon water should be kept under 1,500 mg/L.
4. High pH (>8) favours more ammonia emissions while a low pH (<6) favours more hydrogen sulphide and carbon dioxide emissions.
5. The redox potential of water must be below –300 for methanogenics to thrive.
6. The optimum pH for methanogenics is 6.8 to 7.5, with the lowest pH being 6.2.
7. Acidogenics are more versatile and have much wider working pH range, 5 to 8, with the optimum level being 5 to 6.
8. Well functioning anaerobic digester have Volatile fatty acids (VFA) below 800 mg/L.
9. Heavily loaded anaerobic lagoon have a VFA above 3,000 mg/L.

Improving degradation

1. Gases produced at the bottom of anaerobic lagoons lift sludge to the top surface forming a layer of floating solids.
2. Adding mixing in the anaerobic lagoons has been found to help prevent this solids-rising phenomena.
3. Covering lagoons is a good way to recover the methane gas as a fuel and also to control emissions of ammonia and other odorous gases.

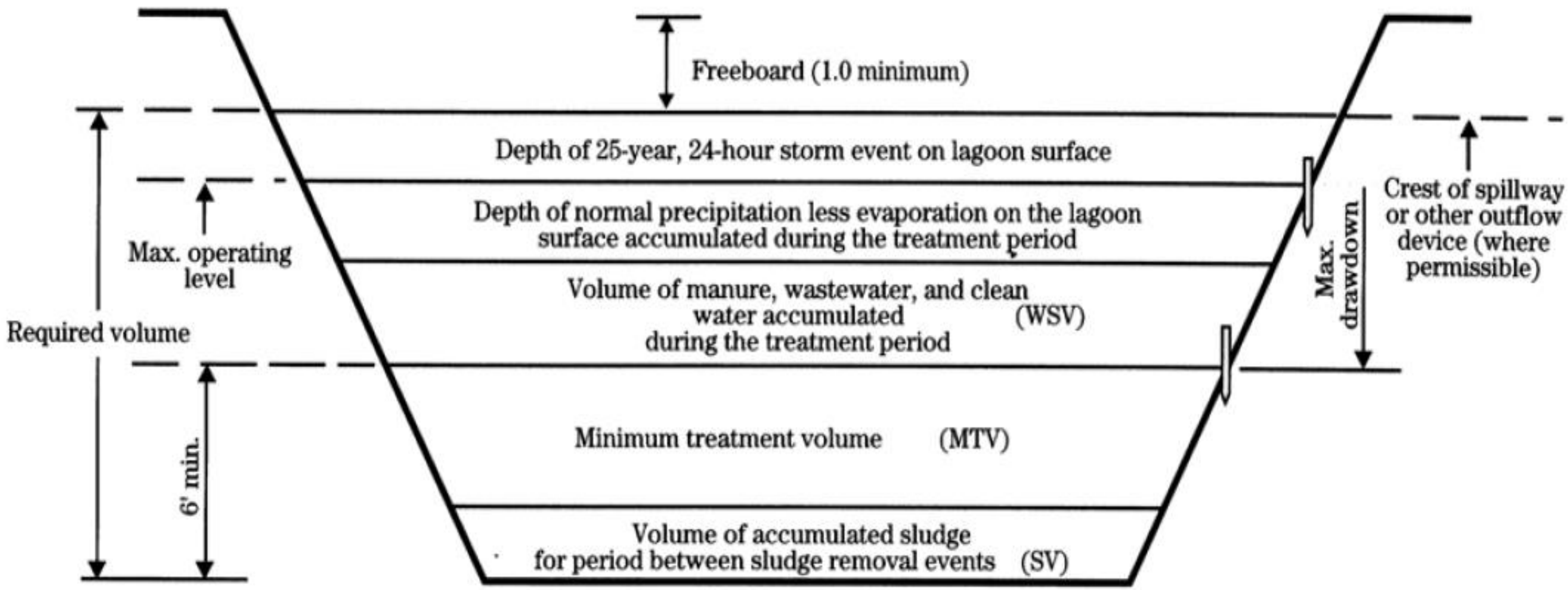
organic loading rate and retention time (1/2)

1. Organic loading rate and retention time are both related to the temperature of the lagoons.
2. Organic loading rate is higher for heated lagoons.
3. For anaerobic lagoons, the organic loading rate is the volumetric loading rate of volatile solids, which is the amount of volatile solids (organic dry matter) loaded per cubic meter of lagoon treatment volume per day.

organic loading rate and retention time (2/2)

4. The chosen design loading rate depends on the treatment objectives being stressed, such as maximizing pollutant reduction, reducing odours, or minimizing sludge production.
5. Minimum 30-day retention time for **single-stage anaerobic lagoon**, which contains wastewater treatment volume and additional sludge storage volume.
6. The minimum treatment volume is finally based on volatile solids (organic dry matter) content.

Anaerobic lagoon cross section



Maximum organic loading rate – digestion temperature

- 0.05 kg/m^3 - 10oC
- 0.65 kg/m^3 - 15oC
- 0.80 kg/m^3 - 20oC
- 1.00 kg/m^3 - 25oC
- 1.50 kg/m^3 - 30oC
- 2.00 kg/m^3 - 35oC
- 2.50 kg/m^3 - 40oC
- 3.00 kg/m^3 - 45oC

Used to calculate
MTV +WSV = Treatment volume

Interpolated and based on different published experiences and case studies (Mang 2010)

Two-stage anaerobic lagoons

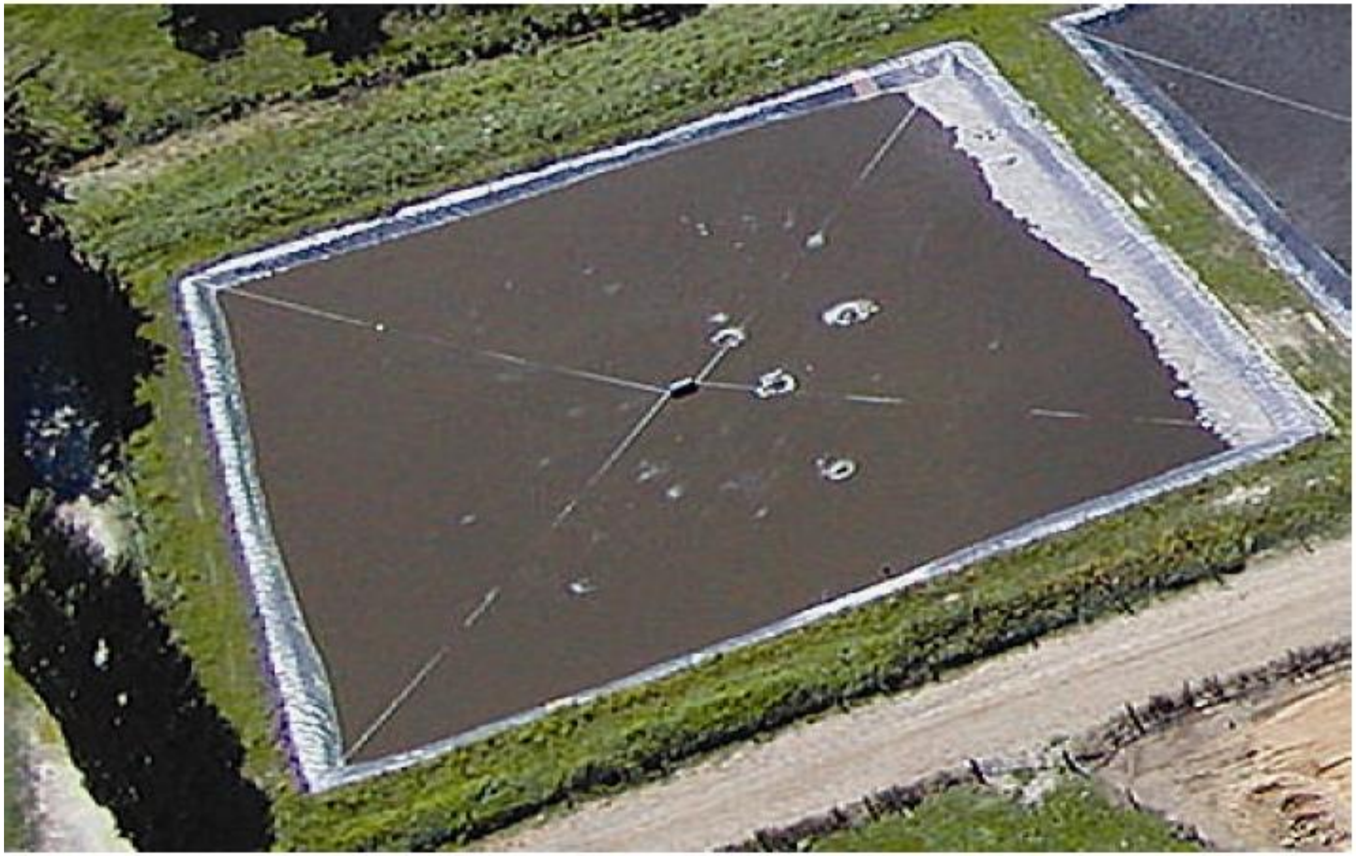
1. Sizing is based on the criteria that the first stage contains the treatment volume and
2. second stage contains the storage volume.
3. Both stages must have the volumes for net precipitation and 25-year/24 hour storm on the lagoon surface and freeboard.

Types of anaerobic lagoons

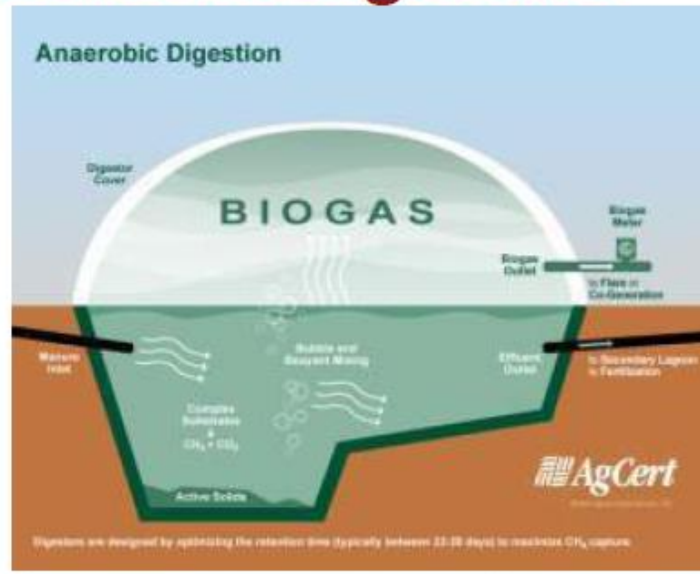
- Open lagoons
  - Single stage (contains wastewater treatment volume and sludge storage volume)
  - Two-stage (1st pond contains wastewater treatment volume and 2nd pond storage volume)
- Covered lagoons (with or w/o heating)
  - Covered anaerobic lagoons (CAP)
  - Sedimentation lagoons (AgCert)
  - Covered High Energy Anaerobic Pond (CHEAP)
  - Covered In-ground Anaerobic Digester (CIGAR)
  - Economic Gas Digester (ECOGAS)
  - Completely stirred lagoons (CSL)

COVERED ANAEROBIC PONDS

Covered Anaerobic Ponds (CAP) incorporate many improvements on traditional anaerobic ponds. They require much less land area than the anaerobic ponds that are currently used in New Zealand and are capable of ***consistently*** providing a higher degree of digestion and biogas production. Moreover, CAP are much easier to operate, and are more economical than other anaerobic digester technologies.

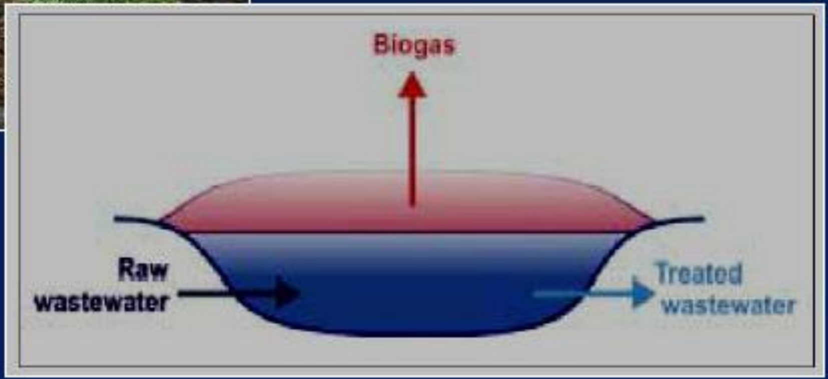


Opportunity Example: Anaerobic Digesters

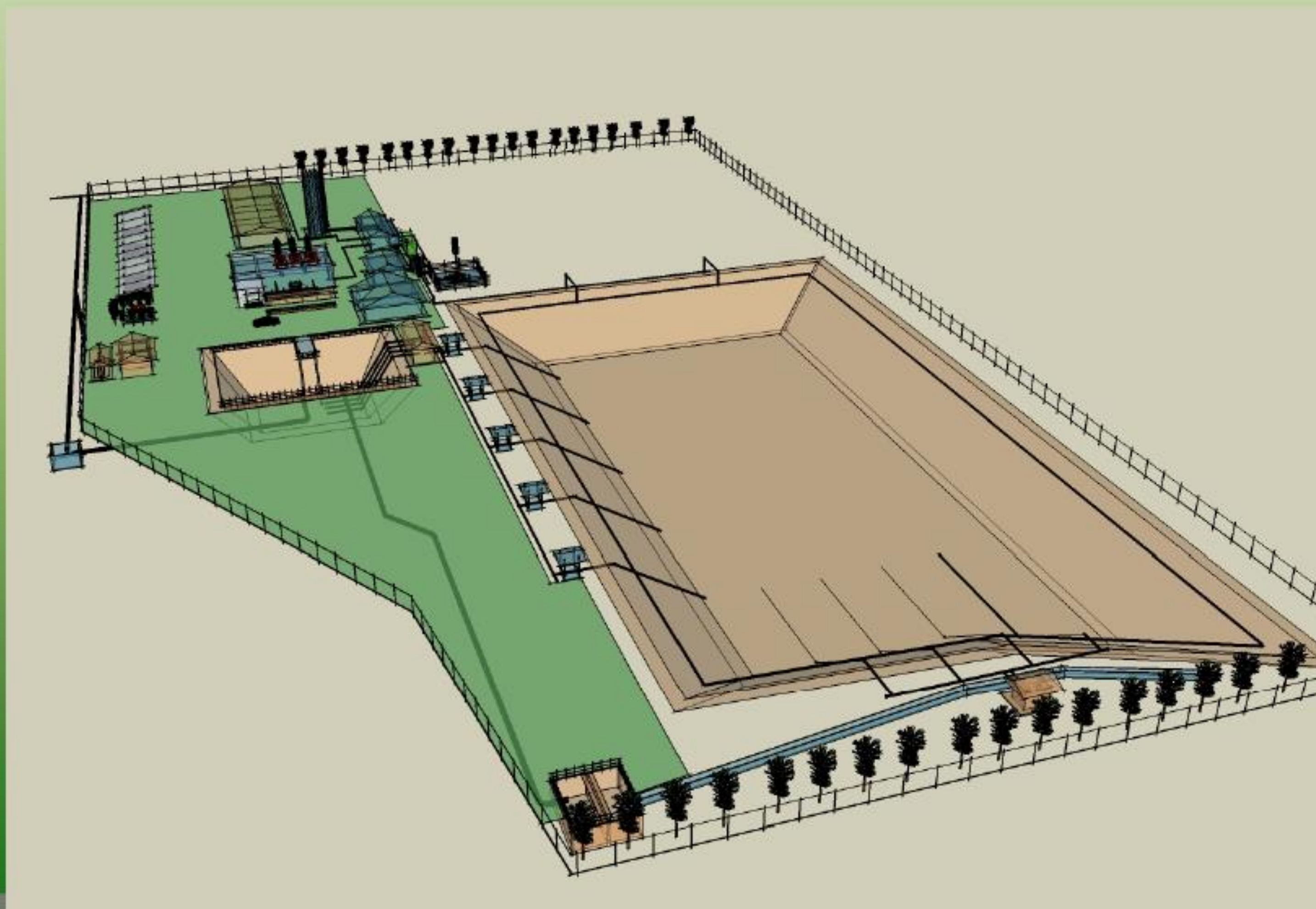


- Move from satisfying individual to village level needs
- NBC Nightly News: Crave Brothers Farm - WI
  - Outputs: Power, Fertilizer,

Covered High Energy Anaerobic Pond (CHEAP™) Technology



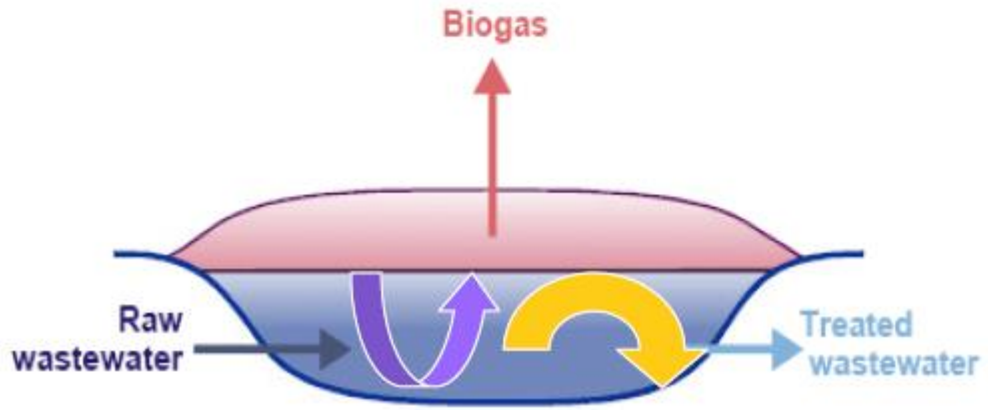
Cassava Biogas & Power Plant Layout Plan



ABR – CIGAR [Covered by HDPE]

ABR – CIGAR [Covered by HDPE]

Fundamental Working Principles of the Covered In Ground Anaerobic Reactor (CIGAR) Design Platform



Wastewater is pumped into the CIGAR, which collects the biogas (red) produced by the bacteria (blue)

- Substantially improved contact with the waste
- High active biomass (bacteria) retention efficiency
- High treatment reliability
- Payback period improved over covered lagoon

Waste Solutions Biotechnology Group

CIGAR

A 'covered in-ground anaerobic reactor', or 'CIGAR', breaks down organic contaminants through a three-step biological process where wastewater is treated in the absence of oxygen. The wastewater is held in the reactor for at least 30 days where specialized bacteria consume the waste and release methane that is utilised as biogas for on-site electricity generation (see figure 1).

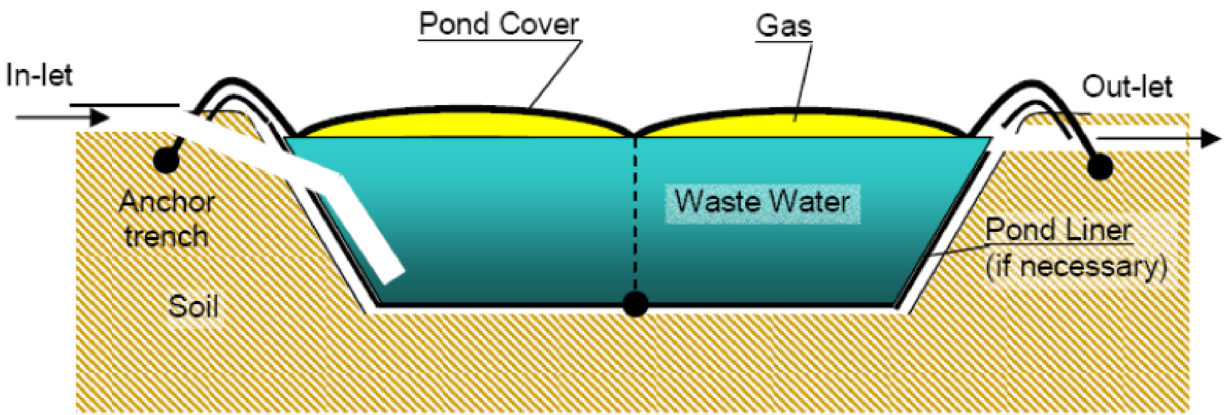


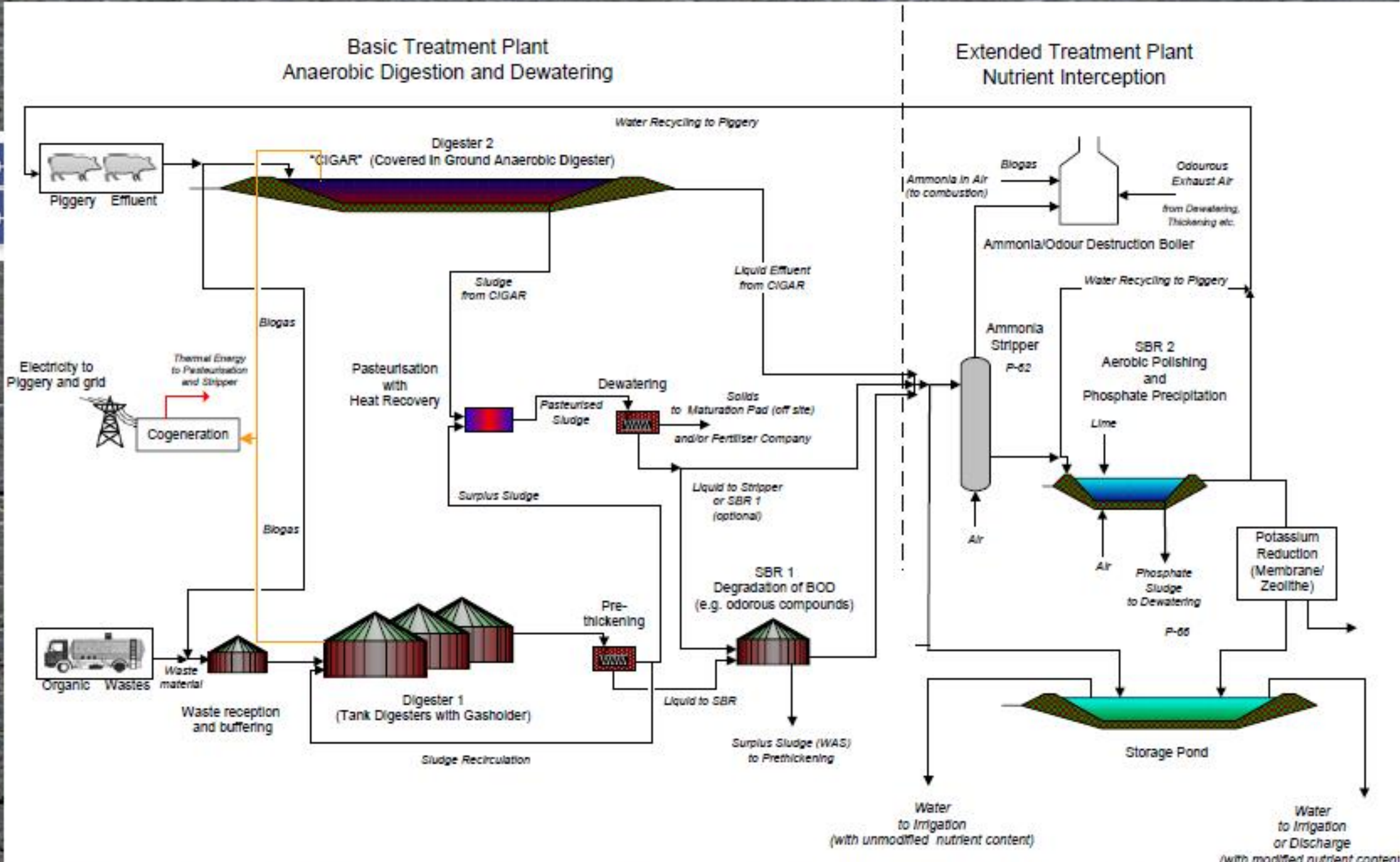
Figure 1: CIGAR pond reactor[1]

The project uses CIGAR anaerobic digestion technology utilizing 1.0mm High Density Polyethylene (HDPE) as a flexible membrane liner. HDPE is an essentially impermeable, resilient plastic which has high durability in sunlight and rainy weather. It is produced by HUITEX from Taiwan.

HDPE liners and covers are used to provide a gas seal to prevent methane from escaping to the atmosphere and prevent leachate from escaping to the underground aquifer. The CIGAR system is sealed 100% of the time and results in at least 95% destruction of BOD, and 80% reduction of COD. Suspended solids, dissolved solids and colour are all improved in the CIGAR. The long retention time of at least thirty days in the CIGAR) at approximately 35 degrees Celsius reduces pathogenic material.


CIGAR

Application Examples



Waste Solutions
Biotechnology Group

CIGAR

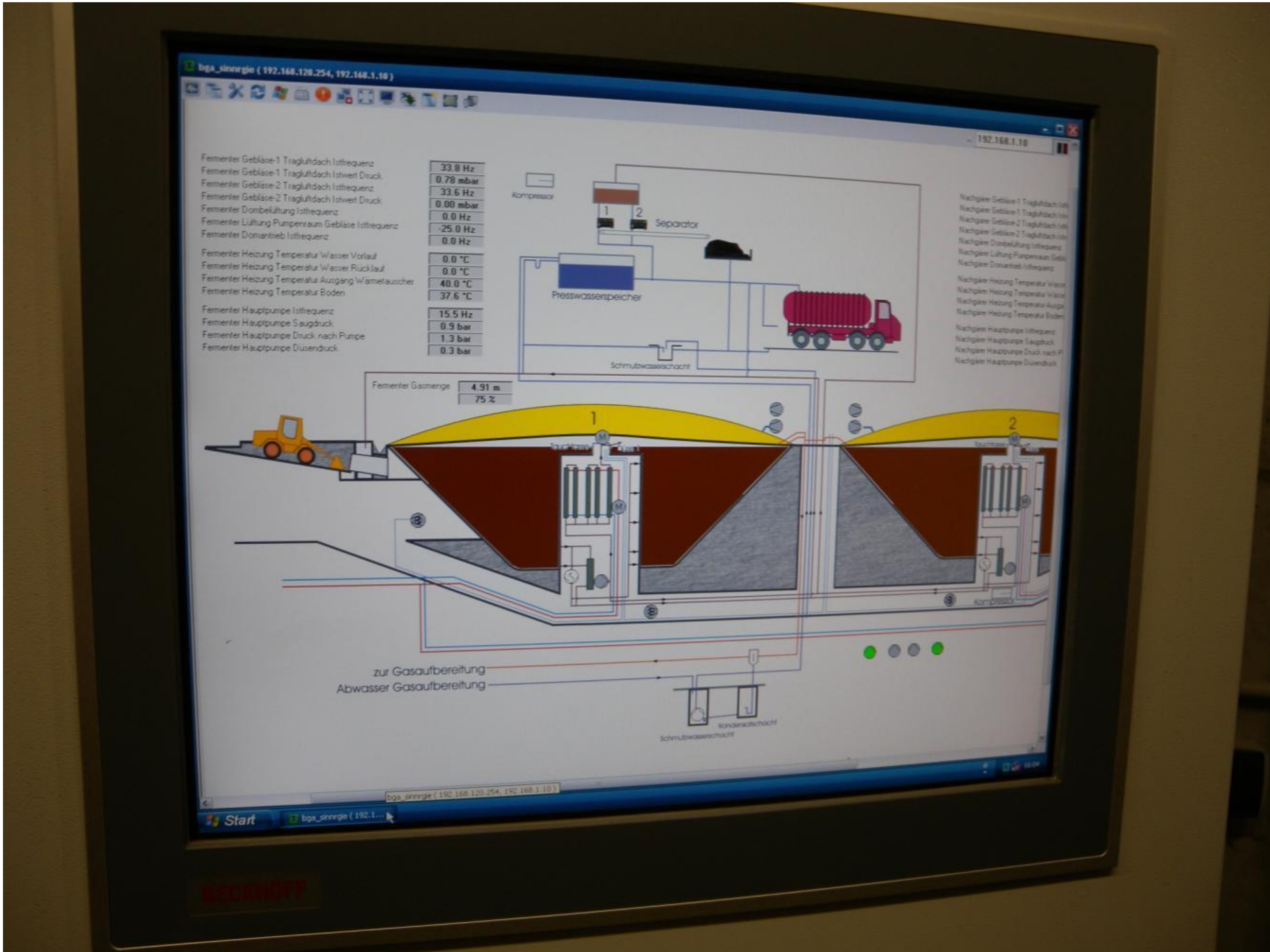
INNOVATIVE BIOGASSYSTEME

ECOGAS

Genial Einfach

- The heart of the ECOGAS process is the spraying the liquid fermenter content instead of conventional stirring. The fermenter content is thereby not completely homogenised, but the various fermentation processes proceed within the zones of the fermenter. Fermentation can be controlled in these zones by the targeted intervention due to varying spray intensity. In this forms, for example, a supply and hydrolysis zone in the feeding area and therefore an extremely beneficial digestion in the fermenter.

  The ECOGAS process enables selective retention times. Since the fermenter content is not mechanically thoroughly mixed, fresh biomass particles are located in the upper area of the fermenter. By extraction from the lower area, almost only fully degraded substrate is removed and a higher gas yield is only achieved in one fermenter. In addition, the process provides the basis for the simple assembly of the system according to ECOGAS technology.


bga_sinnrgie (192.168.120.254, 192.168.1.10)
192.168.1.10
Fermenter Gebläse-1 Tragluftdach Istfrequenz 33.8 Hz
Fermenter Gebläse-1 Tragluftdach Istwert Druck 0.78 mbar
Fermenter Gebläse-2 Tragluftdach Istfrequenz 33.6 Hz
Fermenter Gebläse-2 Tragluftdach Istwert Druck 0.00 mbar
Fermenter Dombelüftung Istfrequenz 0.0 Hz
Fermenter Lüftung Pumpenraum Gebläse Istfrequenz -25.0 Hz
Fermenter Domantrieb Istfrequenz 0.0 Hz
Fermenter Heizung Temperatur Wasser Vorlauf 0.0 °C
Fermenter Heizung Temperatur Wasser Rücklauf 0.0 °C
Fermenter Heizung Temperatur Ausgang Wärmetauscher 40.0 °C
Fermenter Heizung Temperatur Boden 37.6 °C
Fermenter Hauptpumpe Istfrequenz 15.5 Hz
Fermenter Hauptpumpe Saugdruck 0.9 bar
Fermenter Hauptpumpe Druck nach Pumpe 1.3 bar
Fermenter Hauptpumpe Düsendruck 0.3 bar
Kompressor
Separator
Presswasserspeicher
Schmutzwasserschacht
Fermenter Gasmenge 4.91 m
75 %
1
2
zur Gasaufbereitung
Abwasser Gasaufbereitung
Schmutzwasserschacht
Kondensatschacht
Start

With the investment in an "ECOGAS" biogas…

- …plant, you have made a decision in favour of a highly efficient system with the following technical and economic core data:

- the building cost for the system are 10 – 30 percent under the price for conventional biogas systems
- 50 - 70 % lower operating costs as with other biogas systems
- extremely low system energy requirements (approx. 2-5 %)
- plant reaches full capacity after no later than four weeks
- "ECOGAS" technology is capable of processing all kind of organic waste. This includes solid dung, food waste, slaughtering residues, liquid manure, etc. The system thereby makes its contribution in preserving growing areas for useful plants for the foods industry instead of occupying them for the targeted cultivation of energy plants!
- service and maintenance costs are low due to a minimum of movable parts
- sophisticated and proven system that has undergone several years of testing
- in comparison to the input, the gas yield is above-average due to the following reasons:
  - long selective retention time – larger biomass particles have an average retention time of over 200 days in the fermenter
  - zones in the fermenter have different environments – particularly the hydrolysis zone
  - disintegration of the biomass through cavitation on the pump and the spray nozzle

THANK YOU VERY MUCH FOR YOUR ATTENTION!

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