Covered Anaerobic Lagoons
Meat Industry Applications

Introduction

Australian red meat processing plants generate significant volumes of high strength wastewater as part of their normal operations. In the treatment of wastewater onsite, anaerobic lagoons often form one of the first steps, which are a cost-effective process but can suffer from odour emissions where natural crusts do not form.

With the awareness of climate change and the wish for companies to reduce the emissions of greenhouse gases, along with an improvement in technology, CAL's are once again being investigated to not only treat wastewater and reduce odours but also capture and use methane gas to lower emission footprints.

Covered anaerobic lagoons have become popular in the red meat industry overseas and are also becoming more popular in a number of Australian industries, where land is available.

Covered lagoons provide a number of benefits over conventional uncovered lagoons:

- Opportunity to control odours.
- Capture of greenhouse gases.
- Use of biogas to generate electrical energy and thus minimise the carbon footprint of the facility.

CAL Design

CAL Considerations

The lagoon must satisfy a number of design criteria similar to uncovered anaerobic lagoons. These include considerations such as:

- Stormwater/rainfall onto the lagoon/cover.
- Effects of wind and other natural disturbances.
- Build-up of sludge blanket underneath cover.
- Accumulation of scum, fats, oils and grease under cover.
- Need to desludge the lagoon.
- Sizing of gas off take system.

These issues can be avoided by carefully planning and designing a CAL however all systems need a start-up period for sludge seeding and a 'ramping up' of the system before it can operate to its full potential.

Pond Design

The ideal arrangements for a CAL are a deep lagoon with a balance between cost of the cover, cost of excavations and safety of batter slopes being met. A depth of between 4 to 6 metres is typically recommended with batter slopes ranging from 2.5:1 (sandy soils) to 0.5:1 (clay soils), depending on the soil type.

Cover Design

Lagoon covers are most often fabricated from high density polyethylene (HDPE). The HDPE cover is often joined with the pond lining to ensure an airtight seal of the system. The design life of the cover varies from 10 to 20 years.

An example design is shown in Figure 1. It can be seen that the apron creates a gas tight seal within the covered area. It should be noted that one side of the cover is connected to the bank, normally through a berm wall to allow for gas off take.

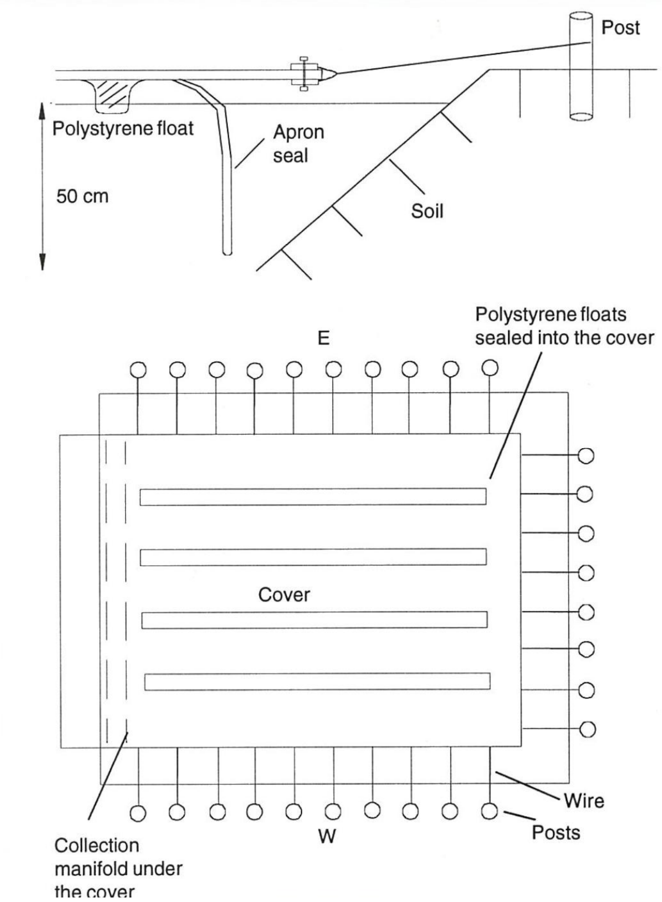

Figure 1 Floating cover installation gas seal

Concrete Berm Walls

Concrete berm walls are used to create a permanent structure to attach and remove covers. The cover is attached by first securing a long narrow sheet of metal to the concrete, laying the cover on top of the metal and then attaching a second metal plate on top of the cover and welding the two metal plates together, creating a gas tight seal refer Figure 2.

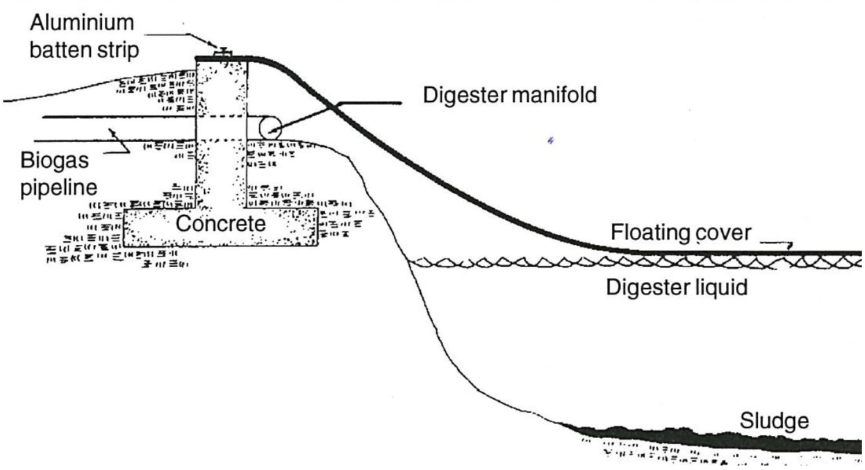

Figure 2 Concrete berm wall with floating cover attached

Trenching

An example of how the trenching is performed is shown in Figure 3. The cover and the PE lagoon lining are used to line the trench and then back filled with concrete to create a gas-tight seal. The photograph depicts the trench, and the gas collection ring main pipe.

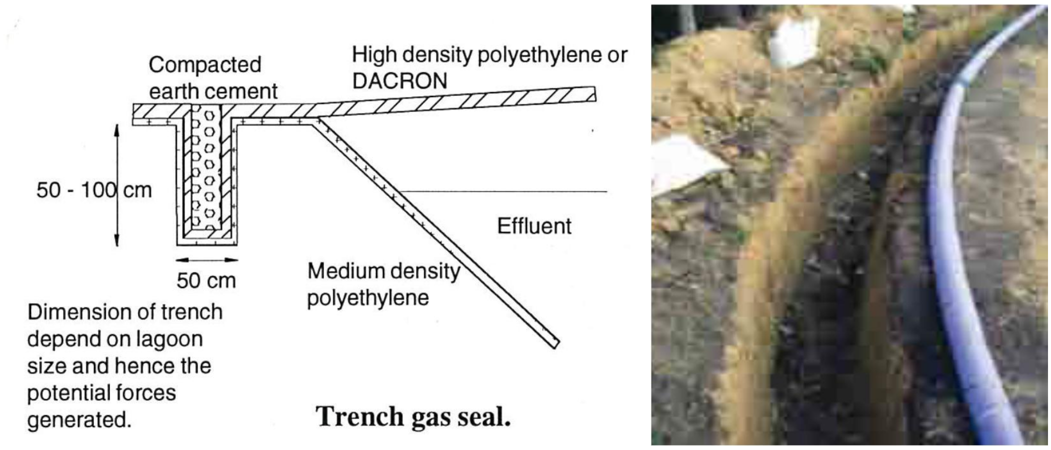

Figure 3 Trenching

Sludge Removal

The difficulty of not being able to easily remove the cover to desludge lagoons has been a significant issue in the past for CAL's, however a number of creative solutions have been found, incorporating both desludging techniques and cover design.

The easiest method sludge withdrawal is likely to involve installation of base pipework with multiple off-takes to enable withdrawal of sludge (via an external pump in a sump, located below the level of lagoon to avoid priming issues). However, entrainment of water into the sludge pipe is a common issue highlighted in **Error! Reference source not found.** and to some extent these problems may be overcome by adopting a more frequent/short pump outtake withdrawal sequence.

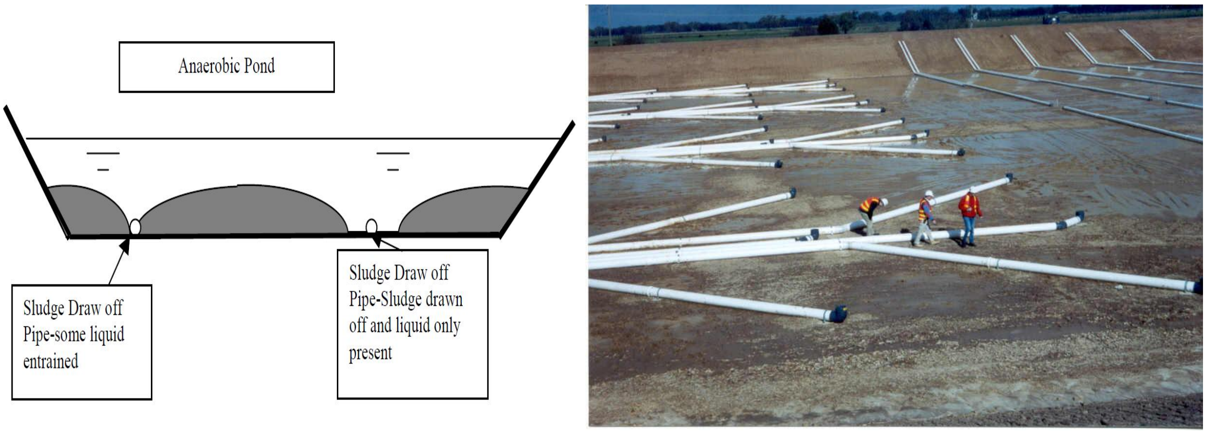

Figure 4 Sludge draw-off issues for anaerobic ponds and photograph showing multiple pipe inlet and sludge take off (right hand side) arrangement

Scum Layer Accumulation

The accumulation of a scum layer underneath the cover is a potentially serious issue as this layer can cause the cover to degrade, block gas intake pipes and can decrease the working volume of the CAL. The ideal method for treatment is the prevention of the layer accumulating through pre-treatment of wastewater to remove fats, oils and grease (e.g., dissolved air flotation). However if the layer forms regardless of the pre-treatment a program of bacterial and enzyme dosing can be initiated to remedy the situation. Alternatively a recirculation line (form outlet sludge layer) to inlet surface to break up the scum could be incorporated into the design.

Rainwater Collection

If the CAL cover is flat, then design needs to include provision for removal of rainwater. This would typically comprise a weighted pipe system, directing all flow to a common sump, in which a pump is located to remove the collected water (level switch basis). Refer to figure below. If wind is variable, then two sumps might be employed.

Figure 5 Weighed pipe and rainwater collection sump arrangement

Gas Collection

The three main uses of biogas are flaring to reduce the methane emissions, powering a boiler to increase the temperature of the sludge within the lagoon, through recirculation, and powering a combustion engine to generate electricity.

Gas Collection

Gas collection systems can be divided into two main categories, negative pressure and positive pressure systems.

Negative pressure systems work in the absence of pressure underneath the cover and use a blower to 'suck' the biogas out of the digester. An example of a lagoon under negative pressure gas collection system is shown in Figure 6.

Figure 6 Covered anaerobic lagoon operating under a negative pressure gas collection system

Positive pressure systems allow biogas to build up underneath the cover and allow the biogas to migrate into low pressure zones, such as gas off takes, naturally. An example of a lagoon under positive pressure gas collection system is shown in Figure 7, where it can be seen the rainwater flow paths drain towards the middle of the cover as well.

Figure 7 Covered anaerobic lagoon operating under a positive pressure gas collection system

Key Benefits, Challenges and Issues of CAL's

The key benefits of covered anaerobic lagoons are:

- Low construction costs.
- Minimal operating costs.
- Simplicity of design and operation.
- Reduced odour admissions.
- Lower hydraulic retention times.
- Higher possible organic loading rates.
- Recovery of biogas for generation of energy.
- Use of biogas for boilers to maintain CAL's to operating at optimal temperatures for anaerobic digestion.

The key challenges and potential issues with operating a CAL are:

- Sludge accumulation and desludging.
- Stormwater/rainwater management.
- Regulation of gas pressure.
- Protecting cover from wildlife, plant growth, rips and tears.
- Safety requirements, i.e. fencing, signage and lifebuoys.
- Scum accumulation.
- Ensuring appropriate pre-treatment of waste.
- Balancing water quality requirements with biogas production.
- Preventing hydrogen sulphide contamination of the bio gas.

Costs

To provide some representation of cost for implementation of a CAL, we have reviewed 2 scenarios for different sized abattoirs. We have included the cost of cogeneration system (which is a significant > 20 % proportion). The presented values above should be regarded as a broad guide only, since, as previously noted, there are many site specific variables. Payback is likely to be of the order of 6 – 8 years, unless government funding grants can be obtained.

Table 1 Capital cost of major items for CAL system (comparison by processing plant size)

Item	Small Plant	Medium Plant
Nominal wastewater flow, kL/d	500 kL/d	1,500 kL/d
Size of CAL, ML	7.5 ML	35 ML
Biogas production, m^3/d	450 m^3/d	1,700 m^3/d
Cogeneration – electrical output Exhaust heat	77 kW 51 kW	135 kW 90 kW
Anaerobic lagoon excavation, cut and fill	$250,000	$380,000
Lagoon liner	$80,000	$150,000
Inlet and out structures	$20,000	$20,000
CAL cover	$150,000	$200,000
Electrical generator	$250,000	$365,000
Biogas flare	$100,000	$100,000
Sulphide scrubber	$20,000	$20,000
Ancillaries, pipework & installation	$380,000	$670,000
Sub-total	$1,250,000	$1,905,000
Contingencies, design, engineering (30%)	$375,000	$560,000
Total	**$1,625,000**	**$2,430,000**

CAL Design Criteria Summary

Loading rate	0.3 – 0.8 kg BOD./m^3.d	Dependent on temperature, wastewater characteristics, local factors
Depth	Minimum 5 m	Preferably deeper, dependent on soil conditions, lining, embankment
Detention time	8 – 40 days	Dependent on temperature, wastewater characteristics, local factors
Pre-treatment requirements	Removal of grease, paunch material	To prevent crust formation under cover
Cover arrangement/type	UV resistant HDPE (minimum 2 mm)	Can be flat, or fixed dome arrangement, but need to allow for stormwater removal. May need multiple stormwater take-off sumps to allow for changing wind direction (and locate away from scum accumulation zone)
Trenching	Earthen trench, or concrete berm perimeter	To provide seal, prevent air ingress. Site specific – integral with liner
Inlet/outlet arrangement	Submerged, multi point	To provide cross sectional flow
Sludge take-off	Sludge pipe	To avoid removing cover. Multi point, able to take off from different areas. Could provide mixing/recycle to inlet as integral part.
Gas extraction	Ring main or multi off-take	Need to ensure level control, avoid blockage. Pressure of cover to enable auto initiation of gas extraction
Operational and Maintenance aspects	Daily, weekly checking: • Gas production • pH • BOD/VS reduction Undertake regular: • Instrument calibration • Equipment servicing • Cover integrity checks • Gas relief valve check	Typically check feed and gas production on daily basis (if gas has dropped off, check pH and VFA's).

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