DBC Wastewater Treatment System

Summary

EEI was engaged by Dardanup Butchering Company (DBC) to design, and commission a new wastewater treatment system for their meat processing plant in Picton, Bunbury to replace their old treatment system. Based on analysis of baseline data, EEI decided to install its proprietary EEI Hybrid Anaerobic Reactor Technology (EEI-HART) and Advanced Nitrogen Removal Using Ponds (ANRUP) system for this project. Previous computer models and laboratory scale studies in the development stages on these processes have contributed significant knowledge of operational aspects. However, there was a significant lack of data on the constructability, operational constraints in a field situation. The HART system was to treat a daily wastewater flow of up to 0.5 MLD with a BOD of 9, 000 mg/L and total nitrogen of 300 to 400 mg/L. The HART system is 4,500ML HDPE lined steel tank and has the advantages of both UASB system and counter current mixing technology for rapid carbon removal and to avoid extra alkalinity addition.

The system was constructed in nearly 40% of the cost of conventional pond system, and over the last 12 months of operation shows that this system has successfully treated wastewater to achieve a reduction of 99.9% of BOD, and about 90% reduction of TN. The HART system produces biogas with about 70% CH_4 content but only <5% CO_2 and non-detective levels of H_2S. The system produces minimal sludge and the HAR system can contain the sludge from the treatment system for over 2 years before regular desludging commences. The system operation is monitored remotely.

- ***Innovative, unique or other outstanding features of this project which sets it apart from common practice among comparable enterprises.***

Typically meat processing industries in Australia and globally use anaerobic lagoons followed by aerobic and polishing ponds for wastewater treatment. This method causes severe odour issues, and although BOD is often reduced, no nitrogen reduction takes place in such plants. Many processors cover the anaerobic lagoon due to odour issues from the anaerobic lagoons. However, nitrogen reduction is still a major issue and many processors then employ activated sludge systems replacing pond systems. This requires substantial electrical power to operate such plants and creates issues such as sludge management.

The solution provided by EEI for treatment of wastewater from Dardanup Butchering Company's abattoir in Picton WA was an integrated method consisting of two technologies developed by EEI; Hybrid Anaerobic Reactor Technology (HART) and Advanced Nitrogen Removal using Ponds (ANRUP) technology. The advantages of this solution in comparison to conventional solutions are provided below.

- **Capital Cost & Operating Cost**

The capital cost of the 0.5 MLD system is significantly lower than conventional systems. The overall project cost only 40% of the conventional systems for similar hydraulic and organic and nitrogen load.

Typically anaerobic ponds are considered to be a cheaper system. In the feasibility study stage, it was found that given the site conditions (high water table during winter), the cost of raising the base of the pond to 2m above the water table was quoted to be twice than the construction cost of the HART system.

The operation and maintenance (O&M) cost of the plant is only a fraction (~ abut 5%) of that of the conventional approach to treating these types of wastewater.

- **Power cost**

The total power requirement of a conventional activated sludge treatment system will be about 5,670 kWh/d for carbon reduction and 1,010 kWh for nitrogen removal (US-EPA Wastewater treatment Fact Sheet, 2002). The HART-ANRUP system requires only 365 kWh of electricity a day (only less than 8% of the energy demand in comparison to conventional approach) for both nitrogen and carbon removal to the approved levels.

The power cost is substantially lower than alternatives by the use of control parameters and online remote monitoring of the system, which allows the plant to be operated with minimum energy requirements during peak hour demand time, thus eliminating the penalty on load factor at peak hours. In addition, the aeration system has been designed in such a way that it makes use of high oxygen transfer and mixing in comparison to blower and fine bubble diffusors or surface aerators.

- **Chemical cost**

The HAR –ANRUP system does not require chemicals to control alkalinity, carbon source for denitrification. The unique design of the HAR - ANRUP system eliminates the requirements of alkalinity addition during the high rate anaerobic digestion, a typical cost incurred with technologies such as UASB.

The ANRUP system does not require external carbon dosing for denitrification, which substantially reduces the operation cost. The system is designed in such a way that a significant requirement of electron donors in the nitrogen removal process is met by ammonia within the system.

Mechanical mixing in the anaerobic reactor has been replaced with counter current flow system, which also provides opportunity for rapid carbon conversion, adsorption of CO_2 and low overall sludge production and nitrogen removal.

This phase of the project did not include phosphorus removal and hence the cost of the chemicals for P removal is not included.

- **Sludge Management**

The sludge produced from the system is much lower compared to conventional systems of this organic and hydraulic load. The system has been designed to contain about 2 years of sludge produced within the HART-ANRUP process as part of the operation. The quantity of stabilized sludge to be removed is about 15 kg (as total solids-TS) per day in a sludge drying bed in the warmer months (October through March) and the dried sludge will be sold to a nearby garden nursery. This eliminates substantial operation costs. On the other hand, a conventional activated sludge treatment system for this project would produce about 2600 kg of TS per day as sludge.

- **Quality of Biogas Produced**

The biogas produced from the HAR system has been tested at the Woodman Point laboratory of Water Corporation as part of a B.Eng Honours thesis of UWA. The samples collected over a period of time consistently showed 70% CH_4, <5% CO_2, and H_2S levels below detection. Typical concentration of CO_2 in biogas is about 30 to 40%. This very low value of CO_2 in the biogas is the major unique feature of the HART system.

At present the HART system is an open (uncovered) system and no biogas capture (except for sampling and testing) is carried out. The low CO_2 value and high CH_4 and no H_2S content in the biogas produced from the HART system will provide a cost effective power generation system which can save over 75% of the total energy bill of DBC in Picton. EEI is currently undertaking this part of the project.

- **Data acquisition and online monitoring**

Typically, regional pond based treatment systems of water utilities such as Water Corporation, and industrial wastewater treatment plants face a number of issues with operation of the plants due to technical personnel not being available to operate these plants.

In this project, a number of probes were installed and connected to a SCADA system which provides remote monitoring of the system and opportunity to carry out any preventive action so that effluent discharge permit conditions will not be breached. In the last one year of operation, the monitoring and control system has helped to run the wastewater treatment system in such a way that the daily or weekly attendance was not required and any electrical or mechanical faults have been identified so that follow up actions to fix them enabled the plant to produce treated water of expected quality.

- **Summary of innovation**

The innovative aspects of this project can be concluded as

- Cost effective CapX and OpeX
- Less than 10% of energy requirement compared to conventional system
- No chemical addition to balance alkalinity during anaerobic and nitrification process
- Highly efficient aeration system (higher oxygen transfer and mixing than diffusor system but low maintenance cost)
- Low sludge production, and the first 2 years of sludge is contained
- Desludging and sludge drying in summer months saving energy and chemical costs
- Implementation of online parameter monitoring and SCADA for nitrogen removal

Innovation aspect of this project

Treatment of wastewater, industrial effluent including tertiary treatment such as nitrogen removal in both urban and regional Australia is an essential requirement. Many regional plants and industrial wastewater plants are based on anaerobic lagoons, and pond based treatment systems that require larger footprint, and no capability for nitrogen removal and cause issues such as odour generation.

This project demonstrates that innovative solutions of Hybrid Anaerobic Reactor Technology (HART) and Advanced Nitrogen Removal Using Ponds (ANRUP) can effectively produce treated effluent of approved quality at a lesser footprint, capital and operation cost, low power consumption and low manpower requirement to operate the system.

This project is useful for both municipal and industrial effluent treatment in both urban and regional areas including mining townships. The HART and ANRUP processes are highly relevant to the Australian water industry for projects due to the benefits and innovations stated in the preceding session.

Nitrogen removal technologies in a cost effective and sustainable manner and without addition of an external carbon source such as methanol and alkalinity correction chemicals (for high nitrogen wastewater) will bring new solutions to the water sector. Similarly, a hybrid anaerobic reactor, which can enable process such as counter current mixing and produces biogas with less than 5% CO_2 is a very innovative process and will bring a new solution to the water sector.

RESULTS

This project has demonstrated that treatment of high strength wastewater to the required level of BOD, TSS and TN could be achieved with less than 10% of that of the conventional activated sludge treatment system (such as SBR, MBR, IDEA) and with no chemical addition. In addition, if there is incentive for onsite energy production using biogas (currently this is very ambiguous, rules and regulations change every time), about 75% of electricity cost of running the business (including the main meat processing operations and refrigeration) at the premise could be met with electricity produced from the biogas at the facility.

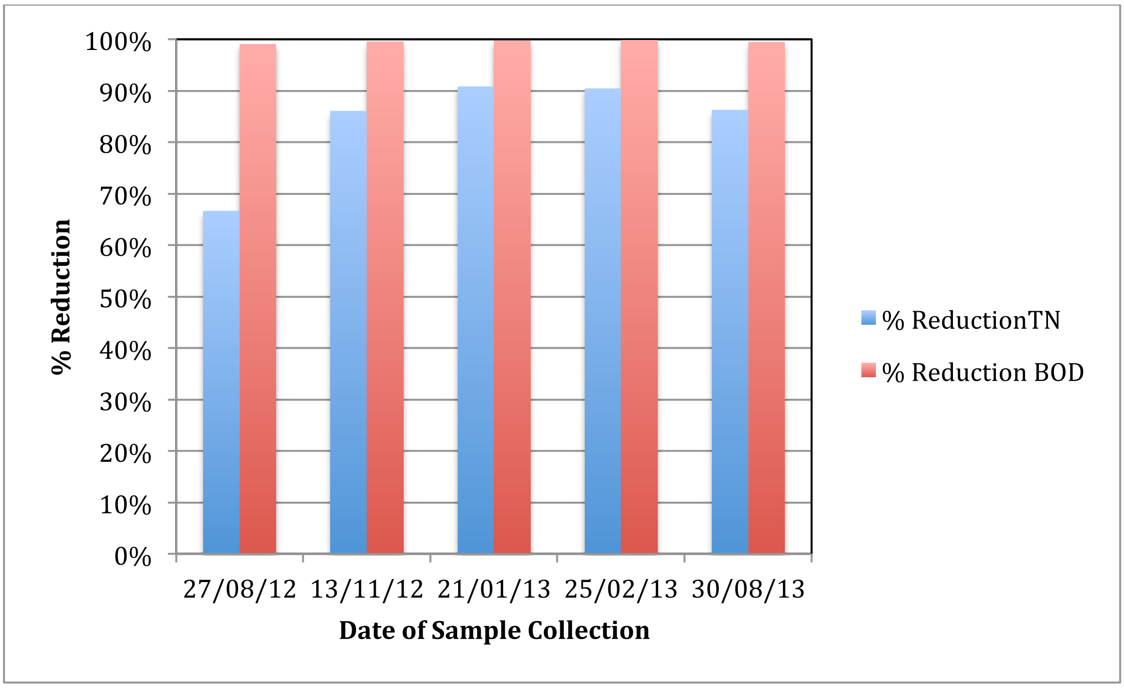

Figure 1: Removal Efficiency: % Total Nitrogen and % BOD_5 removed after installation on 20/8/2012.

As presented in Figure 1, the treatment plant has been steadily achieving removal of nitrogen and BOD_5. The nitrogen removal is sensitive to temperature than BOD removal, and as the system reaches steady state condition and fine-tuning, the system can be enabled to remove higher total nitrogen. In winter months, TN removal can be lower than summer months. Previous application of ANRUP system in another project (Mount Barker Chicken processing plant in Kondinin) achieved an effluent TN value of less than 10 mg/L but the influent TN was nearly half of the influent of this project.

		
Biogas collection from top of HART – floating gas holder	Biogas stored for sampling	Biogas samples collected in Tedlar for analysis

Figure 2: Biogas collection and sampling

Table 1: Analysis of Biogas (sampled on 24 October 2012)

SAMPLE ID	CH_4 (%)	CO_2 (%)	H_2S (ppm)	Comments
Sample 1	70.3	4.9	ND	Remaining % of gas is assumed to be hydrogen and nitrogen; no testing facility available locally
Sample 2	68.0	4.7	ND	
Sample 3	66.6	4.1	0.05	
Sample 4	70.5	4.3	0.05	

Table 1 shows that the biogas produced from the system has CO_2 content well below 5 mg/L and H_2S is very minimum (0.05 ppm) to non-detectable levels. The CH_4 content ranged from 67 to 70%. The remaining content of the biogas from the plant is assumed to be nitrogen and hydrogen, however, we could not get the biogas samples tested for these components as there was no biogas testing faclity in WA equipped with analysis of these gas components.

The performance of the HART part of the project has been studied in detail by a final year Honour's student in environmental engineering of UWA in 2011-12. The research findings have been published in the final year thesis, Palandri,M, 2012, School of Environmental Systems Engineering, UWA).

National Meat Industry Training Advisory Council Limited (MINTRAC), Meat and Livestock Australia and AMPC have highlighted this technology in the recently prepared digital brochure on innovative technologies for wastewater treatment. MINTRAC also organized visits to the project sites and presentation of this project to their industry network of environmental compliance managers in Australia.

PROJECT INCORPORATES SUSTAINABLE DESIGN PRINCIPLES

The project has been conceived based on sustainable design principles.

1. **Social aspects**

- The social aspect of the project is that it provides opportunity for dried sludge to be used as soil amendment. The sludge does not have higher concentration of sodium and would not affect the sodium adsorption ratio of the receiving soil as there is no addition of NaOH in the process by way of increasing alkalinity. The system has been designed by carrying out an alkalinity balance and alkalinity requirements have been met by hydraulic and process manipulation.
- The technology is based on locally developed process, by EEI, which is an Australian based organization.
- The other social aspects of the technology is that the system does not produce any odour such as due to hydrogen sulfide or other odour generating gases, and the energy required for the system is less than 10% of conventional solutions. This enables the energy saved (about 4 MWh per day) could be used for other industries and households.
- As no chemicals classified as dangerous good and hazardous are used for the operation of this project, and no daily operational attendance is required, the opportunity for occupational health and safety hazardous are very minimal or nil.
- The system does not have equipment with high noise. The maximum noise from the plant is within the allowable limit.

2. **Environmental**

- The treatment system requires removal of a very minimal sludge, about 15 kg of TS/d as stabilized sludge for 6 months every year and can be dried using a drying bed. This eliminates electrical and chemical energy for sludge management. The dried sludge is to be used as a soil amendment for a nursery garden near DBC.
- No hazardous chemicals required to operate the plant
- Potential to generate electricity 75% of the energy need for DBC Picton facility and about 50% of the heat requirement using CHP engines that would make use of the biogas produced from the HART system. At this stage, EEI is preparing detailed design and costing for covering the HART system to capture biogas to produce electricity.
- The double lined system for ANRUP system with HDPE double lined pond and the HDPE double lined, bolted steel tanks ensure prevention of leakage and groundwater contamination.

3. **Economical**

- The capital and operating cost of the system is only a fraction of conventional system as has been detailed earlier. The application of HDPE lined, bolted steel tanks is an economical way of constructing anaerobic reactors, and it ensures a minimum of 30 years of life span against leakage and corrosion and UV radiation. The design considered various alternatives on cost, performance, noise generated, and other process and operational parameters and selected this system as the best approach that meets the performance, safety and longevity requirements, at the same time cost effective.

- The system has been designed to lower O&M cost, particularly energy and to avoid replacement cost of conventional equipment or components such as membranes, fine pore diffusors by means of better efficient configuration of components that exceeded the performance of conventional solutions such as specially configured ventury aeration system with increased aeration and mixing capability for a given kW capacity.
- DBC is not a wastewater treatment factory, and the technical personnel of DBC are to support the main operation. It is the same with other industries and wastewater treatment plants in remote locations owned by utilities where the availability of technical personnel for operation is a major hurdle and it increases the cost of operation for the plants. This plant has been designed to operate without daily or weekly physical manual attention and can be monitored remotely for any intervention, making it an economically viable alternative to conventional system of this size.

CONSTRUCTION STAGES

The project was carried out in a phased manner, the HART system was commissioned in late 2011 and the ANRUP was constructed and commissioned in September 2012.

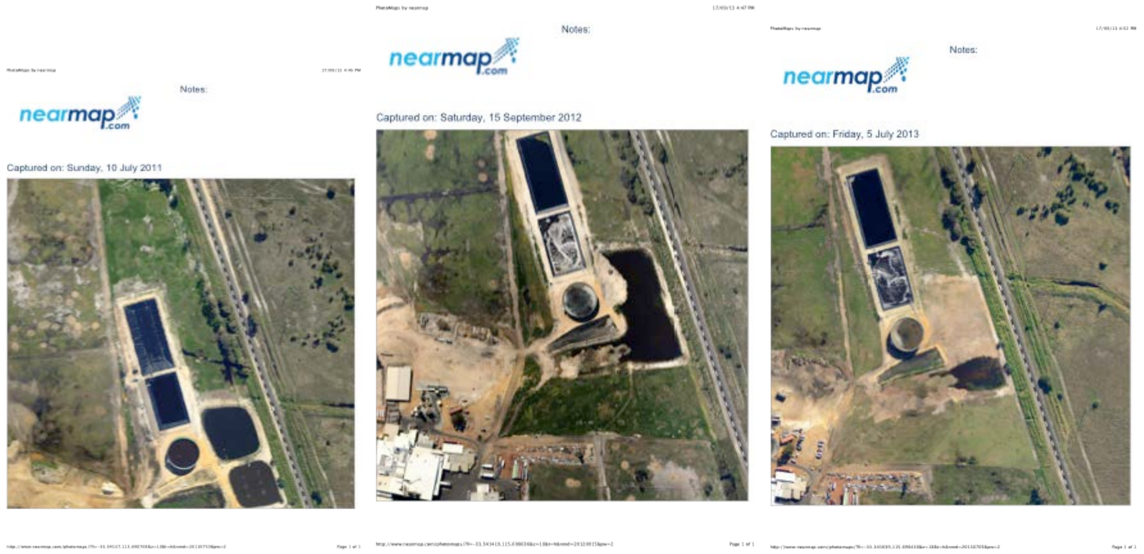

Figure 3: a) Site during construction in 10 July 11, b) during commissioning in 15 September 2012, and c) 5 July13 taken from Nearmap site.