THE USE OF A HIGH RATE ANAEROBIC PROCESS FOR WASTEWATER TRETAMENT PLANT UPGRADES

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THE USE OF A HIGH RATE ANAEROBIC PROCESS FOR WASTEWATER TREATMENT PLANT UPGRADES.

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ABSTRACT

Goulburn Valley Water wish to upgrade the Mooroopna WWTP to improve the final effluent quality and to reduce odours from 39 Ha of anaerobic lagoons. The use of a high rate anaerobic lagoon is seen as a potential method of controlling odour from the Mooroopna works. It will reduce the anaerobic lagoon area from 39 to 2 Ha, thus enabling point source odour control by means of pond covers. High rate ponds will also reduce the anaerobic process volume from 950 to 70 ML, releasing approximately 880 ML of existing anaerobic lagoons for other purposes, such as effluent storage. It may also form the first stage of future treatment units, such as the Dissolved Air Flotation (DAF) or Pond Enhanced Treatment and Operation (PETRO) process, for the removal of final effluent algae.

This paper discusses high rate anaerobic systems and presents the results of a pilot trial at Mooroopna to assess the anaerobic biodegradability of the wastewater.

KEY WORDS

Wastewater, lagoons, anaerobic, UASB.

1.0 INTRODUCTION

A large number of food industries are located across the State of Victoria producing a variety of dairy, fruit and meat products for local consumption and export. They are of great significance both locally and nationally: as employers and as generators of valuable foreign currency for Australia through the export of a sustainable resource.

However, associated with the manufacture of these products is the generation of substantial quantities of wastewater. This industrial wastewater load is generally significantly greater than the domestic wastewater load arising from the local community. For example the population equivalents of the domestic and industrial wastewater loads on the Mooroopna Wastewater Treatment Plant are about 7000 and 250,000 respectively. The industrial wastewater is characterised by high concentrations of soluble and particulate organic matter, nutrients and inorganic salts. The rural treatment plants to which these wastes are discharged have generally employed lagoon-based technologies with the final effluent being disposed of by a combination of evaporation, irrigation and river discharge.

The effluent quality requirements listed in the guidelines for discharge to inland waters (EPA, 1995) issued by the EPA of Victoria far exceed the capability of lagoon based treatment systems.

To achieve the effluent quality listed in the EPA Guidelines requires that total phosphorus must be reduced to a median concentration of 0.5 mg/L and total nitrogen to a median concentration of 10 mg/L. The difficulty in achieving and maintaining such an effluent quality must not be underestimated. In the urban context, Biological Nutrient Removal (BNR) plants designed to operate at this level would, for the Mooroopna population equivalent, cost in excess of $40 million.

The lagoon technologies, traditionally favoured in more rural areas are not, without substantial modification, appropriate to meet the new standards:

- They do not remove phosphorus
- They require long retention times and mild temperatures to achieve removal of ammonia
- They are potential sources of odour
- They are susceptible to algae blooms, which contaminate the final effluent with suspended solids, BOD and organic nitrogen and which may be both odorous and toxic.

However, moving to nutrient removal has the potential to be costly, both in terms of capital and operation, and cost recovery from industrial contributors to a wastewater scheme in accordance with "polluter pays" principles may have a substantial economic impact especially where the costs have to be carried by a single industry. It is inappropriate that the viability of rural Australian industry be compromised by the assumption of high cost technologies. Accordingly, attention should be paid to innovative combinations of low cost and robust technologies to upgrade existing treatment facilities in an effort to achieve the demanding new effluent quality standards.

2.0 THE MOOROOPNA WASTEWATER TREATMENT PLANT.

The Mooroopna Wastewater Treatment Plant is a lagoon treatment system owned and operated by Goulburn Valley Water and comprises 9 anaerobic lagoons and 11 aerobic lagoons. It treats an annual inflow of 1600 ML of which about 500 ML arises from domestic sources and the remainder from a local cannery. The total lagoon volume is 1450 ML with a surface area of 88 Ha. Effluent from the plant is discharged to irrigation on an adjacent dairy farm (34 %) and to the Goulburn River (33%). The remaining effluent is lost to evaporation.

On average the domestic waste comprises 34% of the hydraulic load and 9% of the organic load but during the peak canning season it constitutes about 18% of the hydraulic and about 2.5 % of the organic load.

Goulburn Valley Water resolved to upgrade the treatment plant in order to achieve two principal objectives: (1) to improve the effluent quality in accordance with EPA requirements and (2) to reduce odour emissions from the plant. At present the plant effluent quality does not comply with proposed EPA requirements due to an effluent phosphorus concentration of about 9 mg/L and because algae growth through the lagoons results in excessive BOD, suspended solids and organic nitrogen concentrations (long retention time does however result in an average effluent ammonia concentration of less than 2 mg/L). During the peak canning season the anaerobic lagoons are a source of odour nuisance due to hydrogen sulphide emissions – the cannery wastewater contains sulphate concentrations of about 300 mg/L.

An investigation was commissioned which assessed a number of options to best achieve improved treatment and odour control. These included full BNR, aerated lagoons, high rate anaerobic lagoons, the PETRO process (for nitrogen removal and algae entrapment) and dissolved air flotation (DAF) (for algae and phosphorus removal).

The investigation concluded (CMPS&F, 1997) that a combination of a covered high rate anaerobic lagoon, the existing lagoon system and DAF were the most appropriate technologies. The function of the high rate anaerobic lagoon would be to remove the bulk of the organic load with minimal energy input and to confine the generation of odorous gases to a small area that could be covered to enable the gas to be collected and properly disposed of.

The function of DAF was to treat the final lagoon effluent to comply with EPA requirements on the premise that the dosing of metal salts and the removal of algae would reduce phosphorus, organic nitrogen, BOD and suspended solids concentrations. GVW has undertaken trials at the Shepparton Wastewater Treatment Plant in order to confirm the suitability of DAF.

3.0 THE HIGH RATE ANAEROBIC LAGOON (HRAL)

During peak canning season the existing anaerobic lagoons at Mooroopna remove about 50% of the BOD in an area and volume of 39 Ha and 950 ML respectively. By contrast the proposed HRAL is designed to achieve 70-90% BOD removal in an area of 2 Ha and a volume of 70 ML. The higher anticipated performance of the HRAL is in large measure due to design concepts that have emerged from the design of Upflow Anaerobic Sludge Blanket (UASB) reactors.

Loading rates of up to 10 kg/BOD/m^3/day may be applied to UASB reactors with the provision of sufficient alkalinity, the maintenance of mesophilic temperatures and provision of intimate contact between the sludge and the wastewater feed being vital to ensure successful operation. In high rate anaerobic lagoons, wastewater may be fed into the base of the lagoon via a number of feed nodes so that it may percolate gradually up through a sludge layer in which removal of organics and generation of methane occurs.

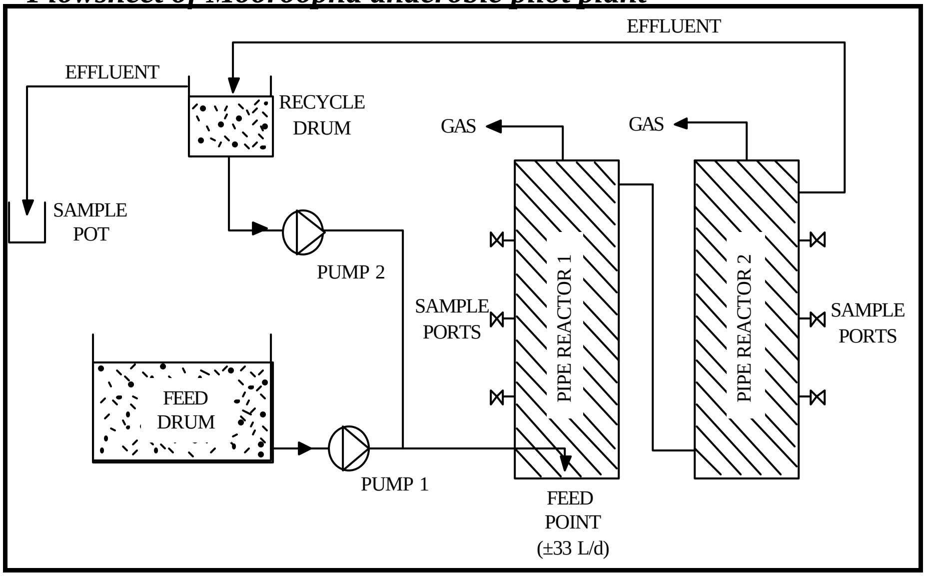
Alkalinity may be provided by a combination of lime dosing and recycle between discharge and feed points. However, mesophilic temperatures are seldom achieved and contact between feed and sludge is inferior to that achieved in a UASB system. Accordingly HRAL design loading rates are significantly lower than for a UASB reactor, typically between 0.1 and 0.4 kg/BOD/m^3/day.

Successful performance of HRALs has been reported for fruit juice (Messenger, 1994), potato and milk wastes. Nevertheless it was decided to assess the anaerobic biodegradability of the Mooroopna waste by conducting a pilot trial at the Mooroopna WWTP.

4.0 THE MOOROOPNA ANAEROBIC PILOT PLANT.

A small pilot plant was constructed at the Mooroopna WWTP comprising two 3 meter lengths of 200 mm PVC pipe reactors connected in series and a peristaltic pump to transfer feed and to provide a 1:1 recycle. The flow schematic of the pilot plant is illustrated in Figure 1.

Figure 1: ***Flowsheet of Mooroopna anaerobic pilot plant***



The trial was not intended to predict the performance of the proposed HRAL but rather to assess the anaerobic biodegradability of the wastewater and to determine whether the high sulphate concentrations in the feed would be inhibitory.

As trial commenced in April 1997 at the end of the peak canning season it was likely that for most of the trial the feed wastewater would not be typical of the peak season. Thus, towards the end of the season, wastewater was collected over a number of days and refrigerated in an attempt to ensure a representative feedstock during the off-season.

Initially the pilot reactor was seeded with anaerobic digester sludge drawn from the Kyabram WWTP but after two weeks of operation the sludge remained inert and was replaced with an active pelletised UASB sludge. The UASB sludge responded immediately. Samples were drawn every second day from the feed, from Pipe Reactor 1 and from Pipe Reactor 2.

5.0 RESULTS OF THE PILOT TRIAL.

The pilot trial lasted for a period of 86 days. Results obtained are summarised in Table 1.

Table 1: ***Summary of Mooroopna Pilot Plant results***

Parameter	Location	Median	90 % ile	No of data
COD	Influent	1200	2230	30
	Reactor 1	140	200	29
	Reactor 2	120	200	29
VFA	Influent	130	562	24
	Reactor 1	14	35	28
	Reactor 2	12	21	30
PH	Influent	12	13.4	30
	Reactor 1	7.4	7.7	28
	Reactor 2	7.4	7.8	30
Temp	Influent	12.4	14.5	30
	Reactor 1	11.6	14.1	27
	Reactor 2	9.8	12.4	29
Sulphate	Influent	225	463	30
	Reactor 1	115	219	28
	Reactor 2	100	213	30
Sulphide	Influent	0.5	1	30
	Reactor 1	24	53	28
	Reactor 2	14	46	30

The following points are worth noting:

- The median removal of COD across the process train was 88% (85% in Reactor 1 alone). The median loading rate on the Reactor No 1 was 0.53 kgCOD/m^3/d and the median residence time in the reactor was 2.4 days. Note that while the pilot trial showed the Mooroopna effluent to be readily biodegradable under anaerobic conditions it cannot necessarily be taken to be representative of full scale lagoon performance due to the use of high grade anaerobic pellets in the pilot plant - such pellets are unlikely to grow in a lagoon environment.

- Notwithstanding attempts to ensure a typical peak season wastewater feed of about 3000 mg/L, the median influent COD was rather low at 1,200 mg/L. Note that the median influent CODs before and after 1 June 1997 were 1900 and 880 mg/L respectively and COD removal rates across Reactor 1 during these periods were 92% and 78% respectively.

- The median volatile acid concentration leaving both reactors is low, and is consistent with the performance of a healthy anaerobic system.

- The high pH of the feed, due to lime dosing into the trade waste sewer, was reduced to an operating pH of about 7.4 by the consumption of alkalinity within the process. Without lime dosing it is most probable that the process pH would have fallen to a level which would have caused process failure.

- It was encouraging that good COD removal was achieved in the reactor notwithstanding the low process temperature of less than 12°C. This low temperature was a result of the large surface area of an uninsulated pilot plant operating outdoors during mid-winter. A full-scale HRAL at Mooroopna would be subjected to peak loading rates during the summer months with wastewater temperatures likely to exceed 25°C – the thermal inertia of the large, covered lagoon would be likely to increase heat retention within the process.

- The median sulphate concentration in the reactor effluent was reduced by 54% from 225 to 100 mg/L. Concerns about sulphide toxicity in the process do not appear to justified, given the high rate of COD removal. This is possibly a result of the high pH in the reactor resulting in most of the sulphide being in the less toxic associated form (H_2S rather than HS^-).

- An attempt was made to collect gas from the process by attaching a large plastic bag to the gas vent pipe but no gas production was detected. However, when samples of pellets were drawn from the reactor into a sample bottle, gas generation could clearly be seen. The most reasonable explanation for this observation is that there was a leak, probably through the water seals at the top of each reactor column.

6.0 CONCLUSIONS

The use of HRAL technology at Mooroopna represents an augmentation of the existing lagoon system rather than a change to an entirely new treatment system. It may be constructed by deepening and partitioning one of the existing anaerobic lagoons at Mooroopna with the most costly component being the plastic cover which is used for odour control and gas collection. It is possible that had the sulphate concentration of the Mooroopna wastewater been lower and had the WWTP been more remote from habitation, then, insofar as odour is concerned, it may have been acceptable to design uncovered lagoons.

By reducing the anaerobic process volume from 950 to 70 ML, approximately 800 ML of existing anaerobic lagoons are released for use as irrigation effluent storage.

While a HRAL is not designed to remove nutrients to enable compliance with EPA requirements for discharge to inland waters, it is able to remove a large fraction of the influent COD with minimal input of energy and thus help to reduce the required size of any downstream biological process such as biological nutrient removal. If correctly designed a HRAL is not demanding on operator attention, the most complex mechanical equipment being associated with the gas collection and disposal. Careful attention has to be paid to ensure that sufficient alkalinity is provided to the process, the simplest indicator being the pH measured at the lagoon outlet which should be maintained at a value above 6.5.

High rate anaerobic lagoons are likely to find increasing application in rural Australia as a cost effective and environmentally acceptable method of treating industrial wastewaters.

7.0 ACKNOWLEDGMENTS

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