Adding Value to Wastes

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Abstract

Challenge Australian Dairy Pty Ltd produces about 1,265 tonnes of sludge and 114,000 litres of wastewater annually from its Capel processing plant, for which AU$350,000 is spent on waste treatment and disposal. These wastes are applied to land without recovering potential resource values. This paper discussed methods and technologies which allow recoveries of valuable resources; and water pinch technology, a type of mass integration involving water-using operations analysis of water-using operations is also presented. The freshwater pinch point is found to be 82.50 mg/L of total suspended solids at contaminant mass load of 130.98 kg/day. Additional analysis on microbial contaminant shows similar result for water reuse on non-food contact surfaces. Reusable wastewater is stored in enclosed vessel and disinfectant is added to prevent microbial growth. Analytic results of wastewater produced from existing treatment plant shows that the water quality is "Class B", according to the Australian Drinking Water Guidelines 2004 (NHRMC AND NRMMC, 2004). Tertiary and disinfection treatments are required for producing "Class A" quality water. Sludge are analysed to contain essential soil conditioner elements, which can be stabilized to produce marketable soil conditioners (Standards Australia International, 2003). Further work has to be carried out to design water-using networks and distributed effluent treatment systems for maximum wastewater reuse, minimum wastewater discharge and freshwater consumption.

1. Introduction

Challenge Australian Dairy Pty Ltd (CAD) is a joint venture of Challenge Dairy Co-Operative (a Western Australia farmer-owned entity based in the South West region of Western Australia) and QAF Limited (a publicly listed Singaporean food company). CAD is regarded as one of the leading major dairy companies in Western Australia.

The processing plant at Capel processes 45 million litres of milk each year, which results in production of 7 million litres of milk, 2500 tonnes of cheese and 1000 tonnes of whey powder (Challenge Australian Dairy Pty Ltd, 2008). Concurrently, 1265 tonnes of sludge and 174 000 kilolitres of wastewater are disposed and/or discharged annually (Challenge Australian Dairy Pty Ltd, 2008).

The total costs of treating and disposing effluent produced are $350,000 per annum. This consists of $90,000 spend on discharging treated wastewater to wastewater irrigation land;

$60,000 spend on disposing sludge to sludge disposal site; and $200,000 spend on maintenance and operating existing wastewater treatment plant (Challenge Australian Dairy Pty Ltd, 2008). In addition, CAD uses more than 60 000 kilolitres of schemed water and 150 000 kilolitres of bore water at its Capel processing plant annually, which adds up $220,000 per annum spent for its water supply (Challenge Australian Dairy Pty Ltd, 2008).

Aside from these financial concerns, effluent also has health and ecological effects on Capel's community and environment. The effluent is of high Biochemical Oxygen Demand (BOD), nutrient content and Total Organic Carbon (TOC). Discharge of improperly treated wastewater will result in a public health threat if it seeps into potable water source (Roy E. Carawan, 1979). High BOD, organic loadings and grease in wastewater will affect growth of flora and fauna (Roy E. Carawan, 1979). Decomposition of sludge also releases unpleasant odour emissions (United Nation Environment Programme, 2005). In addition, the CAD process plant at Capel is located in a small community without abundant potable water sources, thus it potentially presents a major draw on the local fresh water resources (Department of Environment, 2004).

1.1 Current State of the Art

The current understanding of the issues of produced effluent is that there are resources in wastes that are recoverable through reuse and recycling (Dairy Industries Sustainability Consortium, 2004). Instead of spending a large amount of money annually for treatment and ultimate disposal of wastes, both solid and fluid wastes can be treated to become value enhanced (Dairy Industries Sustainability Consortium, 2004). This may be possible with knowledge of proven technologies and methods gathered from established applications.

As proven in other dairy industries worldwide, the large amount of wastewater produced may be recycled for cleaning and manufacturing purposes. Tatura Milk Industries Ltd in Victoria, Australia is able to recycle and reuse approximately 51.77ML of potable water within the Tatura Milk Industry dairy processing plant. With the introduction of a water saving initiative funded by Smart Water Fund, this water is used for cooling purposes during manufacturing processes instead of being discharged into the town sewage system (Smart Water Fund, 2007). Sludge is a potential feedstock for manufacturing soil conditioners as the effluent is rich in nitrogen, phosphate and potassium (Standards Australia International, 2003)

2. Process

Water pinch technology is applied to Challenge Australian Dairy Pty Ltd processing plant at Capel for maximizing wastewater reuse and minimizing wastewater discharge. This technology consists of a mass exchange integration which involves the transferring of contaminant mass to freshwater streams from water-using operations (Mann and Liu, 1999). The technology consists of water pinch analysis, water pinch synthesis and water pinch retrofit (Wang and Smith, 1994). With respect to reusing, regenerating and recycling wastewater, water pinch analysis identifies appropriate targets for minimum freshwater consumption and minimum wastewater generation in water-using operations; water pinch synthesis designs water-using network that achieves these targets through water reuse, regeneration, and recycle; and water pinch retrofit modifies existing water-using network to maximize water reuse (Mann and Liu, 1999; Wang and Smith, 1994).

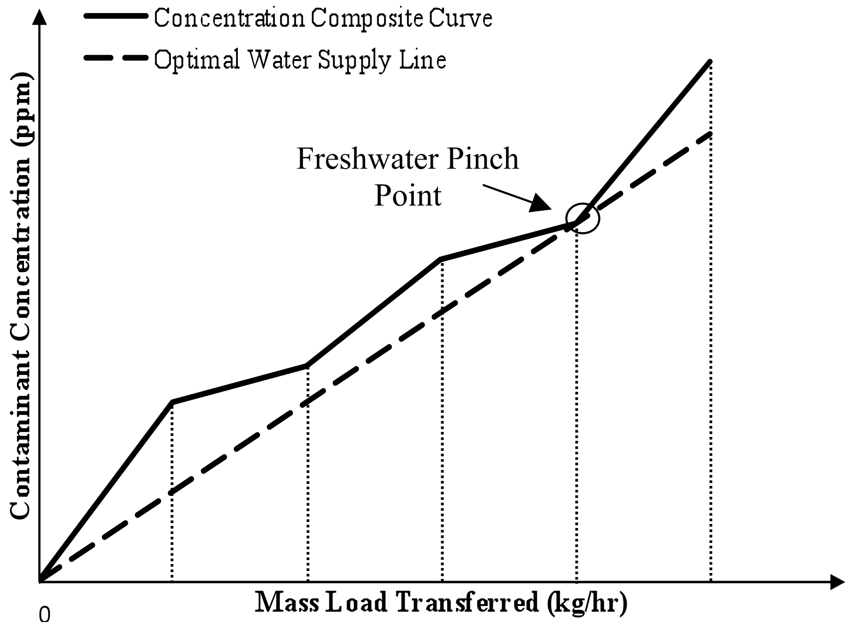

Figure 1 Concentration composite curve and optimal water supply line (Mann and Liu, 1999)

The fundamental step in developing an optimum water reuse system for a given manufacturing process is to analyse the system without any water reuse and determine the minimum freshwater flow rate required to provide each water-using operation with freshwater (Mann and Liu, 1999; Wang and Smith, 1994). By representing each individual water-using operation on a single diagram (concentration composite curve) with a freshwater supply line shown in Figure 1, the freshwater pinch point can be obtained. This point indicates that operations with contaminant levels above the freshwater pinch point concentration do not require freshwater (Mann and Liu, 1999).These operations are able to operate normally using water of lower contaminant concentrations such as reused or recycled wastewater streams from other water-using operations. The data obtained will assist in the design of water-using networks and distributed effluent treatment systems to maximise wastewater reuse as well as minimize wastewater discharge and freshwater consumption.

3. Results and Discussion

According to *Australian Drinking Water Guidelines 2004* (ADWG), results from laboratory analysis of wastewater discharge from existing wastewater treatment plant shows that the wastewater belongs to category “Class B” quality as illustrated in Table 1.

Analysis	Wastewater Sample	ADWG “Class A”	ADWG “Class B”	ADWG “Class C”
E. Coli (CFU/100ml)	85	< 10	< 100	< 1000
Helminth (per L)	< 1	< 1	-	-
Turbidity (NTU)	16	< 2	-	-
pH	6.9	6 - 9	6 - 9	6 - 9

Table 1 Results comparison between wastewater obtained from existing wastewater treatment plant and ADWG. (NHRMC and NRMMC, 2004)

The proposed use of recycled water includes general purpose cleaning such as tanker bay washing and washing of floor. ADWG states that recycled water which is to be used in open systems where there are risks of human exposure has to be of “Class A” quality. This requires tertiary and disinfection treatments which are capable of reducing the E. Coli concentration to be the required value of <10 per 100 mil, as specified by ADWG.

SGS Environmental Services Pty Ltd and PathWest Laboratory Medicine WA are NATA credited laboratories which carried out the testing on waste samples from different waste streams. The analytic results of total suspended solids (TSS) and microbial (E. Coli) concentration are shown in Table 2, and result of sludge analysis is shown in Table 3.

	Pasteuriser	Truck Bay	Housekeeping	Maintenance	Lacto-tank
TSS_{lim} (mg/L)	111.10	11000.00	385.00	276.10	137.50
(CFU_{lim}/100ml)	33000	1100	2090	979	27500
	Cheese Vat	Cheese Tower	Geograph Cheese Vat	Milk Silo	Milk Separator
TSS_{lim} (mg/L)	132.00	159.50	135.30	58.30	715.00
(CFU_{lim}/100ml)	1958	990	2310	55	77
	Whey Separator	Whey Thermalizer	Whey Concentrator	UO Silo	UO Membrane
TSS_{lim} (mg/L)	121.00	82.50	77.00	99.00	55.00
(CFU_{lim}/100ml)	8360	7260	1320	88	5.5
	Yogurt Silo	Fruiting Tank	Boiler	Cooling Tower	Laboratory
TSS_{lim} (mg/L)	363.00	154.00	319.00	283.80	68.20
(CFU_{lim}/100ml)	14850	11000	110	440	660

Table 2 Analytic Results of wastewater from SGS Environmental Services Pty Ltd and PathWest Laboratory Medicine WA (Pathwest, 2009; (SGS Environmental Services, 2009)

The results of water pinch analysis on total suspended solids and microbial (E. coli) contaminant of individual waste stream is illustrated in Figure 2 and 3 respectively. TSS is used as the primary parameter for water pinch analysis as it can directly affect the operation of equipment and processes. Generally, results from water pinch analysis based on TSS and E. Coli shows that wastewater produced from milk silo, UO membrane, whey concentrator and laboratory can be reused in other water-using operations listed in Table 2. However, for dairy processing, water that is reused on food contact surfaces has to be of portable standard (Food Standards Australia New Zealand, 2005). CAD is only able to reuse wastewater in water-using operations that are not in contact with food or food contact surfaces.

Analysis	pH	NH_3-N (mg/kg)	Moisture Content (%)	Phosphorus (%)	Calcium (%)	Sodium (%)	Potassium (%)
Sludge	7.2	920	78.00	4.78	10.00	0.24	0.20
AS 4454-2003	5 - 8	<75	>25	<0.1 dry mass	-	<1 dry mass	-

Table 3 Results comparison between analysis of sludge from CAD and Australian Standards (AS) 4454-2003 (SGS Environmental Services, 2009; Standards Australia International, 2003)

Sludge is found to contain several essential components of soil conditioners such as phosphorus, sodium and potassium. Through stabilization, the moisture content, NH_3-N and organic content of sludge will be lowered to the acceptable levels stated by AS 4454-2003.

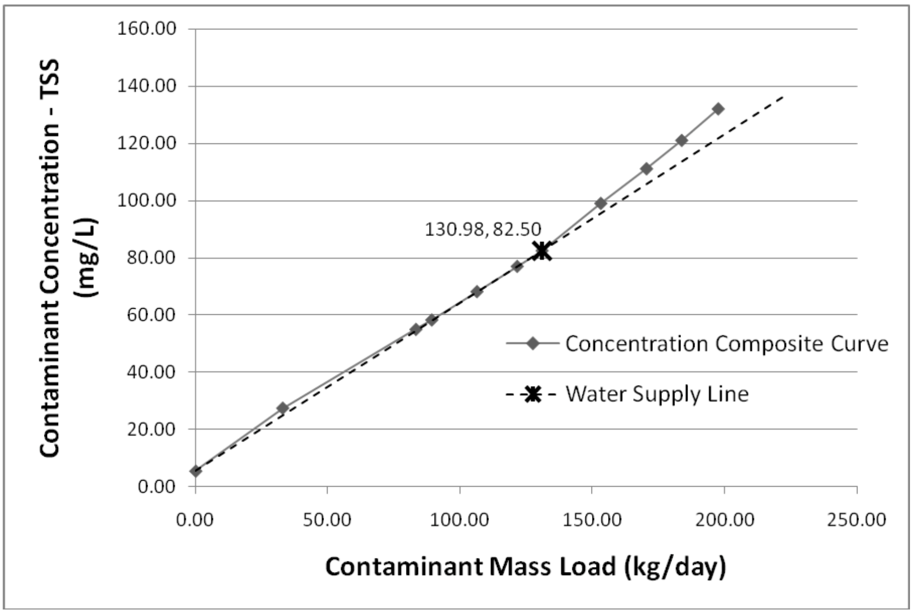

Figure 2 Water pinch analysis on TSS of waste streams

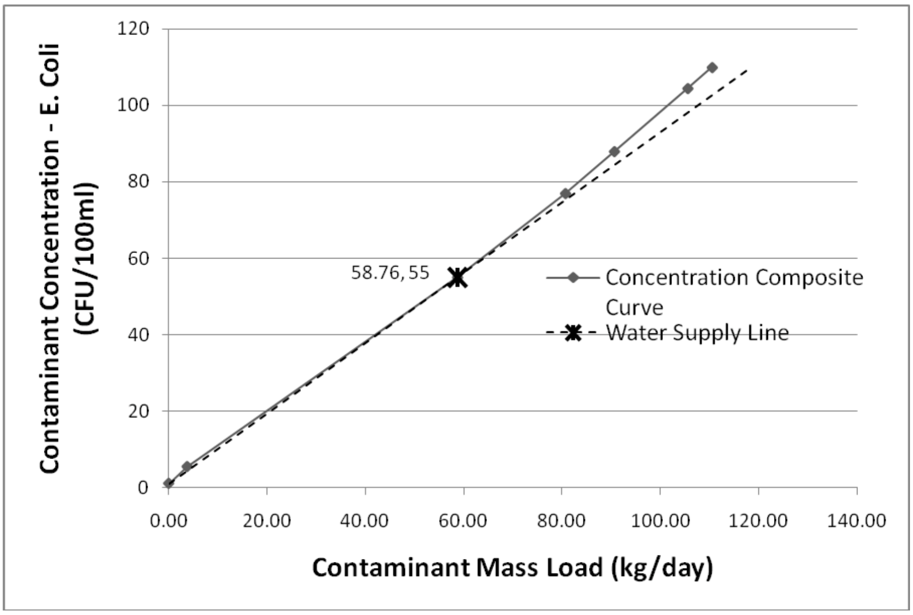

Figure 3 Water pinch analysis on E. Coli of waste streams

4. Conclusions and Future Work

The freshwater pinch point based on TSS is found to be 82.50 mg/L of TSS at contaminant mass load of 130.98 kg/day. Results of water pinch analysis based on TSS, E. Coli and Food Standards Australia New Zealand show that wastewater can be reused for maintenance, housekeeping and floor cleaning, truck bay washing and cooling tower make up water (Food Standards Australia New Zealand, 2005). Enclosed vessels are required to store the collected wastewater, and disinfectant added to prevent microbial growth. According to ADWG, tertiary and disinfection treatments are required to reduce the E. Coli concentration to <10 CFU/100 mil for "Class A" quality to be used in open systems with potential of exposure to workers. Sludge are analysed to contain essential soil conditioner elements, which can be stabilized to produce marketable soil conditioners (Standards Australia International, 2003).

Further work has to be carried out to design water-using networks and distributed effluent treatment systems for maximum wastewater reuse, minimum wastewater discharge and freshwater consumption. In addition, demonstrating the use of non-potable water will not adversely affect the safety of food will greatly improve the efficiency of the water reuse within CAD processing plant.

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