Activated Sludge Treatment Options for Treatment of Meatworks Wastewater
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Introduction

As part of the design of a major new slaughterhouse for pig, beef and goats to be built in the New Territories area of Sheung Shui, Hong Kong by 1999, wastewater treatment facilities were required on-site to meet discharge criteria set down by the Drainage Services Department, Hong Kong Government. A major site constraint for the wastewater treatment plant was that it be located underground because of inadequate above ground area.

An Environmental Impact Assessment (EIA) evaluated various wastewater treatment plant options such as anaerobic treatment, extended aeration lagoons, physico-chemical treatment and activated sludge and concluded that activated sludge was the only acceptable choice given the various site constraints, environmental constraints and discharge requirements.

The design of the wastewater treatment plant was undertaken by Kingston Morrison Limited, with the specialist biological treatment design subcontracted to Black & Veatch.

The wastewater sources and characteristics are summarised in Table 1.

Table 1 :Summary of Wastewater Sources

Components	Q m^3/d	SS kg/d	BOD kg/d	COD kg/d	TKN kg/d	NH_3 kg/d	TTM kg/d	E coli no/d
Process Water	4500	5400	13500	20250	1575	-	-	-
Lairage	263	3150	1348	3500	403	210	-	16E17
Holding Bay	18	-	-	-	-	-	-	-
Total	**4781**	**8550**	**14848**	**23750**	**1978**	**210**	-	**1.6E17**

Table 2 : Treated Water Specification

BOD_5	≤	250mg/L
Total Suspended Solids	≤	250mg/L
Total Nitrogen	≤	50mg/L
Oil and grease	≤	50mg/L
Total phosphorus	≤	25mg/L
pH	=	6.5 to 8.5
Temperature	≤	30°C

It was proposed that $200m^3/d$ grey water (the treated discharge water) be used to convey solids to the wastewater treatment plant. Total wastewater flow for treatment was set at $5,000m^3/d$.

Treatment Plant Discharges

The treated wastewater specification set down by the Drainage Services Department is given in Table 2, with the added proviso that the maximum flow not to exceed $250m^3/h$.

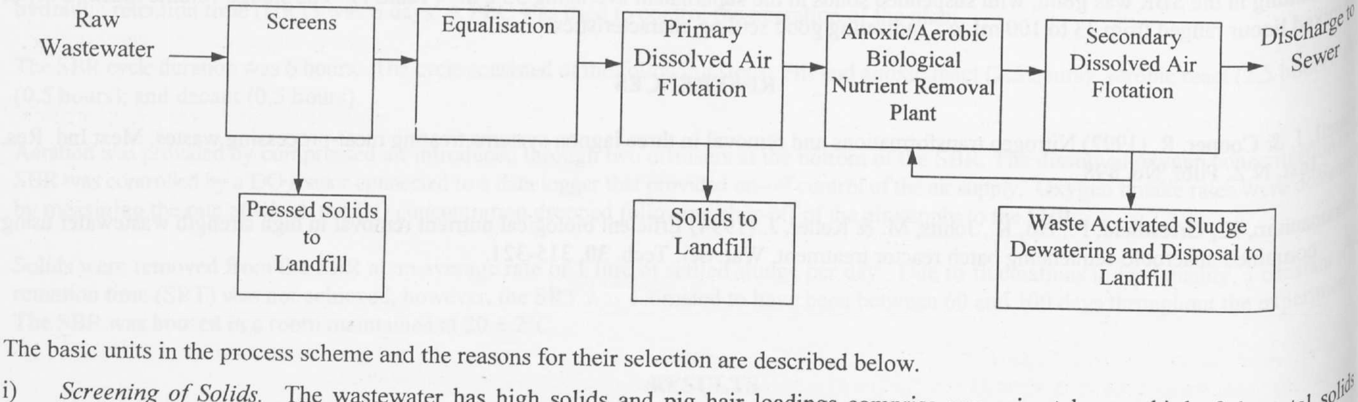
Basic Treatment Plant Design Concept

The process selected for the wastewater treatment plant was designed on the basis of the above discharge criteria and the following assumptions:

- The slaughterhouse would segregate blood from the wastewater system, wherever possible.
- Solids produced at the inlet screens, the dissolved air flotation plant, and the waste activated sludge dewatering plant, to be dewatered to 30% dry solids content, before disposal to landfill.
- The wastewater flow is essentially between the hours of 2.00a.m. and 9.00a.m., seven days per week, 364 days per year. This flow pattern requires flow equalisation ahead of the biological treatment plant.
- Fat and grease removal takes place ahead of the biological treatment plant.

The simplified process schematic which is used to explain the treatment plant, is shown in Figure 1. For simplicity, the recycled streams in the biological treatment system and the solids processing streams are not shown.

Figure 1 : Process Flow Schematic



The basic units in the process scheme and the reasons for their selection are described below.

i) *Screening of Solids.* The wastewater has high solids and pig hair loadings comprise approximately one-third of the total solids loading from the primary screening. A number of conventional screening devices were evaluated and a 0.5mm wedge wire rotary screen was selected on the basis of previous experience in meatworks processing wastewaters.

ii) *Flow and Load Balancing*. An equalisation tank with adequate mixing and aeration of contents was sized to the following criteria:

- the influent flow pattern is variable with high loads associated with slaughtering occurring for periods of seven hours each day;
- a minimum volume of 30% total equalisation tank volume is required in order to provide adequate blending capacity;
- the effluent flow to the biological treatment plant to be maintained constant and continuous over a 24 hour period.

iii) *Fat and Grease Removal*. Fat and grease removal is by dissolved air flotation (DAF) in preference to other alternatives such as grease traps and sedimentation tank and dispersed air flotation.

iv) *Biological Treatment*. The treatment processes deemed to be technically feasible for this project are as follows:

- Option 1: Sequencing batch reactor activated sludge (SBR)
- Option 2: Conventional clarifier continuous activated sludge (CCAS)
- Option 3: Flotation clarifier continuous activated sludge (FCAS).

A comparison of these three options as applied to this project is shown in Table 3.

Table 3 : Viable Biological Treatment Options

Parameter	SBR	CCAS	FCAS
Buffer Tank Volume, m^3	1,250	Not required	Not required
Total Aeration Volume, m^3	23,000	15,200	15,200
Clarifier Surface Area m^2	Not required	540	50
Internal Recycle for Denitrification, m^3/hr	Not required	2,600	2,600
Air Flow, m^3/hr	22,288	11,987	11,987
Blower Power, bkW	580	250	250
Jet Recirculation Pumps, bkW	265	176	176
Lime (CaO) for Nitrification, kg/d	1,650	1,650	1,650
Lime (CaO) for Sludge Dewatering, kg/d	1,000	1,000	1,000
Ferric ($FeCl_3$) for Dewatering, kg/d	1,000	1,000	1,000
Methanol for Denitrification, kg/d	1,240	0	0
Wet Sludge to Landfill, kg/d	44,400	44,400	44,400
Operating Simplicity	Multiple cycles make operation complex; poor	Good	Fair
Reliability	Not demonstrated	Fair	DAF solids capture is questionable to achieve <150mg/L
Commercial Availability	Easily available	Easily available	Limited

The FCAS option occupies significantly less space than either the SBR or the CCAS options. It is particularly beneficial for the maintenance of high suspended growth loadings in the biological treatment basins. It has an added benefit in requiring a smaller sludge handling system because the waste sludge from the flotation clarifier has a higher solids content. Generally, flotation processes are more flexible than conventional clarifiers for removing solids as changes in sludge density and form do not affect the removal and thickening process as significantly.

Operating costs of an SBR plant are significantly greater then the FCAS plant. Reference to Table 3 shows the blower power requirement is more than doubled for a SBR plant. The need to provide over one tonne per day of methanol as a carbon feed source for the denitrification stage of the SBR process also adds to operating costs of this option.

On this basis, Option 3 the flotation clarifier continuous activated sludge (FCAS) was selected.

v) *Sludge Management Dewatering and Disposal*. Dewatering of waste activated sludge requires the addition of chemicals such as lime and ferric chloride to achieve a 30% solids content of the dewatered cake and a membrane plate filter press was selected for this duty. The selection of a membrane plate filter press for pressing the waste activated.

Process Control Philosophy

Denitrification (Anoxic) Basins. The primary process control parameters for the anoxic basins are the mixed liquor oxidation-reduction potential (ORP), DO and pH.

Nitrification (Aerobic) Basins. The key parameters to be monitored and controlled are the mixed liquor suspended solids (MLSS), pH, DO, SRT and food-to-microorganisms (F/M) ratio, specific oxygen uptake rate (SOUR) and temperature.

Avoidance of Upsets to Biological Treatment Plant. Some of the major upsets to the process that could effect the biological treatment plant are:

- Blood Spillage. The principal cause of concern is excessive loading by spillage of even small volumes of blood, being highly concentrated slugs of organic load. The continuos TOC monitor at the inlet equalisation tank provides warning of this and permits time to manage the system to reduce the impact on downstream processes.
- Failure of Primary DAF Unit. The design allows for duplication of the primary DAF units, so that maintenance of treatment can occur even with one unit out of operation.
- Failure of Secondary DAF Unit. The secondary DAF unit is critical in the control of the discharge criteria and the process allows for stand-by chemical dosing of ferric chloride, lime and polyelectrolyte to meet this contingent situation.

Sludge Bulking and Filamentous Growth
This condition can largely be controlled by avoiding low dissolved oxygen levels in the basins and altering the recycle rates and maintaining a balanced flow. The plug flow design of the basins minimises the growth of filamentous bacteria.