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CASE STUDY: FROM FREDERICTON TO FRAY BENTOS

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1. Introduction

Alimentos Fray Bentos is a new plant by La Sibila in Fray Bentos, Uruguay that produces value-added dairy products, primarily demineralized whey. Wastewater from this plant must be treated to stringent standards prior to being discharged to the Uruguay River. ADI Systems was selected to provide process and detailed design engineering, to supply key components of the wastewater treatment system, and to oversee the start-up. GTI provided the cover and liner and over-saw the installation of internal piping and membrane units.

The treatment system consists of two main stages: anaerobic digestion to remove the majority of the organic load with minimal energy requirements, followed by a polishing stage to meet tight discharge limits (including for nutrients). The ADI-BVF® low-rate anaerobic reactor has more than 30 installations treating wastewater from dairy processing industries so it was a well-proven choice for the first stage. For the second stage, a membrane bioreactor (MBR) was selected based on the tight limits that had to be met.

2. Design of the System

Table 1 presents the design wastewater characteristics for this treatment system. It has a hydraulic capacity of 1 025 m^3/d, with provision for expansion to 1 600 m^3/d. The design organic loading is 4 300 kg/d as COD (3 050 kg/d as BOD). The anaerobic stage is intended to achieve 85% COD removal, with the aerobic stage providing polishing for the remainder of the organic load and ensuring low TSS in the effluent due to the physical barrier of the submerged membranes. The aerobic stage also needs to remove nutrients to low levels: 10 mg/l for nitrogen and 0.1 mg/l for phosphorus in the effluent.

Table 1. Design characteristics of raw wastewater, anaerobic effluent, and MBR effluent

Parameter	Influent	Anaerobic Effluent	MBR Effluent
Flow (m^3/d)	1 025	---	---
Total COD (mg/l)	4 200	630	< 75
BOD (mg/l)	2 975	300	< 10
TSS (mg/l)	200	200	< 2
TKN (mg/l)	75	65	---
NO_3-N (mg/l)	---	---	< 10
TP (mg/l)	29	25	0.1
Calcium (mg/l)	< 100	---	---
Temperature (°C)	25 – 35	25 – 35	---

The ADI-BVF® reactor was constructed as a lined earthen basin with a concrete perimeter wall and a floating geomembrane cover. The anaerobic digestion process continuously produces biogas which is collected beneath the reactor cover and extracted under a slight vacuum by biogas blowers. The biogas is delivered to a flare for combustion, although the biogas system was designed to allow for the possible utilization of the biogas in the future.

The MBR system is divided among an anaerobic basin, two anoxic basins, an aeration basin, and a membrane basin. These were constructed as common-wall concrete tanks. In the aeration tank, air is supplied by a jet system to provide oxygen for nitrification and BOD removal. The anoxic tanks promote denitrification to reduce the nitrogen concentration to the required limits. Cycling the mixed liquor between anaerobic and aerobic conditions promotes the growth of phosphorus accumulating organisms (PAOs). The membrane tank contains submerged membrane units, which provide liquid-solids separation. Having low effluent suspended solids is essential for meeting stringent nutrient limits. The physical barrier for solids also improves control over the solids residence time (SRT).

Biological nutrient removal (BNR) depends on having a sufficient carbon source to drive denitrification and luxury phosphorus uptake. Biological removal of phosphorus is augmented with chemical addition in this system, so keeping the percentage of inert solids in the mixed liquor under control was also a concern in the design. If all the influent wastewater was treated anaerobically, then the amount of BOD (relative to TKN and TP) entering the aerobic MBR system would be too low. By sending a suitable flow to bypass around the ADI-BVF® reactor the provision of sufficient BOD was enabled.

3. Project Delivery and Results

ADI was responsible for the engineering design (process design and detailed design of the tank internals and biogas system took place in our Canadian office while the remainder of the detailed design was done by our Brazil office) and technical services for start-up of the system. GTI designed, fabricated, and installed a patented gas collection cover; GTI also installed the liner and internal piping/equipment for the system. Civil works and non-proprietary equipment such as pumps were provided by others.

Start-up of this anaerobic-aerobic wastewater treatment system began in May 2017. The average influent COD concentration has been close to the design value, although the variability is high. After reaching steady-state performance, the effluent COD from the BVF® reactor has been less than 500 mg/l and the biogas production has typically been 1 200 – 2 000 Nm^3/d.

The pair of technologies used to treat the process wastewater from Alimentos Fray Bentos make an effective combination. The low-rate anaerobic BVF® reactor removes the bulk of the organic load, significantly decreasing the energy requirements in the downstream aerobic polishing stage. The aerobic MBR system is able to remove organic matter, suspended solids, and nutrients to low concentrations. Bypassing a portion of the raw wastewater around the anaerobic stage targets a balance between organic load (i.e. BOD) and nutrients (i.e. nitrogen and phosphorus) that is conducive to efficient nutrient removal in the aerobic stage.

The significance of this case study of industrial wastewater treatment is in its innovative combination of technologies, which is able to produce a high-quality effluent for direct discharge while also being energy efficient.