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Anaerobic/aerobic pretreatment of potato chip wastewaters in PEI

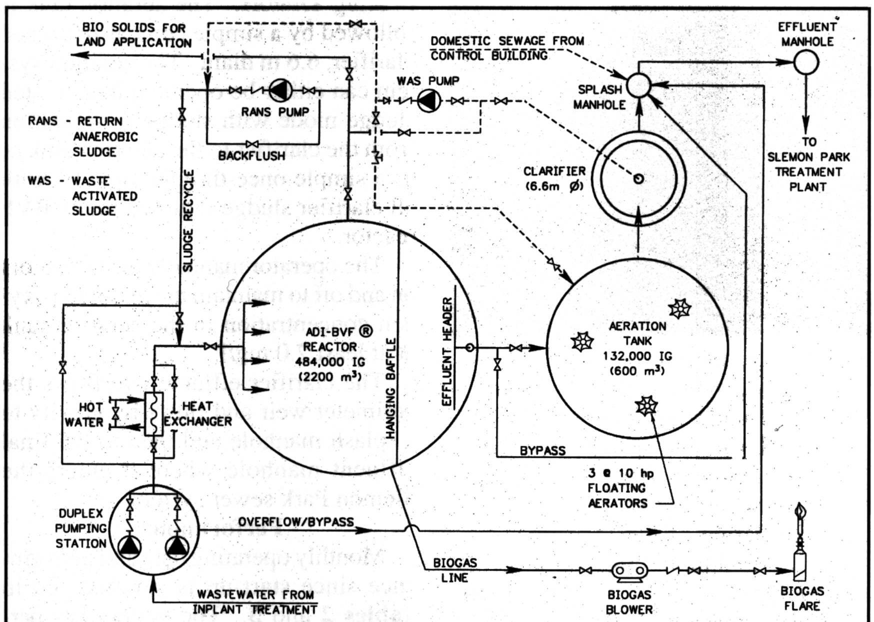

FIGURE 1 - SMALL FRY BIOLOGICAL PRETREATMENT PLANT PROCESS FLOW DIAGRAM

Small Fry Snack Foods Inc. began production at its newly relocated and expanded plant in Slemon Park, Summerside, Prince Edward Island, in the spring of 1996. The new plant, which produces potato chips and other snack foods, utilizes an anaerobic/aerobic waste treatment system to pretreat its wastewater before discharging to the Slemon Park sewage treatment plant. ADI Systems Inc. was chosen for this design-build bid call that included a performance guarantee along with a tight schedule.

Several waste treatment alternatives were considered during the preliminary planning stages for the new plant. It was concluded that a combination of in-plant screening and settling followed by anaerobic pretreatment and a simple aerobic system would be the most cost-effective means of meeting the discharge limits. The anaerobic treatment technology used was the patented ADI-BVF® digester, which is a low-rate upflow sludge blanket process. (US Patent Nos. 4,672,691and 5,505,848; Canada Patent No. 1,253,266)

With the BVF® reactor as the workhorse of the treatment train, the chosen system also offered the key advantages of simple operation and minimal sludge production. Because this digester is a "low-rate" anaerobic system, it has the inherent ability to digest high concentrations of suspended solids (SS); fat, oil, and grease (FOG); and recycled biosolids produced in the aerobic polishing step, with minimal sludge and/or scum accumulation – an important factor given the characteristics of Small Fry's wastewater. Furthermore, the reactor at Small Fry has sufficient sludge storage capacity to hold sludge for several months at a time, allowing the stabilized sludge to be disposed of by direct land application during the most appropriate times of the year (spring and fall).

System Design Criteria

The design wastewater characteristics through each stage of the treatment process are summarized in **Table 1**.

The pretreatment effluent limits for the plant are:

BOD ≤ 300 mg/l
SS ≤ 300 mg/l
FOG ≤ 10 mg/l

The biological waste treatment system is shown in the process diagram of **Figure 1** and in the photograph.

In-Plant Treatment

The waste streams flow by gravity through the plant to a chopper pump sump. A manual bar screen at the entrance to the sump removes coarse solids. The chopper pumps reduce solids to a dimension less than 2.5 cm and deliver them to a static screen. The screenings fall from the static screen to a tote box below. The screening tote box is fitted with decant valves to allow any supernatant which has formed to be decanted. Once the screening tote is full, it is hauled to a local farmer who uses the screenings for animal feed.

The wastewater that passes through the screen is directed to a different tote box where starch and mud settle out. The effluent end of this tote box has a weir for uniform removal of the effluent and a removable section of flexible hose that conveys the screened and settled wastewater to a floor flume which discharges into the main sump in-plant.

Anaerobic System

The anaerobic BVF reactor is the heart of the treatment system. It serves to remove the majority of both the dissolved organics and suspended solids from the wastewater. It also digests the biosolids produced in the aerobic step of the treatment train. The majority of the organic matter which is removed (over 90 percent) gets converted to

Table 1 - Design Wastewater Characteristics Through Each Stage of the Treatment Process

Parameter	RWW Before In-Plant Treatment	Anaerobic Influent	Anaerobic Effluent	Aerobic Effluent*
Flow (m³/d)	306	306	306	306
COD (mg/l)	6,500	6,500	975	---
BOD (mg/l)	4,000	4,000	400	< 150
SS (mg/l)	10,700	2,150	300	< 150
TKN (mg/l)	100	100	100	≤ 80
FOG (mg/l)	150	150	10	< 10
*7-d average				

*ADI Systems Inc.

biogas (methane and carbon dioxide), which is flared.

The insulated reactor consists of a 2200 m^3 thermally-cured, epoxy-coated, bolted-steel tank which is 19.9 m diameter by 7.3 m tall.

The reactor is covered by a floating, insulated, flexible geomembrane cover which is designed to maintain reactor temperature, collect biogas, and prevent the escape of odours. The flexible cover allows for some variation in reactor operating level.

The influent pumps direct wastewater to an influent distribution system along the reactor floor. A return anaerobic sludge (RANS) pump transfers settled sludge from the effluent side of the reactor to the influent distribution system. Typically, the recycle pump is interlocked to run with the influent pump(s). Recycling the sludge maintains sufficient biomass on the influent side of the reactor, improves sludge/wastewater contact, maintains sludge mobility, and buffers the influent sludge bed against raw wastewater variations in pH, COD concentration, temperature, alkalinity, etc.

A shell-and-tube heat exchanger on the influent piping to the BVF reactor heats the wastewater to maintain a minimum design temperature of 20°C.

Biogas produced in the reactor is drawn off under vacuum by the PLC-controlled, variable-speed, positive-displacement blower. The biogas blower compresses the biogas for delivery to the flare for flaring. Blower speed is controlled according to pressure under the reactor cover.

The average daily biogas production at design COD load is estimated at 900 m^3/d at a methane concentration of 70 percent.

The estimated annual waste sludge production at design conditions is 27 000 kg, which represents 930 m^3 at 3 percent solids for land application in spring and fall.

Aerobic System

The aerobic system consists of a 600 m^3 bolted steel tank (2.0 d HRT) equipped with three 10 hp high-speed floating aerators. The aeration tank is followed by a simple conical-bottomed clarifier, 6.6 m diam. The aeration system can either be operated in activated sludge mode with sludge recirculation from the clarifier to the aeration tank or as a simple once-through process with all clarifier sludge returned to the BVF reactor.

The operator manually turns aerators on and off to maintain the dissolved oxygen concentration in the aeration tank at at least 2.0 mg/l.

The clarifier effluent overflows the perimeter weir and flows by gravity to a splash manhole and then to the final effluent manhole where it enters the Slemon Park sewer system.

Performance

Monthly operating data and performance since start-up is summarized in **Tables 2** and **3**. The system has performed quite well from initial start-up and has consistently met all effluent limits.

No significant problems have been encountered with system operation to date.

Conclusions

The performance of the ADI anaerobic/aerobic system has consistently met or exceeded expectations so far. The system has proven to be very simple to operate and requires minimal operator intervention.

One of the system's most attractive features is its ability to treat this raw wastewater, which has high concentrations of SS and FOG, and to digest these substances along with the waste aerobic sludge, while producing a minimal amount of sludge and/or scum. This feature precluded the need for any equalization and primary treatment and sludge dewatering and handling equipment.

Table 2 - Small Fry Waste Treatment System - Monthly Data Summary

Month	Flow (m^3/d)	COD (mg/l) Anaerobic Influent	COD (mg/l) Anaerobic Effluent	COD (mg/l) Aerobic Effluent	SS (mg/l) Anaerobic Influent	SS (mg/l) Anaerobic Effluent	SS (mg/l) Aerobic Effluent
March '96	85	1250	160	98	740	120	40
April '96	163	2920	380	142	1650	240	60
May '96	193	4020	650	236	2100	460	86
June '96	156	4080	560	219	2020	350	148
July '96	170	3930	530	161	1670	400	105
August '96	155	3810	690	69	1770	610	48
mid-Sept '96	142	4340	560	71	2460	410	42

Table 3 - Small Fry Waste Treatment System - Monthly Performance Summary

Month	Anaerobic COD Removal (%)	Overall COD Removal (%)	Anaerobic SS Removal (%)	Overall SS Removal (%)	Aerobic Effluent FOG (mg/l)	Aerobic Effluent BOD (mg/l)
March '96	87.2	92.2	83.8	94.6	--	--
April '96	87.0	95.1	85.5	96.4	0.0	76
May '96	83.8	94.1	78.1	95.9	0.4	110
June '96	86.3	94.6	82.7	92.7	0.4	70
July '96	86.5	95.9	76.0	93.7	0.0	52
August '96	81.9	98.2	65.5	97.3	0.0	38
mid-Sept. '96	87.1	98.4	83.3	98.3	--	--