Treatment of Wastewater from a Whey Processing Plant Using Activated Sludge and Anaerobic Processes

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ABSTRACT

Wastewater from a whey processing plant was treated in two on-site pilot plants, a three-stage activated sludge plant and an anaerobic reactor, each of which had the capacity of treating 230 L/h of wastewater. The activated sludge treatment was very effective. It reduced 99% of 5-d biochemical oxygen demand of the plant wastewater (from an average of 1062 to 9 mg/L) and 91% of total Kjeldahl nitrogen (from 109 to 10 mg/L) after a total retention time of 19.8 h. The intermediate 5-d biochemical oxygen demand reductions were 86% after 3.8 h in the first stage and 97% after another 8 h in the second stage. The completely mixed anaerobic reactor reduced only 87% of 5-d biochemical oxygen demand after 2 d of retention. However, with an additional 8 h of activated sludge treatment the total 5-d biochemical oxygen demand was reduced by 99%. Both pilot plants were operated smoothly in spite of the considerable fluctuations in pollutant levels of the plant wastewater.
(Key words: activated sludge, anaerobic treatment, whey wastewater)

Abbreviation key: BOD_5 = 5-d biochemical oxygen demand, COD = chemical oxygen demand, HRT = hydraulic retention time, MLVSS = mixed liquor volatile suspended solids, TOC = total organic carbon, TSS = total suspended solids, VSS = volatile suspended solids.

INTRODUCTION

Whey is the liquid waste generated from the process of cheese making. It constitutes 80 to 90% of the total volume of the milk entering the process and contains more than half of the solids of the original milk, including 20% of the protein and most of the lactose (6). Because of its high levels of protein and lactose, discharging whey directly into the waterway could cause a severe pollution problem. Dairy farmers have commonly given whey to other farmers as animal feed or as fertilizer free of charge. However, the potential pollution problem still exists should other farmers decide not to haul away the whey. More recently, some dairy farmers have used sophisticated technology to process whey, producing dry protein powder and crystallized lactose. By so doing, they not only alleviate a potential pollution problem but also produce two marketable products.

This article discusses a pilot-scale study for the treatment of wastewater from processing plant that generated an average of 910 m^3 of wastewater daily. The primary aim was to develop a simple biological process to reduce the 5-d biochemical oxygen demand (BOD_5) of the wastewater from about 1000 to 250 mg/L or lower, so that the effluent could be discharged to the municipal sewage. The secondary aim was to determine the feasibility of further reducing the BOD_5 to less than 20 mg/L should that become a discharge limit in the future.

Aerobic treatment, such as activated sludge process, has been commonly used for wastewater from food industry (3, 7). However, only in recent years has anaerobic treatment emerged as a viable means for wastewaters containing high levels of organics (2); some have applied it to the treatment of dairy wastewater with certain degrees of success (4, 5, 8). In this study, both activated sludge and anaerobic processes were tested for the treatment of wastewater from the whey processing plant.

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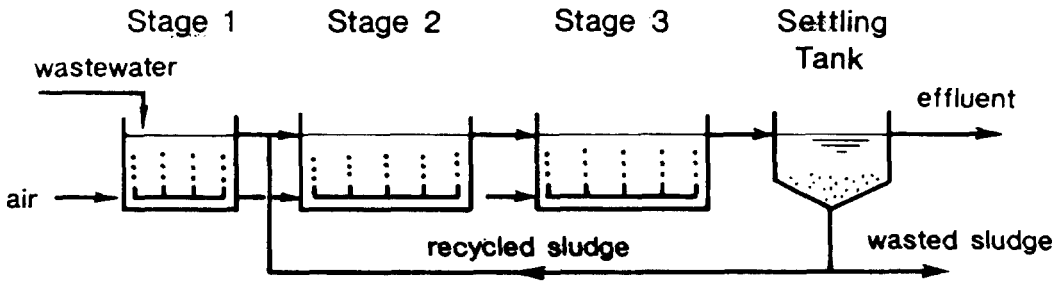

Figure 1. Three-stage activated sludge process.

MATERIALS AND METHODS

Pilot Plants

An aerobic and an anaerobic pilot plants were constructed for this study. Each pilot plant continuously treated 230 L/h of the whey processing plant wastewater that had been held in an equalization tank for 6 h to dampen any fluctuations. The 4.5-m^3 aerobic pilot plant was composed of three stages of activated sludge treatment, as shown in Figure 1. The plant wastewater was treated sequentially for 3.8 h in Stage 1 and 8.0 h each in Stages 2 and 3. Effluent from Stage 3 overflowed to a .75 m^3 circular settling tank. Part of the settled sludge was recycled to Stage 2 in order to maintain a mixed liquor volatile suspended solids (MLVSS) at 2500 mg/L level; the remaining settled sludge was discharged. Fine bubble diffusers were used for the aeration. The dissolved oxygen level in each stage was kept at about 1.5 mg/L.

The anaerobic reactor was a 11.4-m^3 vessel equipped with an agitator for complete mixing, as shown in Figure 2. The plant wastewater had a hydraulic retention time (HRT) of 48 h in the reactor. After the treatment, the effluent was settled in a settling tank; the settled sludge was then recycled to the reactor to build up the sludge level.

Both pilot plants were initially seeded with sludges obtained from a local municipal sewage treatment plant. The aerated sludge was used to seed the three activated sludge vessels, whereas sludge from an anaerobic digester was used to seed the anaerobic reactor. After seeding, both pilot plants were immediately fed with plant wastewater from the equalization

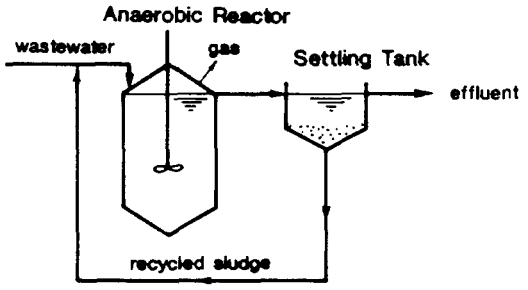

Figure 2. Anaerobic treatment.

tank at the designed rate of 230 L/h. The activated sludge was rapidly acclimated, reaching over 90% BOD_5 reduction in 1 wk. Full-scale sample collections and analyses were conducted for 12 wk, starting 2 wk after seeding. The anaerobic sludge took about 6 wk to acclimate; effluent samples were collected and analyzed for 10 wk. In the last 4 wk of the anaerobic treatment, the effluent from the reactor was diverted to the Stage 2 of the activated sludge for further aerobic treatment, as shown in Figure 3. During this period, the effluent from Stage 1 of the activated sludge process was diverted to a separate settling tank, and the operation of Stage 3 was discontinued.

Sampling and Analytical

Two months before experiments started, a program was initiated to collect daily samples of plant wastewater from the equalization tank and to analyze its characteristics while the pilot plants were being constructed. The wastewater sampling program continued until