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TREATMENT OF WASTEWATER FROM THE POTATO CHIPS AND SNACKS MANUFACTURING INDUSTRY

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ABSTRACT

A small industrial effluent treatment plant has been designed and installed for the treatment of wastewater from a potato chips and snacks factory. The total daily flow rate to the plant was 115 m^3/d, while the influent COD mass flux was 838.7 kg/d and the BOD mass flux was 626.7 kg/d. The applied method of treatment is a simple upflow anaerobic reactor with internal settling and gas collection units, followed by aerobic treatment based on the activated sludge process with diffused air system. The quality of the treated water is better than requested and the overall treatment process efficiencies are 99.2% for COD removal and 99.5% for BOD_5 removal. The results of the operation of the plant during the first five months are examined and described in this paper. © 1997 IAWQ. Published by Elsevier Science Ltd

KEYWORDS

Aerobic treatment; anaerobic treatment; industrial effluent; potato chips wastewater.

INTRODUCTION

Potato chips and snacks factories discharge wastewater with high COD and BOD concentrations. The industrial process, mainly the peeling and cleaning of potatoes, produces high solids content, which must be removed before the biological treatment of the industrial effluent.

Anaerobic treatment with different types of reactors is a well-established technology for treatment of several kinds of industrial wastewaters, applicable also for the potato chips and snacks manufacturing industry. In this case, for the improvement of the anaerobically treated water, an aerobic treatment plant with extended aeration has been applied. In this way the final effluent can be discharged into the central sewerage system, or can even be reused within the industry.

DESCRIPTION OF THE TREATMENT PROCESS

The treatment process includes preliminary, anaerobic and aerobic treatment.

Mechanical pretreatment

Fine screen and screening's press unit. An automatic self-cleaning fine screen is installed at the front of the plant for the removal of coarse solids present in the wastewater. The screenings are compressed and dewatered in a press unit of piston type and transferred to a container.

Grit trap. The soil particles that may cause abrasion or damage to the electromechanical equipment, the potato peelings and other ballast materials are removed in the grit trap. The separated particles are collected at the bottom of the grit trap and pumped out to a tanker.

Balancing tank. The mechanically pre-treated wastewater flows into a balancing tank. Equalization serves two purposes: physical homogenization (flow, temperature) and chemical homogenization (pH, nutrients, organic matter, toxicant dilution) and partial acidification of the anaerobic reactor influent. For the proper homogenization of the tank content a submersible mixer is used and an amount of the pumped influent is recirculated.

Anaerobic Treatment

Anaerobic reactor. In Figure 1 is simply presented the construction of the anaerobic reactor. The reactor is constructed from reinforced concrete with special plastic coating and all the metal parts are made from stainless steel. Figure 2 shows the entire treatment process.

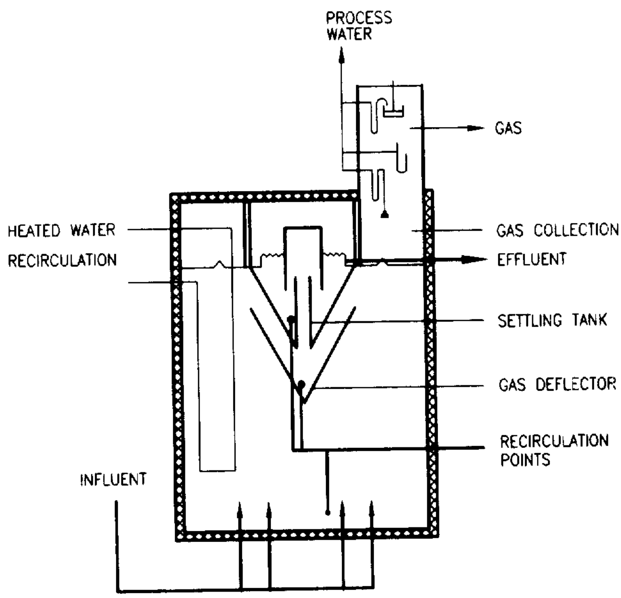

Figure 1. Anaerobic reactor.

The anaerobic mixture (pretreated wastewater and returned sludge) is led into the reactor via four (4) downflow inlet lines, each equipped with four pipe endings. Sixteen inlet parts uniformly located at the reactor bottom lead the mixture which passes the sludge blanket in an upflow direction. The pH of the influent mixture is continuously monitored by dosing of a 10% caustic soda solution.

The reactor body is equipped with a special built-in baffle system of inverted pyramid shape (deflector) that creates favourable flowing conditions of the anaerobic mixed liquor. The applied hydraulic loading rate and the produced biogas bubbles keep the biomass expanded. The biogas is directed by means of the gas deflector to the gas collecting chamber, situated at the top of the anaerobic reactor.

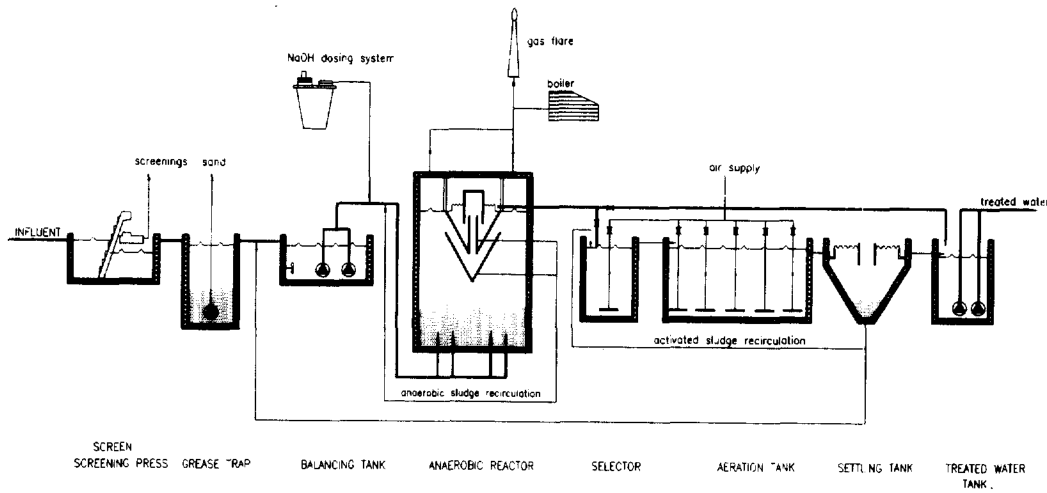

Figure 2. Sketch diagram of the treatment process.

The anaerobic mixed liquor leaves the bioconversion zone overflowing the crest of the deflector and flows down before it is directed into the upper part of the solids-liquid separation unit. The anaerobic sludge is settled in this settling tank and the anaerobically treated water overflows to the aerobic stage of treatment.

The anaerobic sludge is continuously recirculated into the reactor conversion zone in order to keep the desired hydraulic loading rates. The return/excess sludge can be pumped out from the following reactor parts:

- the internal settling tank
- the area between deflector baffle and settling tank
- the bottom of the anaerobic reactor

The space over the built-in settler is ventilated in order to increase the degasfying efficiency of the anaerobically treated supernatant.

Biogas utilization. The biogas produced in the anaerobic treatment process is collected at the top of the anaerobic reactor and is led to a gas boiler. This boiler is used for heating the recirculated water of a heat exchanger serpent, installed inside the anaerobic reactor. If it is necessary the excess gas is flared in the waste gas burner.

Aerobic treatment

The aerobic treatment is based on the activated sludge process with diffused air system. The air is supplied by rotary displacement air blowers.

Selector/Activation zone. An aerobic selector, divided in small compartments, is constructed at the beginning of the aerobic treatment. In the selector a high organic loading rate is kept for suppressing growth of filamentous microorganisms and avoiding bulking of the activated sludge.

Aeration - Settling. The aeration tank is designed with high hydraulic time to ensure a high organic removal efficiency. The tank is equipped with fine bubble air diffusers.

The settling tank is a vertical tank of Dortmund type. The settled activated sludge is recycled by means of an air-lift pump into the selector tank, while the excess sludge is pumped to the balancing tank for further anaerobic stabilisation. The settling tank is also equipped with a scum collecting box. The treated water overflows through V-notch weirs and is led into the treated effluent tank.

TECHNICAL DATA - DESIGN PARAMETERS

The technical data upon which the design of the industrial effluent treatment plant is based are the following:

Wastewater characteristics

Total daily flow	115 m^3/d
Hourly peak flow	15 m^3/h
Chemical Oxygen Demand (COD)	838.7 kg/d (7293 mg/l)
Biochemical Oxygen Demand (BOD_5)	626.75 kg/d (5450 mg/l)
Total Suspended Solids (TSS)	149.5 kg/d (1300 mg/l)
pH	4-10

Design parameters

Balancing tank

Volume:	113.68 m^3
Retention time:	23.72 h
Balancing flow:	6.0 m^3/h

Anaerobic reactor

Reactor volume:	245 m^3
Design volumetric loading:	3.41 $kgCOD/m^3.d$
Retention time:	2.13 d
Internal settling tank loading:	0.375 $m^3/m.h$

Aerobic treatment process

Volume of selectors:	12.4 m^3
Volume of aeration tank:	170 m^3
Selector volumetric loading:	20.3 $kgCOD/m^3.d$
Aeration loading rate:	1.48 $kgCOD/m^3.d$
Aeration time:	35.5 h
Settling tank loading:	0.375 m^3/h

START-UP AND PERFORMANCE OF THE PLANT

Start up

The anaerobic reactor was filled with tap water up to working level and the gas collecting areas were flushed by pressurized nitrogen gas.

The feeding of the reactor was done with a mixture of partially digested sewage sludge from a well-operating municipal plant and digested pig slurry sediment. This combination was proved to be suitable for starting up the reactor containing both acidogenic and methanogenic bacteria species. The quantity of seed sludge was approximately 30 m^3 with an average concentration of 80 kg/m^3.

Performance of treatment process

Analyses of COD, BOD and TSS were carried out nearly every day during the first five months of plant operation. Samples were collected from the balancing tank (influent), after the anaerobic reactor and after the aeration activated sludge process. The results of the sampling procedure are presented in Figures 3, 4 and 5. The quality of the incoming wastewater was not constant but it varied as follows:

COD:	4000-7000 mg/l
BOD_5:	2000-3000 mg/l
TSS:	1000-3000 mg/l

The efficiency of the anaerobic reactor proved to be quite satisfactory. After approximately 60 days of operation the quality of anaerobically treated water was better than the design requirements: COD = 200-400 mg/l, BOD_5 = 150-200 mg/l and TSS = 100-150 mg/l. At this time the average daily flow rate of wastewater and the influent mass fluxes were about 75% of the design parameters.

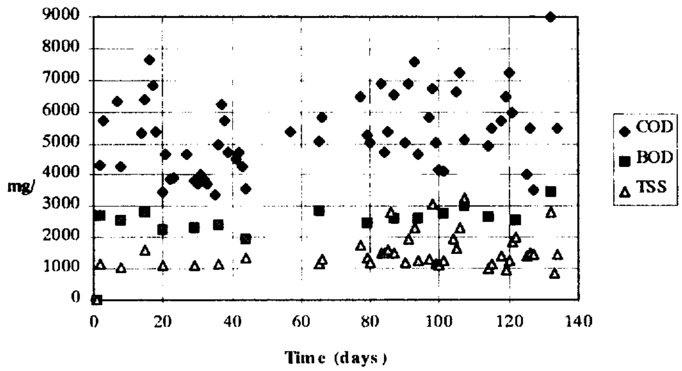

Figure 3. Concentration of COD, BOD_5 and TSS in the influent.

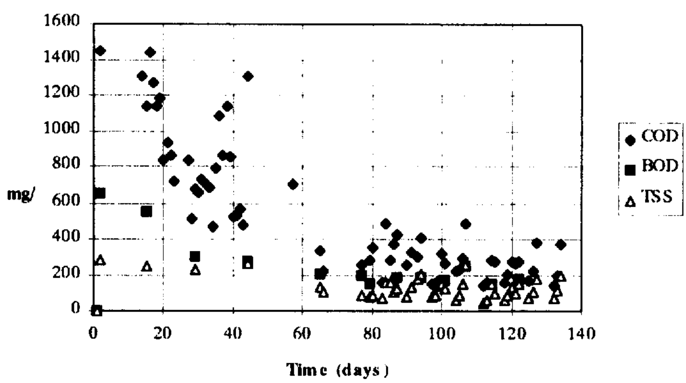

Figure 4. Concentration of COD, BOD_5 and TSS after the anaerobic reactor.

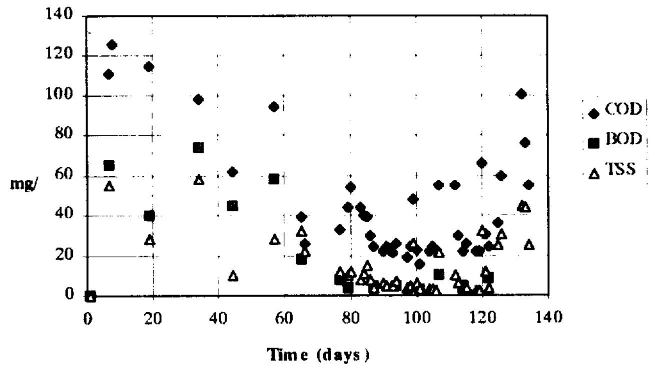

Figure 5. Concentration of COD, BOD_5 and TSS after the aerobic process.

In Tables 1 and 2 are shown the removal efficiencies of COD, BOD_5 and TSS as the average values of the first five months of plant operation. During the last month the BOD_5 and TSS concentrations were even better and in many cases less than 10 mg/l.

Table 1. Average concentration of COD, BOD_5 and TSS during the first five months of operation

Parameter	Influent (balancing tank)	After anaerobic Reactor	After aerobic treatment
COD, mg/l	5300	540	45
BOD_5, mg/l	2625	266	25
TSS, mg/l	1565	131	16

Table 2. Removal efficiencies of COD, BOD_5 and TSS

Parameter	Anaerobic reactor	Aerobic process	Total efficiency
COD, mg/l	88.3	86.5	99.2
BOD_5, mg/l	89.5	94.9	99.5
TSS, mg/l	75.2	90.2	99.0

ENERGY CONSUMPTION

The average daily power consumption of the whole plant is 212 kW.h/d, while the specific power consumption per m^3 of wastewater is 1.8 kW.h/m^3.

CONCLUSION

The medium loaded industrial effluent from a potato chips and snacks factory can be successfully treated by a combination of anaerobic and aerobic treatment processes. The final effluent can be discharged to the central sewerage system or can even be reused within the industry.

Topics currently being researched include:

- Production and utilization of biogas.
- Removal of nitrogen and phosphorus, considering the application of a denitrification step in the aerobic treatment process.
- Improvement of final effluent quality with the installation of high a rate filtration system for reclamation and reuse of water.

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