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Treatment of Food Processing Industrial Wastewater using Anaerobic system

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Abstract

The food industry manufacturing different type of products, mainly Dairy products, Ice cream, biscuit, pickle and some biodegradable pharmaceuticals products suppose cellulose, glucose etc. The wastewater produced by manufacturing industry is known for its high concentration of COD and suspended solid. In wastewater treatment, anaerobic process is favourable due to its low cost, biogas production, low sludge production and more. In this study Upflow anaerobic sludge bed (UASB) reactors. This study was focused on the performance of UASB treatment systems. Wastewater taken from Food Manufacturing Factory. Parameters measured to evaluate the performance of the process were pH, COD, NH3-N, oil and grease and total suspended solids, total dissolved solids. The highest average COD removal efficiency, at 90 % was detected in systems. UASB reactor had performed better.

Key words: UASB, Food Industry, Pharmaceuticals

Introduction

Water is important to all living things in this world. 70.9% of the Earth's surface is covered with water. The ocean holds about 97% of surface water, the glaciers and polar ice caps holds 2.4%, while the other 0.6% of water in this world can be found at lakes, rivers and ponds. Unfortunately, the water quality has deteriorated from time to time due to human's daily routines. Making matter worse is the production of wastewater discharged by domestic residences, commercial properties, industry and agriculture that cover a broad range of potential contaminants and concentrations.

The industrial processes inevitably results in uncontrollable and high production of wastewater which if not treated properly will contaminate the environment. There are many factories contributing to industrial wastewaters such as complex organic chemicals industry, and food industry. Industrial wastewaters are considerably diverse in their nature, toxicity and treatability, and normally require pre-treatment before being discharged to sewer. Food processing in particular is very dissimilar to other types of industrial wastewater, being readily degradable and largely free from toxicity. However, it usually has high concentrations of biological oxygen demand (BOD) and suspended solid (Gray, 1999).

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Compared to other industrial sectors, the food industry uses a much greater amount of water for each ton of product (Mavrov *et al.*, 2000). One of a well-known food industry, chips industry, is also getting bigger in GIDC Naroda .

1.2 Problem Statement

The food manufacturing wastewater contains high concentrations of several organic compounds including carbohydrates, starches, proteins, vitamins, pectines and sugars which are accountable for high chemical oxygen demand (COD) and suspended solids (Kobya *et al.*, 2006). Nowadays, there are various treatments that can be applied to treat the industrial wastewater. The commonly preferred treatment is anaerobic treatment due to its low cost and high effectiveness. On the other hand, this study had applied the UASB single stage anaerobic treatment systems to study their performance in treating food industry wastewater.

1.3 Objective of the Study

The objectives of this study are:

a) To investigate the performance of UASB.

b) To characterize and study the development of sludge granulation in UASB reactors.

Literature revue

Agro-industries are major contributors to worldwide industrial pollution. Effluents from many agro-food industries are a hazard to the environment and require appropriate and a comprehensive management approach. Worldwide, environmental regulatory authorities are setting strict criteria for discharge of wastewaters from industries. As regulations become stricter, there is now a need to treat and utilize these wastes quickly and efficiently. With the tremendous pace of development of sustainable biotechnology, substantial research has been devoted recently to cope with wastes of ever increasing complexity generated by agro-industries. Anaerobic digestion is an environmentally friendly green biotechnology to treat agro-food industrial effluents. In addition, the carbon emission and, therefore, the carbon footprint of water utilities is an important issue nowadays. In this perspective, it is essential to consider the prospects for the reduction of the carbon footprint from small and large wastewater treatment plants. The use of anaerobic treatment processes rather than aerobic

Would accomplish this purpose, because no aeration is required and the biogas generated can be used within the plant. Anaerobic digestion is unique, as it reduces waste and produces energy in the form of methane. Not only does this technology have a positive net energy production, but the biogas produced can also replace fossil fuel; therefore, it has a direct positive effect on greenhouse gas reduction. Thus, the carbon-negative anaerobic digestion process is considered as a sustainable wastewater treatment technology, which also provides the best affordable (low-cost) process for public health and environmental protection, as well as resource recovery. The attractiveness of biogas technology for large scale applications has been limited, essentially, because of the slow rate and process instability of anaerobic digestion. The slow rate means large digester volumes (and consequently, greater costs and space requirements) and process instability means the lack of assurance for a steady energy supply.

These two major disadvantages of conventional anaerobic processes have been overcome by high rate anaerobic reactors, which employ cell immobilization techniques, such as granules and bio films. Thus, various reactor designs that employ various ways of retaining biomass within the reactor have been developed over the past two decades. The purpose of this article is to summarize the current status of the research on high rate anaerobic treatment of agro-food industrial wastewater and to provide strategies to overcome some of the operational problems.

The composition and concentration of different agro-food wastewaters vary from low (wash water from sugar mill or dairy effluents) to high strength substrates (cheese, winery and olive mill wastewaters), particularly in terms of organic matter, acids, proteins, aromatic compounds, available nutrients, *etc.* [Rajagopal 2008, Ganesh 2010, Zhao2012]. The main parameters of the agro-food industrial wastewater, such as total solids (TS), total nitrogen (TN), total phosphorus (TP) and biochemical and chemical oxygen demand (BOD and COD).

The social and economic requirement for low-cost, low-technology wastewater treatment technologies has stimulated study of more advanced level wastewater treatment, including the development of new reactor designs and operating conditions (McHugh *et al.*, 2003).

Toxicity

Sodium toxicity is a common problem causing inhibition of anaerobic digestion. Digesters treating highly concentrated wastes, such as food and concentrated animal manure, are likely to suffer from partial or complete inhibition of methane-producing consortia, including methanogens [Suwannoppadol and Hierholtzer 2012]. Zhao *et al.* confirmed that organ fluorine compounds, such as 4-fluorophenol (p-FP), 4-fluorobenzoic acid (p-FB) and 4-fluoroaniline (p-FA), have a potential toxicity on methanogenesis and biodegradability. Procházka *et al.* described that high ammonia nitrogen concentration (especially the unionized form) (4.0 g L−1) would inhibit methane production, while low ammonia nitrogen concentration (0.5 g L−1) could cause low methane yield, loss of biomass (as VSS) and loss of the acetoclastic methanogenic activity. Chen *et al.* indicated that certain ions, such as Na+, Ca2+ and Mg2+, were found to be antagonistic to ammonia inhibition, a phenomenon in which the toxicity of one ion is decreased by the presence of other ion(s). At high concentrations, potassium, light metals ions (Na, K,Mg, Ca and Al) and other salts can also interrupt cell function . *Toxicity Control Strategies* Vyrides *et al.* described that when grass clippings were added at the onset of anaerobic digestion of acetate containing a sodium concentration of 7.8 g Na+ L−1, a total methane production of about 8 L CH4 L−1 was obtained, whereas no methane was produced in the absence of grass leaves. Another way of tackling the sodium salts problem is by allowing the anaerobic sludge to acclimate to high sodium concentrations [80], but this technique requires time for the methanogens to adapt to the saline conditions, which in turn, results in a prolonged period before the anaerobic reactor can achieve its full-loading capacity.

The Concept of CETPS NEPL(Naroda Enviro projects)

The common effluent plant (CETP) not only helps the industries in easier control of pollution, but also acts as a step towards cleaner environment and service to the society at large. Small scale industries, by their nature of jobs cannot benefit much from economies of scale and therefore the burden of installing pollution control equipment, falls heavy on them. Realizing this practical problem , under the policy statement for abatement of pollution the Govt. felt to extend the scheme for promoting combined facilities for treatment of effluent and management of solids wastes for cluster of small-scale industrial unites and also to provide technical support to them. The wastewater is collected from deferent type of industry's such as dairy and Ice-cream and cheese, potatoes cheeps production industries, bakery and dharma industry etc... Present NEPL wastewater collected every day 0.4 MLD per day and treat in UASB reactor and used in Dilution for chemical industries wastewater.

Technical Details for Anaerobic Process At NEPL

Effluent Characteristics:

Table :1

SR.	PARAMETER	RAW EFFLUENT	TREATED EFFLUENT
1	Effluent flow rate	1,000 m^3/d	1,000 m^3/d
2	pH	4.5-9.5	7.0-8.5
3	Chemical oxygen demand	10,000 mg/L	< 2,500 mg/L
4	Biochemical oxygen demand	6,500 mg/L	< 30 mg/L
5	Total Suspended Solids	2,000 mg/L	< 100 mg/L
6	Oil & Grease	250 mg/L	< 10 mg/L
7	Total Inorganic Dissolved Inorganic Solids	< 8,000 mg/L	< 8,000 mg/L
8	Sodium as Na^+	< 4,000 mg/L	< 4,000 mg/L
9	Calcium as Ca^{2+}	<2,500 mg/L	<2,500 mg/L

The plant is designed to treat effluent quantity of about 1,000 m^3/d. Following design parameters are taken for the plant design:

Anaerobic Process Description:

The Anaerobic Process contains following unit processes / operations:

- Raw effluent collection tank: For reception and storage of raw effluent.
- Anaerobic Reactor system: For degradation of waste and generation of biogas.
- Primary clarifier: For polishing an aerobically treated effluent
- Biogas Holder: For intermediate storage of biogas.
- Biogas compressors: For pumping of biogas to biogas to biogas burner in boiler / engine.

Process:

- 1,000 m^3/d of raw effluent from different food processing industries in brought to the CETP by tanker and it gets collected in raw effluent collection sump for homogenization and pH correction.
- Homogenized and neutralized Effluent from collection tank is pumped to UASB reactor from the bottom to distribute uniformly through the inlet distribution system.
- The feed effluent moves upwards through the dense anaerobic sludge bed. Organic matter gets rapidly utilized by biomass and converted to methane rich biogas. Upward movement of water and biogas bubbles generated from the bottom of the reactor keep the biomass in suspension and break any scum formation.
- The three-phase separator allows effective degasification to occur. The dense, granular sludge particles, devoid of attached gas bubbles, sink back to the bottom establishing a return downwards circulation. The treated effluent flows into collation channels at the top of the settlers for discharge and transferred to the clarifier – 1. Washed out anaerobic biomass is recovered and recycled to the reactor. Excess biomass from Anaerobic Process will be wasted to sludge drying beds, if required.
- Treated effluent from Clarifier – 1 is transferred to ETP for further treatment.
- Biogas is collected in gas collection portion of three phase separator at the top of the reactor and transferred to biogas holder for intermediate storage. Then the gas can will be pumped through a compressor / receiver system and will be used in the boiler / Gas Engine.

Biogas generation and utilization:

- Total biogas generation is in true of 3,000 - 3,500 m^3/d at design loading. The biogas will have CF value of 5,600 kcal / d. Biogas production is continuous and for 24 hours. The biogas holder has about 15 m^3 storage volume.

- This biogas is equivalent to 4,000 - 4,500 kg of steam coal and it can replace steam coal worth Rs.28, 000 – 30,000 every day.
- 300 KVA (7,000 KWH) power can be generated from this biogas and Rs. 50,000/- can be saved every day.

Unit Processes / Operations:

Design data and specification of treatment units:

1. Specification of Raw combined Effluent Collection Tank:

a) Total combined effluent Inflow: 1,000 m^3/d from all units

b) Average hourly flow rate: 50 m^3/h

c) Collection Tank Size: 24.0 m × SWD 3.5 m from invert level,

d) Volume: 1,000 m^3

e) Material of construction: RCC with form acid proof lining inside

2. Anaerobic Reactor:

a) Type: Up Flow Anaerobic Sludge Blanket (Fixed roof type with integrated tube settler)

b) Total organic load: 10,000 kg/d

c) Volumetric Organic Loading Rate: 2.25 kg/m^3/d

d) Size: Volume 4,530 m^3

e) Reactor Size: I.D.: 31.0 m, SWD 6.0 m

f) Inlet / outlet COD: 10,000 mg/L 2,500 mg/L

g) Material of construction: RCC.

3. Clarifier – 1:

a) Type: Hopper Bottom Settling Tank with tube settler

b) Solid Loading Rate: 125 kg/m^2/d

c) Surface Overflow Rate: 25 m^3/m^3/d

d) Clarifier size: 6 m × 4 m

e) Material of construction: RCC M20 with form finish inside and sand faced plaster outside.

1) List of Equipment and Machinery:

1. Anaerobic Reactor Feed Pump

- Type: Submersible slurry transfer pump, semi open impeller, CI body and SS 316 working parts, Mech. Seal
- Flow: 60 m^3/h
- Head: 18 m
- Power: 10 HP
- No.: 2(1+1 stand by)

2. Aerobic Biomass Recycle Pump

- Type: Centrifugal slurry transfer pump, semi open impeller, CI body and SS 316 working parts, Mech. Seal
- Flow: 30 m^3/h
- Head: 18 m
- Power: 5 HP
- No.: 2(1+1 stand by)

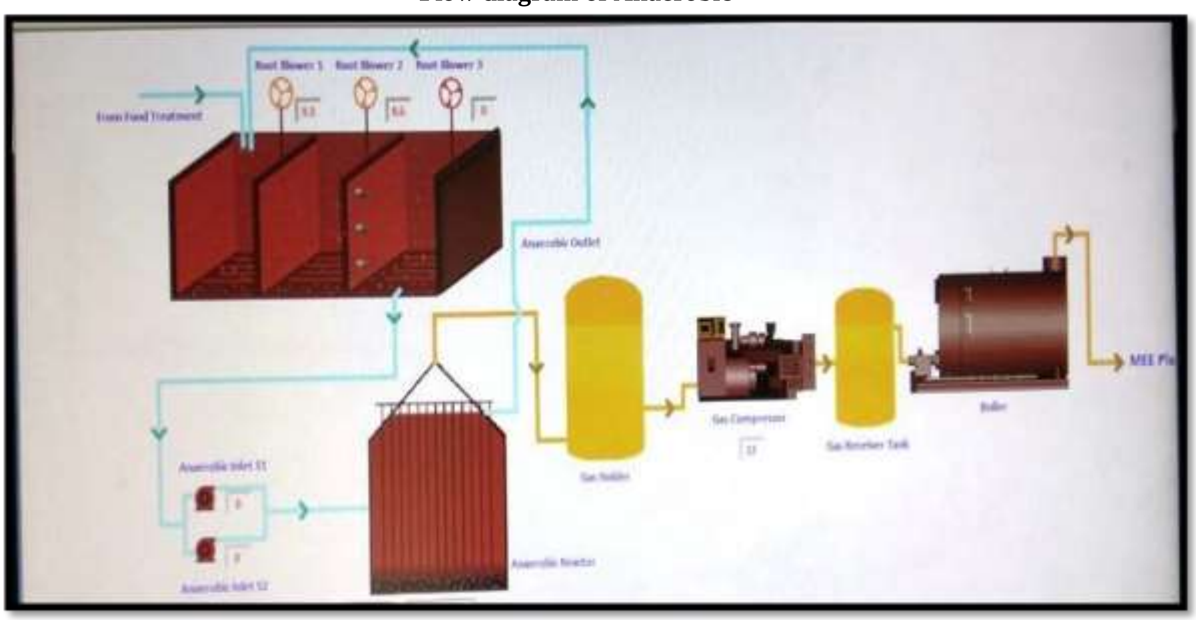
3. Biogas Compressor

- Type: Reciprocating compressor

- Flow: 100 m^3/h
- Head: 3 kg/cm^2
- Power: 10 HP
- No.: 2(1+1 stand by)

UASB reactor at NEPL (Naroda Enviro projects ltd) GIDC, Naroda Ahmedabad

Flow diagram of Anaerobic



Experimental methods

The samples for analysis were collected in pre-washed 1.5 L plastic bottles. The samples were taken from the anaerobic inlet buffer tank and outlet treated sump from six days, integrated and a representative sample was drawn. The sampling was carried out in the months of Samples were collected in these month february-2017.

Physicochemical Analysis of water was carried out referring the 'standards methods' (APHA-1992).Various methods used are listed in table-1. The temperature ,pH ,TDS, TSS, Oil and Grease ,Biological oxygen Demand and Chemical oxygen demand in the field. The collected samples were brought to laboratory and analyzed within 24 hours, except the Biological Oxygen Demand, which require a period of five days for incubation at a temperature of 20^0C using standard methods (APHA -1992).

Table-2 Physicochemical Analysis by Different Method:

Parameter	Method/Equipment used
pH	Digital pH meter
TDS	Oven dry-weight
TSS	Oven dry-weight
Total Hardness	Titrimetry method
Oil and Grease	
BOD,COD	Winkler method

The collected samples were stored at 4^oC. The pH of the water samples was measured by using the electrometric methods and other physicochemical parameters were analyzed by standard methods given in APHA (1989).

Results of Anaerobic Inlet and Outlet
Table-3

Results For Dye wise	Temperature ^{0}C	pH		TDS (mg/l)		TSS (mg/l)		COD (mg/l)		BOD (mg/l)	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Day1	35	6.1	7.2	8004	8070	3000	100	9000	890	3500	20
Day2	35	6.0	7.4	9000	9020	2800	90	7000	722	2500	25
Day3	35	6.5	7.4	10025	9088	3500	98	11030	1095	1500	17
Day4	35	6.5	7.0	9071	10180	3680	111	9008	820	3000	25
Day5	35	6.3	7.1	8090	9080	3800	80	9080	873	2800	40
Day6	35	6.0	7.6	9076	8273	3100	90	10145	982	2100	25

Results and Discussion

The colour of the effluent was turbid and yellow and Odourless. The analysis of theses effluents showed that some physical and chemical parameters. The concentration of the COD is estimated between 7000 and 11030 mg/L in inlet and outlet between 722 to 1095 Mg/L, while concentration of the BOD5 is limited between 1500 and 3500 mg/L in inlet and outlet between 17 to 40 mg/L . The pH varied from 6.0 to 7.6, and the pH concentration of the mostly inlet in 6.0 and outlet is 7.0. The best results obtained at temperature equal to 35°C and pH equal to 6.5. At the outlet of pilot, the water became clear. The concentration of TDS is 8004 to 10180 mg/L and TSS is 80.0mg/l in outlet and 3800 mg/L inlet the decreasing of the outlet water goes up in Aerobic system.

Conclusion

The aim of this work is to set an anaerobic process of treatment that can reduce the pollution of Wastewater produced by the food industry. The analysis of this effluent after treatment allowed defining chemical parameters of pollution degradation of COD, BOD and TSS is 90% efficiency of UASB respectively.

According to the obtained results, the anaerobic treatment can be applied to the effluent of the Dairy-cheese, Ice-cream and other Food factory. This allows reducing pollution and protecting the receiving environment.

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