Characterization And Treatment Of Ice Cream Industry Wastewater Using UASB Reactor

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Abstract: Pollution is the main nuisance creating havoc nowadays for public as well as for other living beings. In olden days (40-50 year back) as there were not many industries in existence disposing of wastewater was not a big problem because there was ample land to dispose it. But nowadays because of rapid industrialization disposing of water creates number of problem as industries dispose their waste product in country side rivers or streams causing water pollution and affecting marine and human life as a result of which human and other being are threatened with various diseases.

In view of all the adverse effects of pollution a need for redressing the rules and regulations regarding the disposal of waste products from industries has to be enforced keeping this in mind, a remedy was suggested by the bureau of environment authority that the waste water must be treated for various organic and inorganic impurities before disposing it off into the river and land.

Hence, the study comprises of the characterization and treatment of ice cream factory wastewater situated at "Ramani Top'N Town ice cream factory, govindpura", Bhopal Madhya Pradesh.

I. INTRODUCTION

Industries play an crucial role in development of all countries. And nowadays the industrialization is in their peak but a big problem is behind this development is the pollution generated by such industries. To insulates the environment from such pollution is the proper treatment of effluent of industries. So much attention is now given in India on the treatment of industrial wastes, due to is growing pollution potential arising out of the rapid industrialization of the country. Thus we have three alternative viz.

i. The direct disposal of waste into the stream without any treatment
ii. Discharge of the wastes into the municipal sewer for combined treatment and
iii. Separate treatment of the industrial waste before discharging the same into the water bodies.

The selection of a particular process depends on various factors like-

(a) Self purification capacity of stream
(b) Permissible limit of the pollutants in the water bodies established by law
(c) Technical advantages, if only in mixing the wastes with domestic sewage.

In the last few years ago due to increasing necessity to preventing pollution of the environment and to conserve energy and other resources, new method and policies towards waste handling and treatment are finding applications involving recovery, bioconversion and utilization of valuable constituents from food processing water.

Efforts are made to characterize the ice cream industry wastewater, chemical and biological treatability of the waste water and also suggest the suitable treatment system . the scheme for the treatment of effluent has also been suggested. the study has been carried out in **TOP' N TOWN** ice cream factory, govindpura industrial area Bhopal Madhya Pradesh.

1.2 POLLUTIONAL EFFECTS AND JUSTIFICATION

i. The waste from ice cream industries are basically acidic in nature. this is also acidic when fresh. when these waste are allowed to go into the stream without any treatment, a rapid depletion of dissolved oxygen in the stream occurs.
ii. As wastewater generated from ice cream factory is acidic in nature, a high biological dilution or treatment anaerobicity is developed in the receiving water resulting in sever odor problem.
iii. Depletion of DO causes the threat to aquatic life.
iv. The growth of algae covers the entire stream and submerged pool of the hydraulic structure within it.
v. It is also observed that the COD values are much more than its permissible limits, including that the waste is highly polluted.
vi. It also contains numerous pathogenic microorganisms, some percentage of nutrients content in it can stimulate the growth of plants if discharge in stream. for these reasons the immediate and nuisance free

removal of wastewater from its source of generation followed by treatment and disposal it not only desirable but also necessary in an industrialized society.

Hence , it is necessary to reduce the pollution load of such wastewater and ensure that the standard stipulated by regulatory for discharge of effluent are met with. choice of treatment showed however, be based on the quantity and characteristics of the wastewater and treatment goals.

1.3 SCOPE OF STUDY

The treatment and disposal of any industrial and domestic waste water is of concern to all measures and their implantation. with constant escalation in the energy cost and methods which conserves or produce energy is of many new modified biological treatment system .also the selection of particular treatment process depends on the characteristics of the wastewater.

The present study is carried out in "**TOP' N TOWN ice cream factory**."

That includes .

(1) Measurement of discharge of wastewater .
(2) Characterization of wastewater from ice cream industries effluent .
(3) Fabrication and setup of pilot scale up flow Anaerobic sludge blanket (**UASB)** reactor.
(4) The performance evaluation of **UASB** process for the treatment of wastewater from "**TOP'N TOWN"** ice cream factory effluent.
(5) Suggestion of the appropriate treatment flow sheet.
The detail scope of the work includes performance evaluation of effluent treatment plant for **TOP'N TOWN** ice cream factory, govindpura industrial area Bhopal.(M.P.)

II. RESEARCH METHODOLOGY

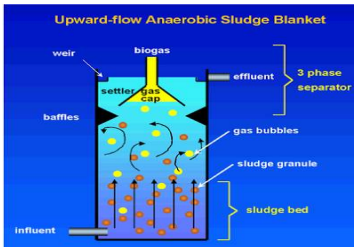
2.1 GENERAL

The personal study is carried out in "**RAMANI TOP'N TOWN"** ice cream factory located at govindpura industrial area Bhopal. Efforts are made to characterize the wastewater and suggest the biological treatability of wastewater from ice cream industry.

After studying the characteristics of different sampling point appropriate UASB pilot plant was erected in the **TOP'N TOWN** ice cream factory with various components of that pilot plant as shown in fig

The analysis of wastewater was done in Environmental Engineering Laboratory of S.A.T.I. vidisha as per the standard methods of analysis of water and wastewater by manual of (APHA), manual of NEERI, and laboratory manual

2.2 UP FLOW ANAEROBIC SLUDGE BLANKET (UASB) REACTOR



Up flow anaerobic sludge Blanket (UASB) Reactor has been successfully used in the recent post to treat variety of individual as well as domestic wastewater. The reactor was erected for the study of treatment of the wastewater and the performance evaluation of the reactor.

1. Pilot Plant

A pilot scale **UASB** Reactor was fabricated and set up to study the anaerobic biological treatability of wastewater.

PVC pipe was used to fabricate reactor. The physical features of the pilot plant scale reactor.

Sr. No.	PARAMETER	VALUE
1	Internal diameter of reactor mm	153
2	Total height of reactor mm	2000
3	Inlet pipe to feed the influent into the reactor mm	12.7
4	Total volume of reactor lit.	37

The PVC pipe dummies were used to close button and top of the rector. A hole was made at the center of dummy to fix the inlet pipe of diameter ½ in the connectors used in electric were used as inlet pipe. Four numbers of sampling points were provide at the height of 30cm, 70cm, 120cm and 200cm to collect the sample and analysis. Two plastic funnels of size 150 mm diameter and 300 mm height were used for preparing gas collection dome and sloping base.

The gas collection system was also provided to collect the gas by connecting gas outlet to glass bottle of three and half water capacity. A steel framework was installed and reactor was fixed with it. The volume of reactor was 37 lit.

Math

Reactor volume and dimensions- To determine the required reactor volume and dimensions, the organic loading, superficial velocity, & effective treatment volume must all be considered. The effective treatment volume is that volume occupied by the sludge blanket and active biomass. An additional volume exists between the effective volume and the gas collection unit where some additional solids separation occurs and biomass is dilute. The nominal liquid volume of the reactor based on using an acceptable organic loading is given by-

$$Vn = QxSo / Lorg$$

Where, **Vn** – Nominal liquid volume of reactor, cu.m. **Q** - Influent flow rate, cu.m / h
So - Influent COD, Kg COD / cu.m. **Lorg** – Organic loading rate, Kg COD / cu.m.d

Total liquid volume can be determined by –

$$VL = Qn / E$$

Where, **VL** – Total liquid volume of the reactor, cu.m.
Vn – Nominal liquid volume of the reactor, cu.m.
E – Effectiveness factor, unit less

$$Area\ of\ reactor = A = Q / V$$

Where, **V** - Design up flow superficial velocity, m/h **A** – Reactor cross section area, sq.m.
Q – Influent flow rate, cu.m. / h

The liquid height of the reactor is determined ny using the following relationship –

$$HL = VL/A$$

The gas collection volume is in addition to the reactor volume and adds an additional height of 2.50 to 3.0 m. thus the total height of the reactor is

$$Ht = HL + Hg$$

Where, **Ht** – Total reactor height in m
Hl – Liquid height in m.
Hg – Gas collection and storage height, in m.

2 Hydraulic Testing Of Pilot Plant

Hydraulic testing of the plant was carried out after the complete fabricated and erection of the pilot plant by discharging the influent from the tubs using pump. Following problems were across during testing and rectified as discussed below.

3 Flow Rate Adjustment

For 24 hrs total flow of wastewater is 0.037 m3 / day. Then the flow rate becomes 0.001541 cu. m / hr. For the required flow rate the PVC tube was installed and pump is used for making up flow of wastewater in the reactor. A tap was used for adjusting the flow rate so as required flow rate is maintained as shown in photographs.

4 pump

The pump is installed in our small scale plant for up flow of effluent wastewater and tap is used to adjust the flow rate as shown in fig.

5 Nutrients and Chemical Requirements

After the extensive characterization of the wastewater of ramani ice cream factory, it was noticed that the wastewater was acidic and they neutralize that by using castic soda(NaoH) or washing soda(Na2Co3) . **6.Early Start up of UASB reactor**

For early start up of the reactor the sludge from the Bio Gas plant transported from Govindpura and near by village was filled in the reactor up to full depth. For three days the reactor was operated with the same sludge of Bio Gas plant at the flow rate of 0.037 m3 / day that using 25 % wastewater of ice cream factory and 75 % of Bio Gas sludge for next three days operated the reactor.

For the next phase of three days 50 % of each wastewater and Bio Gas sludge are used for operation of the reactor. The dosing of wastewater is increased as 75 % and Bio Gas plant sludge was 25 % and the reactor is operated for next six days.

After that the wastewater of ice cream factory is again diluted with water in the proportion of 25 %, 50%, 75% and 100% of wastewater was used in reactor with adopting flow of 0.0185 m3 / day.

7. Working of UASB Reactor

In this the wastewater was collected in a blanket. The tub was filled with wastewater and added required quantity of nutrients in it and checked the pH. And pump were use for making up flow in reactor. The tap was opened as per required flow and the wastewater was allowed to enter inlet pipe. The wastewater was allowed to enter inlet pipe. The wastewater flows up word in the UASB reactor and the treated wastewater was collected from the top and the discharge in to nearby stream. And also use a layer of resins in this reactor on the top of material of about 4-5cm depth. Which is used as a softener in food factory. Gas collection device was installed at the top of the reactor and the record is maintained. **8.Sampling Ports**

For characterization, analysis of wastewater and of it and to determine the efficiency and kinetics of UASB the sampling paints are provided as under.

1) Outlet pipe at the top of reactor.
2) 0.30 from the bottom of the reactor.
3) 0.70 m from the bottom of the reactor.
4) 1.20 m from the bottom of the reactor.

The wastewater analysis has been carried out in the Environment laboratory of the **SATI Vidisha** as per the Standard Methods and norms.

9.Gas Collection

To measure the quantity of gas generated during the treatment process by UASB, reactor an arrangement was made in which three and half liters capacity glass bottle was used and connected to the outlet of the reactor.

OBSERVATION RESULTS AND DISCUSSION

3.1 OBSERVATION

1. Wastewater Characterization

The waste generated per day from a Top' N Town ice cream factory was 1,50000 lt/ day. The wastewater was collected in a huge tank. Few grab samples from the tank were collected and analyzed for colour, temperature, pH, alkalinity, COD, BOD, total solids, total suspended solids and total Dissolve solids.

Discharge of wastewater was also measured at the time of collection.

2. Performance of UASB Reactor

An UASB reactor pilot plant scale reactor was set up shown in photograph study the biological treatability of wastewater.

The pilot plant was erected and hydraulic testing was completed up to 21.07.2015 and feeding of the Gobar Gas Plant effluent of bacteria was done from 22.07.2015 to 05.08.2015. After that the feeding of diluted wastewater was done from 05.08.2015 to 18.08.2015. The samples of raw wastewater, influent and effluent were collected in different container.

The reactor was operated from 05.08.2015 to 20.10.2015 and the performance was recorded regularly from raw influent and effluent with studying the different parameters. The wastewater was first neutralized to pH 7 with Na_2CO_3. The reactor was fed continually at HRT and 24 hours. The samples as raw wastewater, neutralized wastewater influent to the UASB and the treated wastewater (effluent) from the reactor were collected and analyzed for colour, temperature, pH, COD, total solids, total suspended solids, total Dissolve solids intermittently with the help of "Standard method of analysis of water and wastewater", manual published by ALPHA. Laboratory Manual and Manual of NEERI, Nagpur.

For the flow rate studied, the corresponding values for organic loading rates for UASB were computed. pH variation, COD variation and COD removal has been presented is fig. total solid variation in UASB also shown has been presented in fig. respectively

Fig. 1. pH Variations in UASB

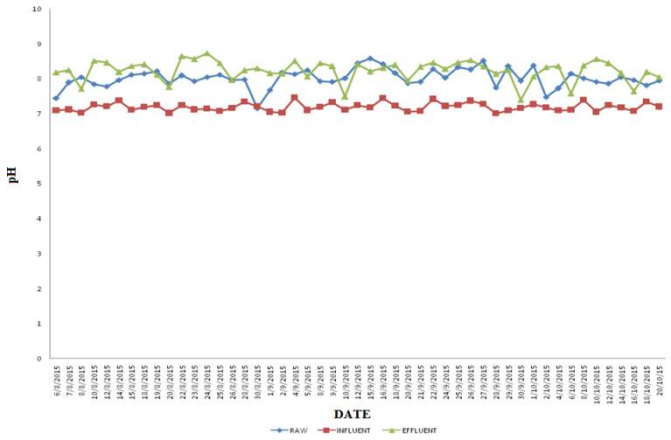


Fig. 2. COD Variations in UASB

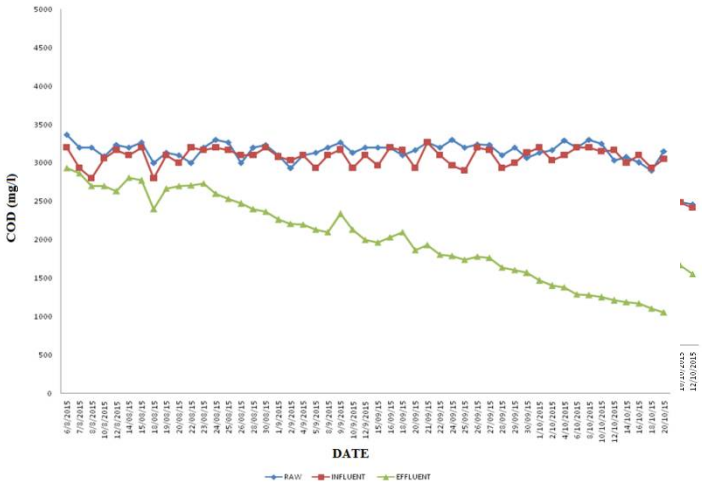


Fig. 3. Percentage COD Removal

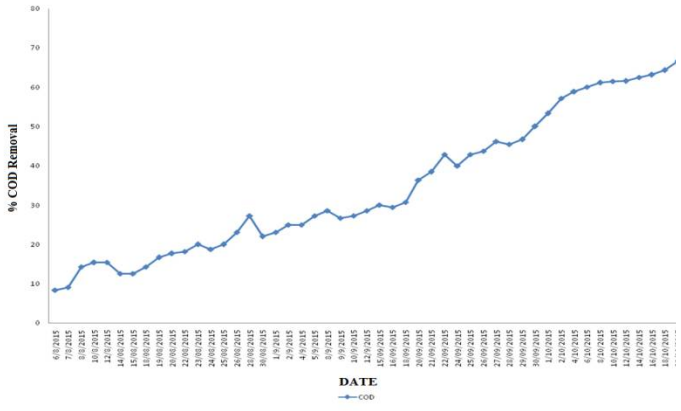
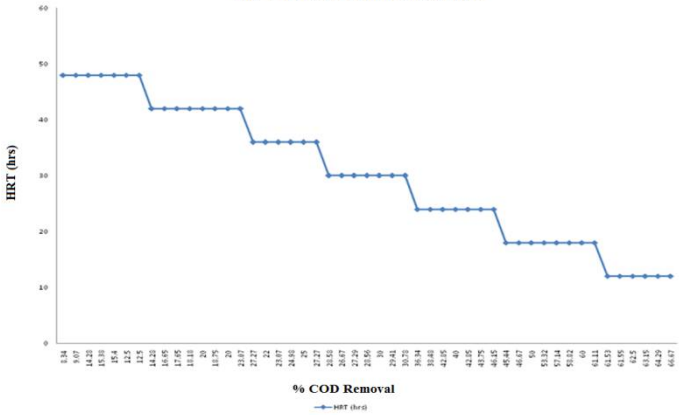


Fig. 4. Percentage COD Removal vs HRT



3.2 RESULTS AND DISCUSSION

1. Characteristics

The characteristics of wastewater from ice cream industry has been enumerated.

The ranges of various parameters are calculated and the characteristics are briefly outlined below.

1. Temperature

The temperature range of different sampling points was nearly equal and the range of temperature was 30°C to 40°C.

2. pH

The pH of wastewater was found to be in little acidic range. pH of wastewaters collected at tank was found to be 6.96 to 7.95, which is closer the tolerance limit of 5.5 to 9.0 for discharge in the surface water. The wastewater was acidic hence there is a need of to add small quantity of alkalies in wastewater make it neutral for efficient biological treatment.

3. Chemical Oxygen Demand (COD)

The strength of the wastewater was measured in terms of chemical oxygen demand (COD). There was a slight fluctuation in COD concentration of wastewater. The range of different sampling points was 1600-3200 mg / lit, which are against the corresponding permissible limit of 250 mg / lit for the disposal into the stream or surface water.

4. COD / BOD Ratio

The COD / BOD ratio was observed for all the sampling points wastewater varies from 1.52-1.84 which indicates that the wastewater is less biodegradable.

5. Solids

The total solids variations in range for wastewater from tank are observed to be 3788-3800, As well as the total suspended solid range for that was found to be 1158-1183.

Similarly the total dissolve solids range from 2600-2694 mg / lt.

Thus based on the observation at the observation at can be seen that ice cream factory wastewater is polluted and large in volume. Hence it requires proper treatment before disposing off it into the water bodies.

2. Performance of UASB Reactor

There is a slight variation in pH value and it was observed as acidic in nature. There is a very little variation in pH in case of influent wastewater to UASB. This indicates that the neutralization has been achieved properly with the help of Na_2co_3 or Noah. The fluctuation of pH in reactor. and corresponding plot shown in fig 1. The pH of all effluent wastewater ranges between 7.19 to 7.87 which is good pH requirements in the reactor for anaerobic treatment.

From the observation fig. 3 and fig. 4 the COD removal during the started period is fluctuated due to instability of reactor or system. But after its stabilized the COD removal was observed to be 66.67 % at a organic loading of 7.50 kg / COD / m^3 / d with Hydraulic retention time of 12 hr.

The plot between the COD removal and HRT is indicated in fig. 4 which proves that as the reactor was acclimatized after certain period, the rate of COD reduction war constant even after reduction in HRT.

The plot between COD removal and OLR in fig. 5 represents that the COD removal increases as the organic load rate increase.

The removal of total solids, total suspended solids and total dissolve solid was found to be 63.80%, 64.95% and 61.45 % respectively at HRT of 12 hr. and plot of total solid variation, is shown in fig.6,

An attempt was made to asses the performance of the reactor by observing the gas production but there was a very less production of the gas. The gas production varies in the range of 0.075 m^3 / kg to 0.2427 m^3 /. Kg.

3.3 CONCLUSION

The work carried out under in this thesis comprises characterization of ice cream factory wastewater, feasibility studies of different treatment methodology and there after suggesting wastewater treatment scheme.

Based on the present study following conclusion can be drawn.

i. The wastewater from ice cream factory is polluted.
ii. The wastewater is acidic and pH ranges between 4.72 to 4.90.so they mix castic soda or washing soda to maintain pH of wastewater. And then it will be around 7.02-7.86.
iii. There is slight fluctuation in COD concentration of wastewater and its ranges from 3200 mg / lit to 3000 mg / lit.
iv. The COD / BOD ratio ranges from 1.62 to 2.20, which indicate that the wastewater is less biodegradable.
v. The variation in the COD necessitates the provision of the equalization of wastewater before biological treatment.
vi. The wastewater is acidic hence it is suggested to add Noah or Na_2co_3 to make it neutral for effective biological treatment.
vii. At HRT 12 hr. COD removal efficiency of the order of 66.67% is obtained using pilot plant scale UASB reactor. But with proper equalization of wastewater higher efficiency would be achieved if UASB reactor is operated for more days.

viii. The gas generations was found to be very less is found to be 0.2427 m^3 / kg of COD removal. The biogas from the system may be used to meet the energy requirement of the industry during load shading as well as for domestic purpose.

ix. The average COD value after treatment will be (3250X66.67%) is 1150 mg / l and according to average COD / BOD ratio of 1.89 and BOD from 1800 mg/l which after treatment BOD will be 518 mg / l which is 70 % reduction of BOD. which are more than the standards for the disposal of wastewater into the stream.

To remove total impurities of effluent up to permissible limit UASB based ETP should use which include neutralization cum equalization tank coagulation sedimentation tank UASB reactor stabilization tank respectively required. Some amount of COD and BOD may also removed along with solids if physio-chemical (coagulation and sedimentation) is applied. (The study is required to be carried out in detail).

Thus from the above study two stage biological treatment is recommended.

The anaerobic process is more effective and efficient method of effluent treatment because it having a high organic load and for high organic load wastewater UASBR is more effective that includes following points are as follows :

Anaerobic process UASB require less land than aerobic process so UASB process is land effective and therefore cost effective also.

UASB reactor remove COD and BOD totally so it is more effective than aerobic process.

Biogas production is a big advantage in UASB process and biogas can used for energy(but usually first require scrubbing)

High reduction of BOD.

Can withstand high organic and hydraulic loading rates

Low sludge production (and, thus, infrequent desludging required)

Effluent is rich in nutrients and can be used for agricultural irrigation

Low land demand, can be constructed underground and with locally available material

Reduction of CH4 and CO2 emissions

Nowadays for the industrial effluent treatment of having high organic load the anaerobic process UASBR is more often useful because this is more efficient than aerobic process.

From above study it seems that the UASBR based ETP process is more effective for industrial wastewater treatment and it is noted that if we make this ETP plant for this TOP'N TOWN Ice cream factory for 1,50000 lit/day capacity and as for factor of safety for future aspect the UASBR based ETP is suggested for 2,50000 lit/day capacity then from above study ample merits of UASB over aerobic process may given and they are as follows

1. **Land effective**
   The land required very less to set UASB based ETP it will be around 40,000 sq.f. approximately including all the parts as well as gardening also there. And aerobic process take around 60,000 sq.f. for the same. which is very less than aerobic process. so it is land effective therefore cost effective also.
2. **Bio Gas production**
   It is another major advantage of UASB which not in aerobic process so the biogas can be use as for power. if UASB work for 2,50,000 lit per day capacity then gas will produce 3500 m^3/kg or 520 m^3/d. Which can be use to achieve energy requirement for factory or any other as a whole. the biogas production in **UASB** rector depends upon the organic load of wastewater, high organic load wastewater produce more biogas. And it also depends on COD and BOD value, if COD and BOD will more than the biogas production will more in the reactor.

Sludge generation in this process is also less so maintenance for sludge will be less than others. So this process is totally efficient for industrial effluent treatment than other methods of aerobic treatment.

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