Removal of Chemical Oxygen Demand from Textile Industrial Wastewater by Anaerobic Digestion
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Abstract— This work focuses on monitoring the COD removal by anaerobic digestion of liquid textile wastewater under controlled conditions. A laboratory scale models of anaerobic digester of 8L capacity, with gas collecting bottles were setup to treat textile industry wastewater. The performance of the reactor in removing COD, Total Solids and Alkalinity were studied, with reference to different organic loading rates of 0.01, 0.02, 0.03 kg COD/m3.d. The highest yield of alkalinity, percentage COD removal and total solid is 1123.28mg/L, 62.49% and 89.28% respectively.

Key words: Anaerobic Digestion, COD, Organic Loading Rates, Total Solids, Textile Wastewater, Alkalinity

I. INTRODUCTION
Textile industries consume large volumes of water and chemicals during wet processing of textiles. Slashing, bleaching, mercerizing and dyeing are the major consumption activities as well as wastewater generation. The chemical reagents used during manufacture and processing are diverse in chemical composition ranging from inorganic compounds to polymers and organic products. The pollutant features of textile wastes differ widely among various organic substances such as dyes, starches and detergents in effluent undergo chemical and biological changes which consume dissolved oxygen from the receiving stream and destroy aquatic life. Such organics should be removed to prevent septic conditions and avoid rendering the water body unsuitable for municipal, industrial, agricultural and residential uses. Treatment of wastewater will definitely reduce the waste, prevent and make positive effects on its further uses. [1]

Instead of using the physic-chemical treatments, various biological methods can be used to treat the wastewater from the textile industry. Biological treatment (aerobic and anaerobic type) is the most common and widespread technique used in textile wastewater treatment [Hunger 2003]. The biological treatment method include biosorption, use of enzymes, aerobic and anaerobic treatments [Nuran and Esposito 2000]. Only biotechnological solutions can be used for the reduction of COD. [1]

1.1 ANAEROBIC DIGESTION
If free dissolved oxygen is not available to the sewage, then anaerobic decomposition called putrefaction will occur. Anaerobic bacteria as well as facultative bacteria operating anaerobically will then flourish and convert the complex organic matter into simple organic compounds. The organic acids including alcohols produced are further converted into methane (CH₄), hydrogen sulphide (H₂S) and carbon dioxide gas (CO₂), if methane forming bacteria are also especially present in the reactor. This conversion is represented by the equation: [2]

\[ \text{Organic acids} \rightarrow \text{CH}_4 + \text{CO}_2 + \text{Heat (energy)} \]

Fig. 1:

1)Anaerobic Digestion (stages)
Biogas production through anaerobic digestion is a biochemical process involving microbial flora of bacteria adapted to oxygen free environment to convert complex biological and inorganic waste in sequential stages into methane, the major energy fuel.

2) Hydrolysis
This is the first step, carried out by strict anaerobes such as bacterides, clostridia and facultative bacteria such as streptococci etc. This stage is very important because large organic molecules are simply absorbed and used by microorganisms as a substrate/food source.

3) Acidogenesis
The monomers produced in the hydrolytic phase are taken up by different facultative and obligatory anaerobic bacteria and are degraded further into short chain organic acids such as butyric acids, propanoic acids, acetic acids, alcohols, hydrogen and carbon dioxide. In general, during this phase, simple sugars, fatty acids and amino acids are converted into organic acids and alcohols. [3]

4) Acetogenesis
The products produced in the acidogenic phase are consumed as substrates for the other microorganisms, active in the acetogenic phase and thus convert the organic acids into hydrogen, acetate and carbon dioxide (gas).

5) Methanogenesis
In the methanogenic phase, the production of methane and carbon dioxide from intermediate products is carried out by methanogenic bacteria under strict anaerobic conditions. Methanogenesis is a critical step in the entire anaerobic digestion process as it is the slowest biochemical reaction of the process. [3] Figure 1.0 shows the whole anaerobic process.

B. Objectives of The Study
The main objective of this study is to remove the COD, Alkalinity and Total solids from the textile wastewater using...
anaerobic digestion process. To study the variation of alkalinity, total solids, and percent removal of COD from textile industrial wastewater. To know the performance of the digester at ambient temperature. To know the effect of increase in organic loading rate on the performance of anaerobic digestion process.

II. LITERATURE REVIEW
As textile industry is one of the largest industries in the world and different fibers such as cotton, silk, wool, natural fibers as well as synthetic fibers are all pre-treated, processed, colored and after treated using large amounts of water and a variety of chemicals, there is a need to understand the chemistry of the textile effluents very well. Major pollutants in textile wastewaters are high suspended solids, chemical oxygen demand, heat, color, alkalinity and other soluble substances whose chemistry will be emphasized. Parallel to usage of huge amounts of water and chemicals, the textile dyeing and finishing industry is one of the major polluters among industrial sectors, in the scope of volume and the chemical composition of the discharged effluent. Dyeing, desizing and scouring are the major sources of water pollution in textile effluent. Specific problems pertaining to the textile industry include COD removal from textile industry wastewater. [1]

Simmi Goel (2010) in present paper, continuous anaerobic treatment technology has been developed in anaerobic baffle reactor and some parameters HRT, OLR, pH and temperature were optimized. Active bacteria for degradation were added as digested sewage sludge. Highly coloured wastewater has successfully been treated in anaerobic baffle reactor. Textile industrial waste organic matter gave maximum biogas yield of 1.64±0.02 L/d, methane of 83%, and COD removal 71.5% at optimal parameters of OLR 0.5 kg/m²·d, pH of 6.5-7.3 and at a temperature of 30-35°C. [4]

M. Shohidullah Miah (2012) To minimize the cost effective treatment process a treatment process has been setup at Dalas Fashion Ltd and Liz Fashion Ltd, Gazipur, Dhaka. The treatment process consisted of a combined process (anaerobic and bio-filtration process) to remove the pollution through biological processes. The anaerobic process followed by Up-flow Anaerobic Sludge Blanket (UASB) process and Bio-filtration was maintained by polyurethane materials followed by down-flow process. The treatment processes are successfully operating without any chemical treatment process being thus more economic than the traditional chemical alternative. The raw textile wastewater is highly polluted with the characteristics of high alkaline in nature, pH=9-10, suspended biomass TSS=1229-1500 mg/L, Chemical oxygen demand, COD = 1448-2000 mg/l, and biological oxygen demand, BOD= 550-800 mg/L. Significant reductions were achieved to remove TSS (98%) through bio-filtration process. In addition in the final effluent the removal efficiency were found COD (98%), BOD (94%). [5]

III. MATERIAL AND METHODOLOGY
A. Fabrication and experimental setup:
The schematic diagram of experimental setup used for the present study is shown in figure 2. Aspirator bottle no.1 of 10.0L capacity will be used as digester with working volume of 8.0L. The digester was connected with the bottle no.2 of 5.0L capacity, which will contain the brine solutions. The amount of gas collected in bottle no. 2 replaces the same amount of brine solution to bottle no. 3. For the initial startup, cow dung slurry and septic waste are used as seed sludge and mixed with wastewater and placed in the digester for acclimatization. From 5th day, regular wasting of digested sample and feeding of the fresh sample were continued until steady state conditions were reached. The steady was carried out for different organic loading rate of 0.01-0.03 kg COD/m³·d at ambient temperature (room temperature).

![Experimental Setup of anaerobic reactor](image)

**Fig. 3: Experimental Setup of anaerobic reactor**

B. Startup of Reactor
During the start-up of the reactor, the reactor was loaded with 1.5 L of cow-dung slurry and septic waste & 6.5 L of textile wastewater with a COD concentration of 1040 mg/L, this mixture gave a composite COD of 375 mg/L. By wasting 300mL of digested sludge, the reactor was loaded with fresh wastewater of volume 300mL with a COD concentration of 300 mg/L. The reactor pH was adjusted to 7.0 every day and the reactor was operated till stabilization achieved (30 days). During organic loading of 0.01-0.03 kg COD/m³·d, 300mL of effluent sample was collected for analysis of various physico-chemical parameters such as pH, COD, alkalinity, total solids and the analysis were carried out as per the standard methods for the examination of water and wastewater (AWWA) 20th edition.

C. General Characteristics of Textile Wastewater:
The fresh wastewater samples were brought from “ETCO Denim Infrastructure, Vijayapur, Karnataka.” to P.D.A Engg. College laboratory and preserved in deep freeze, to analyze the typical characteristics. The key pollutants in the wastewater are organic compounds and solids. Biodegradability may be estimated on the basis of BOD / COD ratio. This ratio ranges between 0.42-0.64, which indicates that the part of the organic compounds in the wastewater is not easily biodegradable. The BOD₅ is 693mg/L, COD is 1040mg/L & Total Solids in wastewater was found to be 3200 mg/L. When wastewater contains high concentration of organic matter, dissolved oxygen depletes because of the breakdown of organic matter, in absence of oxygen, sulphate acts as an electron acceptor to produce H₂S and odour.
IV. RESULTS AND DISCUSSION

The results of variation of alkalinity, total solids and percentage COD removal are shown in Figure 3, Figure 4 & Figure 5 for varying Organic Loading Rate.

The reactor was started with an OLR of 0.01 kg COD/m³.d and operated for a period of 26 days till it attains stabilization. During this period the pH is maintained from 7.04-7.00, the alkalinity decreased from 654.11-997.2 mg/L, total solids reduced from 3060-1476 mg/L & COD reduced from 419.33-280.69 mg/L, refer Figure 3. On 61st day the maximum COD removal efficiency obtained is 54.65 %. As the time increased, %COD removal increased & attained optimum value on 61st day. When the OLR was increased from 0.02 to 0.03 kg COD/m³.d (67-91 days) & operated for a period of 25 days till the reactor stabilizes. Throughout the study period the pH is maintained from 7.03-7.04, the alkalinity increased from 550.12-845.00 mg/L, total solids reduced from 3000-782 mg/L & COD reduced from 521.00-373.36 mg/L refer Figure 5. On 91st day the maximum COD removal efficiency obtained is 61.74 %. As the time increased, %COD removal increased & attained optimum value on 91st day. Add cod, solids, alkalinity dal

V. CONCLUSIONS

The maximum COD removal efficiency is 62.49 % achieved after 30th day (optimizing time) at an organic loading rate of 0.01 kg COD/ m³.d. It was noticed that the percent COD removal was increased and attained optimum value on 91st day from the start up. As the OLR was increased from 0.01 to 0.03 kg COD/m³.d, percent COD removal increased from 18.33-62.49%, 32.25-54.65% and 46.51-61.74%, total alkalinity was decreased from 783.33-1123.28 mg/L, 654.11-997.20 mg/L and 550.12-845.00 mg/L respectively. Total solids decreased from 3060-1476 mg/L, 3101-343 mg/L and 3000-782 mg/L respectively.

REFERENCES