Treatment of Paper industrial wastewater by Anaerobic Digestion

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Abstract

The aim of this study was to treat Paper Industrial wastewater by anaerobic digestion. Digestion lasted for a hydraulic retention time of 93 days. The total quantity of biogas produced was 992ml. A laboratory scale models of anaerobic digester of 8L capacity, with gas collecting bottle were setup. The performance of the reactor in removing COD, BOD, Nitrate , Chloride, Total Solids and Alkalinity were studied, with reference to different Organic loading rates of 0.5, 1.0, 1.5 kg COD/m^3.d. The highest yield of Alkalinity, COD removal, BOD removal, removal of chloride, removal of Nitrate and Total solid is 1235mg/L, 82.32%, 84.61%, 94.51%, 84.62%, 78%.

Keywords: Anaerobic Digestion, COD, Organic Loading Rates, Total Solids, Paper wastewater, Alkalinity.

1.0 Introduction

Water pollution is a serious problem in India as almost 70 percent of its surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic, and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities, such as irrigation and industrial needs. This shows that degraded water quality can contribute to water scarcity as it limits its availability for both human use and for the ecosystem.

The pulp and paper Industry is one of India's oldest and core Industrial sector. The socio-economic importance of paper has its own value to the country's development as it is directly related to the Industrial and economic growth of the country. Paper manufacturing is a highly capital, energy and water intensive Industry. It is also a highly polluting process and requires substantial investments in Pollution Control equipment. In India, around 905.8 million m^3 of water is consumed and around 695.7 million m^3 of wastewater is discharged annually by this sector. India's current average fresh specific water consumption of about 150 m^3/tone of product is far above the global best specific water consumption of 28.66 m^3/tone (for large scale wood based pulp and paper mill) and this large gap is primarily attributed to the use of obsolete technology / equipments and poor water management practices. The large water requirements and consumption by the Indian pulp and paper industries has led to water fast becoming a scarce commodity and lowering of the groundwater table and thus increased pumping costs and more importantly water shortage in many regions. Realizing the importance of water and excessive usages of water by pulp and paper sector, Central Pollution Control Board (CPCB) has taken initiative to develop the water conservation guidelines and water consumption standards and entrusted National Productivity Council to undertake the study to address these issues.[1] Instead of using the physico-Chemical treatments, various biological methods can be used to treat the wastewater from the Paper Industry. Biological treatment (aerobic and anaerobic type) is the most common and wide spread technique used in Paper wastewater treatment.

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 gas (CH_4), Carbon dioxide gas (CO_2), etc.

1.1 Anaerobic Digestion Stages:

Stage 1: The Hydrolytic Bacteria primarily are involved in the breakdown of complex Organic waste streams into simple sugars, fats and oils, and amino acids. This stage involves splitting of the complex Organic biological molecules into simpler forms, the process is known as Hydrolysis or Liquefaction.

Stage 2: The Fermentative Acidogenic Bacteria convert the hydrolyzed portion into Organic acids.

Stage 3: The Fermentative Acetogenic Bacteria then convert the Organic acids into Hydrogen, Acetate and CO_2(g).

Stage 4: Finally, the Methane producing Bacteria, the Methanogens simultaneously produce Biogas from the Acetate, or from Hydrogen and Carbon dioxide.

2.0 Materials and Methodology

2.1 Wastewater collection:

The wastewater sample is collected from Local Paper Mill. The grab sample of wastewater is collected and brought to PDA Engineering College, Kalaburagi and kept in Deep Freezer for analysis.

2.2 Fabrication and Experimental setup

The Schematic Diagram of Experimental setup used for the present study is shown in Figure 1. Aspirator bottle no.1 of10.0L 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 start up, the filtered cow dung are used as seed sludge and placed in the digester for acclimatization. From 6th day regular wasting of digested sample and feeding of the fresh sample were continued until steady state conditions were reached. The study was carried out for different Organic loading rate of 0.5-1.5 kg COD/m^3.d at ambient temperature (room temperature).

During the start-up of the Digester was loaded with 2.0 L of cow-dung slurry (300gm of Cow dung + 1500mL water and Fresh Sewage of 500mL) and 6.0 L of Paper wastewater, this mixture gave a composite COD of 382mg/L. The reactor was adjusted to 7.0 every day and the reactor was operated till stabilization achieved (30 days).

3.0 Results and Discussion

3.1 General

The characteristics of Paper wastewater and the Experimental data relating to Anaerobic Digestion are discussed here.

3.2 Characteristics of Paper Wastewater

The characteristics of Paper wastewater are presented in Table 1

3.3 Performance of reactor at 300mg/L COD concentration for Organic loading rate of 0.5 kg COD/m^3.d

The reactor was started with an OLR of 0.5 kg COD/m3.d and operated for a period of 25 days till it attains stabilization. During this period the pH is maintained from 7.02-7.01. The COD reduced from 382-139mg/L, BOD reduced from 156-42mg/L, Nitrate decreased from 67mg/L to 19.3mg/L, Chlorides decreased from 456-70mg/L, Total solids decreases from 1840mg/L to 1386mg/L, Yield of Alkalinity varies from 810-1020mg/L, as shown in figure 2.

3.4 Performance of reactor at 600mg/L COD concentration for Organic loading rate of 1.0 kg COD/m^3.d

When Organic Loading Rate increased from of 0.5 kg COD/m^3.d to 1.0 kg COD/m^3 and operated for a period of 25 days till it attains stabilization. During this period the pH is maintained from 7.02-7.04. The COD reduced from 746-165mg/L, BOD reduced from 325-50mg/L, Nitrate decreased from 67mg/L to 18.2mg/L, Chlorides decreased from 456-68mg/L, Total solids decreases from 1840mg/L to 1190mg/L, Yield of Alkalinity varies from 810-1235mg/L, as shown in figure 3.

3.5 Performance of reactor at 2100mg/L COD concentration for Organic loading rate of 1.5 kg COD/m^3.d

When Organic Loading Rate increased from of 1.0 kg COD/m^3.d to 1.5 kg COD/m^3 and operated for a period of 25 days till it attains stabilization. During this period the pH is maintained from 7.02-7.06. The COD reduced from 1013-179mg/L BOD reduced from 424-95mg/L , Nitrate decreased from 67mg/L to 10.3mg/L, Chlorides decreased from 456-25mg/L, Total solids decreases from 1840mg/L to 1050mg/L, Yield of Alkalinity varies from 810-1143mg/L, as shown in figure 4.

3.6 Gas production

The amount of gas produce in this work is 562ml, 872ml and 1228ml at Organic Loading Rate of 0.5 kg COD/m^3, 1.5 kg COD/m^3 and 1.5 kg COD/m^3 as shown in Fig 5.

4.0 Conclusion

On analyzing the results based on the laboratory experiments conducted, the following conclusion is drawn.

1. The maximum COD removal efficiency is 82.32 % achieved after 93rd day (optimizing time) at an organic loading rate of 1.5 kg COD/ m^3.d.
2. The maximum BOD removal efficiency is 84.61 % achieved after 62nd day (optimizing time) at an organic loading rate of 1.0 kg COD/ m^3.d.
3. The maximum Biogas produced is 1228mL after 93rd day at an OLR of 1.5 kg/m^3.d.

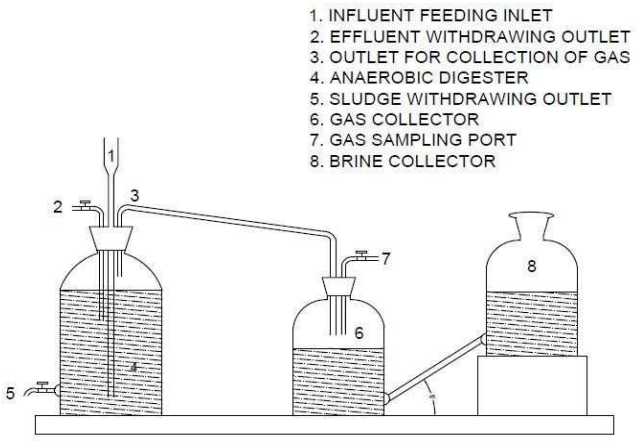

Fig 1 Experimental setup of anaerobic digester

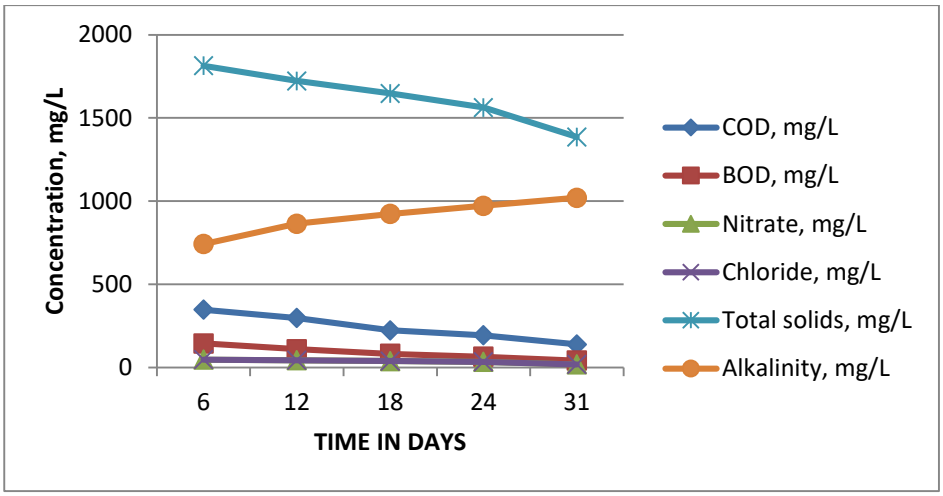

Fig 2: Graph showing removal of COD, BOD, Nitrate, Chloride, Total Solids and Alkalinity at OLR 0.5kg COD/m^3.d

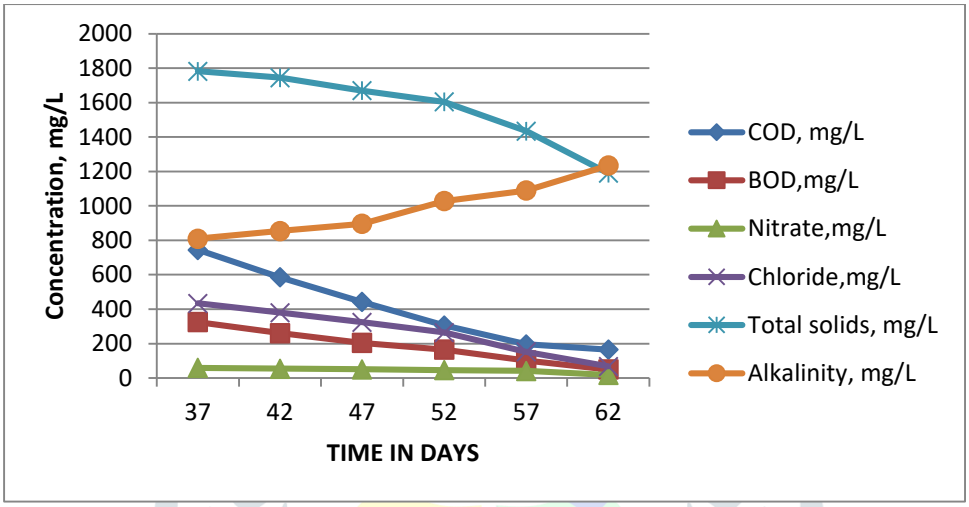

Fig 3: Graph showing removal of COD, BOD, Nitrate, Chloride, Total Solids and Alkalinity at OLR 1.0kg COD/m^3.d

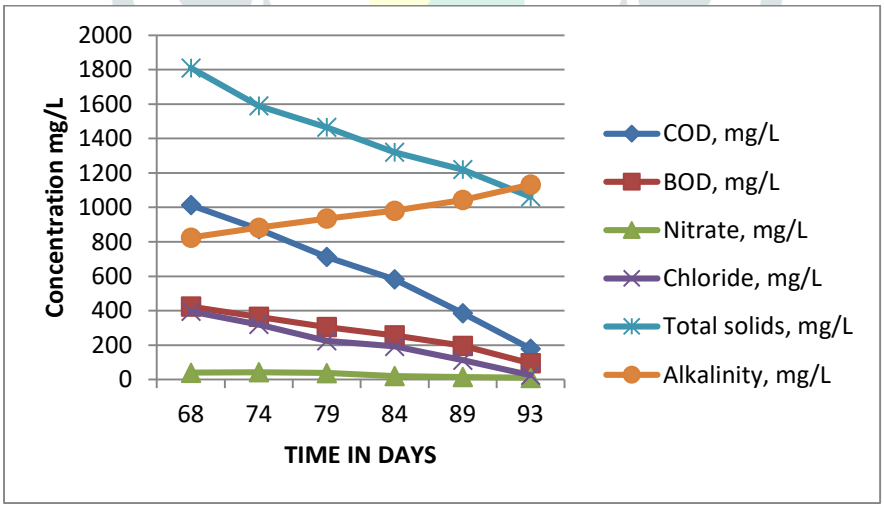

Fig 4: Graph showing removal of COD, BOD, Nitrate, Chloride, Total Solids and Alkalinity at OLR 1.5kg COD/m^3.d

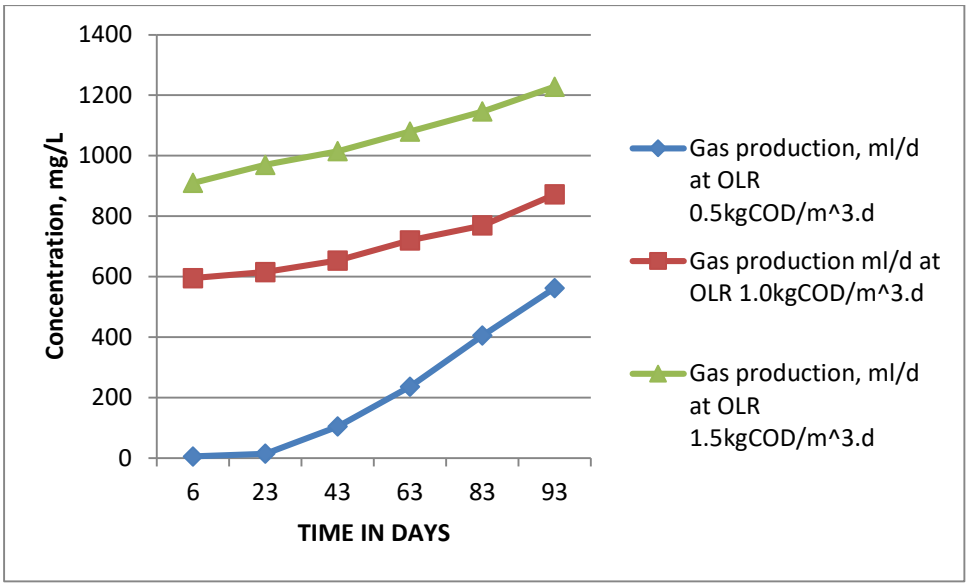

Fig 5: Biogas production at varying OLR

Table 4.1 Characteristics of Paper wastewater

Sl. no	Characteristics	Paper waste water
1	Color	Brown
2	pH	11
3	Total solids, mg/L	1840
4	Dissolve solids, mg/L	1460
5	Suspended solids, mg/L	380
6	BOD_5@20^0C, mg/L	487
7	COD, mg/L	1120
8	Chlorides, mg/L	456
9	Alkalinity, mg/L	810
10	Nitrates, mg/L	67

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