

Evaluation of Anaerobic Digester for Treating Paper Mill Waste Water

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Abstract

Background/Objective: The Indian paper industry accounts for about 3% of the world's production of paper. So the generation and disposal of paper and pulp industry wastewater is very high. Disposal of untreated mill effluent will damage the environment. Therefore treatment of papermill effluent is necessary. **Methods/Statistical Analysis:** In this investigation the bleach liquor from the paper mill wastewater is subjected to biological treatment process. Usually bleach liquor is not effective in the biological treatment process. In this study along with the effluent, cow dung and activated sludge from domestic wastewater are added as a seeding materials by the ratio of 20%, 30%, 40%, 50% replacement in the 500ml serum bottle and closed tightly to maintain anaerobic condition. The wastewater initial characters are analyzed and evaluated the biogas production daily. Finally if the gas production stopped the wastewater and the seeding materials inside the reactor is characterized. **Findings:** The 50% wastewater and the 50% seeding materials (cow dung and activated sludge combination) gave the high yield of biogas and degrade the organic contaminants effectively. **Improvement/Applications:** The activated sludge is used as a seeding material to biodegrade the organic pollutants present in the wastewater especially the bleach liquor. It will help to improve the biological treatment process of bleach liquor effluent treatment with activated sludge in continuous mode of operation to treat the effluent.

Keywords: Anaerobic Digester, Activated Sludge, Batch Reactor, Biogas, Biological Treatment Process, Paper and Pulp

1. Introduction

Pulp and paper industry is considered as one of the most polluting industries in the world. The Indian paper industry accounts for about 3% of the world's production of paper. The demand of the paper is very high, but the paper making process required large amount of water. The volume of water required for the production of paper is based on their raw materials and their production process^{1,2}. The natural raw material used for the process are wood, bamboo, recycled fibre, bagasse, wheat straw, rice husk, etc., approximately 31% are based on wood, 47% on recycled fibre and 22% on agro-residues. The production process consists of two main steps: pulping and bleaching. Pulping is the initial stage process and that can require high amount of freshwater meanwhile it can discharge the wastewater approximately 200m³ /tonne³. The major raw materials like wood chips which consists of high composition of cellulose fibres, carbohydrates

such as starch, sugars and lignin is an adhesive substance which help to bond the cellulose fibres⁴⁻⁶. Bleaching is the last stage of process; it is treatment of cellulosic fibre with chemicals to increase brightness^{1,4}. The wastewater generated from the paper mill industry which consists of high concentration of organic and inorganic chemicals including lignin, cellulosic compounds, phenols, sulphides and chlorinated compounds. In this investigation the wastewater is collected from the final stage of the production, next to the bleaching³. In this bleached effluent usually consist of high amount of halogenated organic compounds, Because of the biological persistence and toxicity of these compounds to aquatic organisms, the conventional bleaching process is responsible for the most severe water pollution of the whole pulp and paper industry. It consists of high amount of chlorine, chlorine dioxide, and hypochlorite etc⁴. These chlorine components are not initiated the generation of microbes in effluent. Therefore the attention is turned

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to physicochemical treatment method like oxidation, precipitation, flocculation, adsorption and ion exchange³. Then only this kind of effluent is undergoes chemical treatment process instead biological treatment process⁷. In this study is to determine the biological investigation of effluent and their characteristics in an anaerobic process⁵ to produce the biogas in the treatment of paper and pulp effluent.

2. Sample Collection and Seeding Material Preparation

The paper mill wastewater sample was collected from the Paper and pulp industry which is located at Erode. The required amount of sample for the experimental purpose was preserved in a closed airtight non react able high dense polyethylene container. The seeding materials like activated sludge from the sewage treatment plant was collected. Activated sludge from the sewage treatment plant was collected and used as inoculums in the experiment. After the collection of the sludge it was left to settle under gravity for 14 days and then it was dewatered manually. To the dewatered sludge, nutrients were added for microbial and were maintained in an anaerobic condition for 5 days before starting the experiment. The nutrients like ammonium chloride, calcium chloride, magnesium sulphate added to the sludge⁶. The seeding materials are prepared for the ratio optimization. The ratio optimization method was done to acquire the best ratio of paper mill effluent and seeding material with the recovery of maximum biogas. The bottling process was used to evaluate the optimum ratio of wastewater and seeding material mixture for biogas production⁸.

3. Experimental Study

3.1 Initial Characterises of Wastewater and Activated Sludge

The paper mill wastewater is to be collected and that wastewater initial characteristics are done. The chemical characteristics were done. There are pH, Dissolved solids, Conductivity, Alkalinity, Chloride, BOD, COD, and DO. The obtained results are produced is shown in the Table 1.

Table 1. Initial Characterises of Paper mill Wastewater and Activated sludge

Parameter	Value (WW)	Value (AS)
pH	7.6	7.25
Total dissolved solids	0.4 ppt	1.2 ppt
Conductivity	0.4 mS/cm	2.4 mS/cm
Total suspended solids	2000 mg/l	4000 mg/l
Dissolved solids	12000 mg/l	1000 mg/l
Total solids	14000 mg/l	5000 mg/l
Total fixed solids	12000 mg/l	4000 mg/l
Total volatile solids	2000 mg/l	1000 mg/l
Chloride	65 mg/l	68 mg/l
Alkalinity	275 mg/l	250 mg/l
Dissolved oxygen	20 mg/l	20 mg/l
BOD	100 mg/l	40 mg/l
COD	1280 mg/l	2040 mg/l

The activated sludge are used as a seeding material that to be useful for a producing of microorganisms. Activated sludge is also the name given to the active biological material produced by activated sludge plants. Excess sludge is called “waste activated sludge” and is removed from the treatment process to keep the ratio of biomass to food supplied in the wastewater in balance. Due to the presence of microorganisms the gas production are to more.

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3.2 Bottling Process Test

The bottling process is used as an index of the anaerobic biodegradation. The ability of a biomass produce biogas can be assessed by bottling process. It has been widely used to determine the methane yield of organic substrate in specific condition. The duration of the test varies depending on the biodegradation of organic substrate under study. This method can be used to determine the amount of organic carbon in a given material that can be an aerobically converted to methane and to evaluate the biogas production efficiency of the anaerobic process on a given material. The information provided by bottling

process is valuable when evaluating anaerobic substrate and for optimizing the design and operation of an anaerobic digester⁸.

3.2.1 Experimental Setup for the Bottling Process Test

The experiment was performed in 500 ml serum bottles. The effective volume of the reactor was maintained as 400 ml rest of 100 ml space was left free for gas collection. Anaerobic seed sludge and the wastewater substrate was mixed at different ratio and added to the bottles and the process is started by batch reaction⁹. Then the batch system is sealed with rubber cork throughout the experiment. The reactor was stirred by daily shaking and swirling. A retention time of minimum 30 days was maintained for the reactors or till the end of the biogas production^{8,9}. A tube is inserted through the cork such a way that one ends a syringe. This syringe was connected to the rubber cork of the serum bottle to measure the gas production by displacement method. This setup is done to minimize the contact of oxygen⁸. The schematic bottling process is shown in the Figure 1.

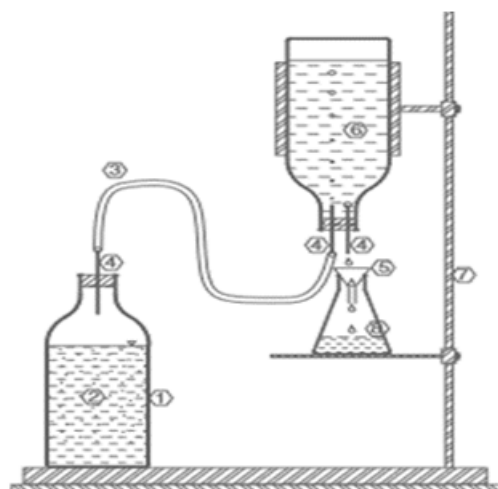


Figure 1. Schematic Diagram of Bottling process.

3.2.2 Ratio of the Reactor by Wastewater and Activated Sludge

In these processes 500ml reactor named as R1, R2, R3, and R4 was done in the different ratio with the volume of 500ml. The wastewater is placed in reactor respectively. The respective % of seeding material is added. The seeding material was used as cow dung and activated

sludge. The ratio of the reactor by 50%, 60%, 70%, 80%. The proportion ratio of wastewater with cow dung and activated sludge are shown in the Table 2. The ratio of the reactor R1 by 50% of wastewater & 50% activated sludge are to be done. In the 500 ml of bottle the 250 ml of wastewater and 250 ml of activated sludge are poured in to the bottle and there gas production by the ratio is collected by the conical flask by the water through a water displacement method. The ratio of the reactor R2 by 60% of wastewater & 40% activated sludge are to be done. In the 500 ml of bottle the 300 ml of wastewater and 200 ml of activated sludge are poured in to the bottle and there gas production by the ratio is collected by the conical flask by the water through a water displacement method. The ratio of the reactor R3 by 70% of wastewater & 30% activated sludge are to be done. In the 500 ml of bottle the 350 ml of wastewater and 150 ml of activated sludge are poured in to the bottle and there gas production by the ratio is collected by the conical flask by the water through a water displacement method. The ratio of the reactor R4 by 80% of wastewater & 20% activated sludge are to be done. In the 500 ml of bottle the 400 ml of wastewater and 100 ml of activated sludge are poured in to the bottle and there gas production by the ratio is collected by the conical flask by the water through a water displacement method^{10,11}.

The characteristics are done and the range of the parameter of wastewater with seeding material by the ratio of 50% 60% 70% 80% are shown in the Table 3, 4. The percentage removal of chloride, alkalinity, DO, BOD, COD of wastewater with seeding material VS activated sludge are shown in the Figure 2.

Table 2. Proportion ratio of Waste Water (WW), Cow Dung (CD) and Activated Sludge (AS)

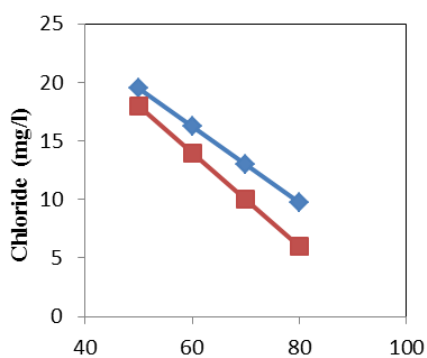
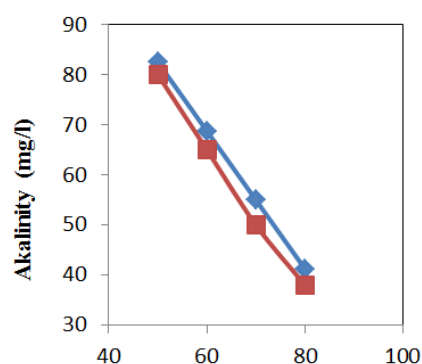
Symbol	WW, %	CD, %	AS, %
R1	50	50	0
R2	60	40	0
R3	70	30	0
R4	80	20	0
R5	50	0	50
R6	60	0	40
R7	70	0	30
R8	80	0	20

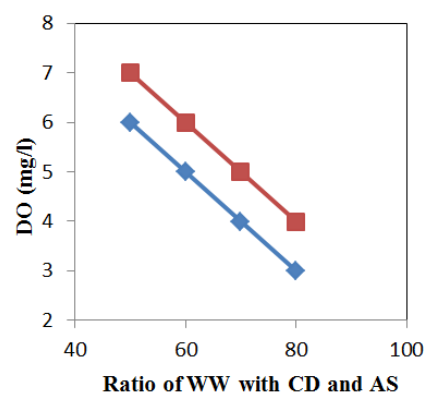
Table 3. Characterises results of Waste Water by Cow dung

Parameter	Ratio of WW and CD			
	(50:50)	(60:40)	(70:30)	(80:20)
pH	7.6	7.6	7.6	7.6
Total dissolved solids	0.4 ppt	0.45 ppt	0.4 ppt	0.47 ppt
Conductivity	0.7mS/cm	0.7mS/cm	0.7mS/cm	0.7mS/cm
Total suspended solids	1400 mg/l	1500 mg/l	1400 mg/l	1700 mg/l
Dissolved solids	8400 mg/l	9000 mg/l	8400 mg/l	10200 mg/l
Total solids	9800 mg/l	10500 mg/l	9800 mg/l	11900 mg/l
Total fixed solids	8400 mg/l	9000 mg/l	8400 mg/l	10200 mg/l
Total volatile solids	1400 mg/l	1500 mg/l	1400 mg/l	1700 mg/l
Chloride	45.5 mg/l	48.75 mg/l	45.5 mg/l	55.25 mg/l
Alkalinity	192.5 mg/l	206.25 mg/l	192.5 mg/l	233.75 mg/l
Dissolved oxygen	14 mg/l	15 mg/l	16 mg/l	17 mg/l
BOD	70 mg/l	75 mg/l	80 mg/l	85 mg/l
COD	896 mg/l	960 mg/l	896 mg/l	1088 mg/l

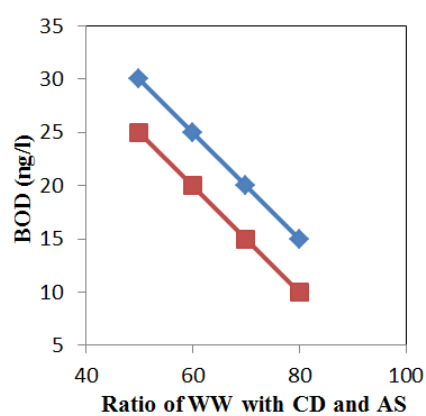
Table 4. Characterises results of Waste Water by Activated sludge

Parameter	Ratio of WWand AS			
	(50:50)	(60:40)	(70:30)	(80:20)
pH	7.25	7.25	7.25	7.25
Total dissolved solids	1.2 ppt	1.2 ppt	1.25 ppt	1.27 ppt
Conductivity	2.5mS/cm	2.5mS/cm	2.5mS/cm	2.5mS/cm
Total suspended solids	3500 mg/l	3500 mg/l	3700 mg/l	3800 mg/l
Dissolved solids	650 mg/l	650 mg/l	750 mg/l	800 mg/l
Total solids	4150 mg/l	4150 mg/l	4450 mg/l	4600 mg/l
Total fixed solids	650 mg/l	650 mg/l	8400 mg/l	10200 mg/l
Total volatile solids	1400 mg/l	1500 mg/l	750 mg/l	800 mg/l
Chloride	48.5 mg/l	48.5 mg/l	55 mg/l	58 mg/l
Alkalinity	167 mg/l	167 mg/l	195 mg/l	208 mg/l
Dissolved oxygen	13 mg/l	14 mg/l	15 mg/l	16 mg/l
BOD	15 mg/l	20 mg/l	25 mg/l	30 mg/l
COD	1650 mg/l	1720 mg/l	1764 mg/l	1848 mg/l

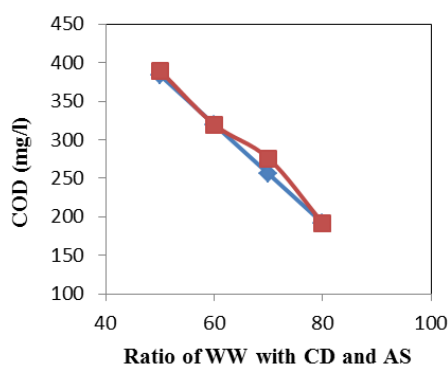
**Ratio of WW with CD and AS****(a) Chloride removal (mg/l)****Ratio of WW with CD and AS****(b) Alkalinity removal (mg/l)**



(c) DO removal (mg/l)



(d) BOD removal (mg/l)



(e) COD removal (mg/l)

Figure 2. Graphical Representation of various chemical characteristics removal by cow dung VS activated sludge.

4. Results and Discussion

In the 50% of wastewater and seeding material as well as activated sludge the biogas production are more when we compare to rest of those percentage but in 50% also after 10 days the gas production was stopped. In 50% by

their waste water and seeding material by cow dung the gas production is more than when we compared to 50% of wastewater and activated sludge where we used^{12,13}. In the bottling process the amount of gas produced by the small quantity which was collected through the conical flask by the water in the mean of water displacement method. The value of biogas by water displacement method of wastewater with cow dung is given in Table 5. The values of biogas production by water displacement method by cow dung VS activated sludge in the various proportions are shown in the Figure 3.

Table 5. Evaluation of biogas production Waste Water with Cow dung

Days	R1	R2	R3	R4
1	5.5 ml	3.5 ml	3.5 ml	3 ml
2	4.5 ml	1 ml	1 ml	1.5 ml
3	3.7 ml	1 ml	0	0
4	2.4 ml	1 ml	0	0
5	1.7 ml	1 ml	0	0
6	1.4 ml	0	0	0
7	1.2 ml	0	0	0
8	1.1 ml	0	0	0
9	1.1 ml	0	0	0
10	0	0	0	0

In the activated sludge the microorganisms are became to death, so there is no gas production. Instead of activated sludge any other seeding material are too be used for an example cow dung, so hope the gas production will improve by adding of an another seeding material in the reactor by the different ratio. The volume of gas production is measured by water displacement method of wastewater with activated sludge are shown in the Table 6 and Figure 3 respectively.

Table 6. Evaluation of biogas production Waste Water with Activated sludge

Days	R5	R6	R7	R8
1	4.7 ml	3.2 ml	2.7 ml	2 ml
2	4.5 ml	2.6 ml	1.9 ml	1.7 ml
3	3.7 ml	1.7 ml	1.2 ml	1.2 ml
4	2.4 ml	1.3 ml	1 ml	0
5	1.9 ml	1 ml	0	0
6	1.4 ml	0	0	0
7	1.2 ml	0	0	0
8	1 ml	0	0	0
9	1 ml	0	0	0
10	0	0	0	0

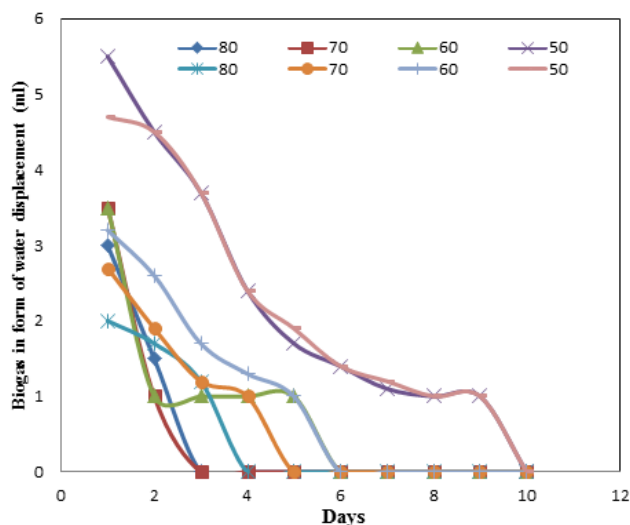


Figure 3. Evaluation of biogas production Wastewater by Activated sludge Vs. Cow dung.

5. Conclusion

The removal of chloride, alkalinity, dissolved oxygen, BOD, COD was obtained by wastewater with seeding material as a maximum of 15% to 46% were removed. The biodegradation was also found in this research were we done.

The biogas was obtained by 10 days in ratio of 50% when we compare to other percentage. In the both case of seeding material by cow dung as well as activated sludge the biogas was produced by 10 days.

Further study the reactor was insisted to continuous mode of operation to improve the performance of the biological degradation of organic contaminants in the paper and pulp industry effluent.

6. References

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