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Digestion of Sugarcane Effluent Using Continuous Stirred Anaerobic Reactor

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Abstract— this project is designed to investigate anaerobic digestion of sugarcane effluent which when disposed to the environment causes potential hazards, for this study the untreated effluent is collected from sugar mill around Perambalur District. The main challenge is to remove organic matter and heavy metals with the aid of microbial species *Enterobacterasburiae* which was inoculated into the reactor. Initial characterization of untreated effluent is done. The effluent is digested in the reactor for 45 days with complete stirring for 6 hours per day at 55 rpm. After the speculated time final characterization of the treated effluent is performed and presence of heavy metal is detected and differentiated during both initial and final characterization using Gas Chromatography (GC).A comparative study of initial and final characterization concluded the removal of heavy metals and extraction of Biogas periodically. At the end the disinfection process is carried out. As per the CPCB direction every industry should adopt the Zero Liquid Discharge (ZLD) in their industry premises to avoid discharge of effluent without treatment. In the present study the effluent was analyzed of a sugar industry and revealed that the pollutant concentration was comparatively high. And it has been observed that the effluent consists of certain amount of heavy metals such as Zn, Cu, Pb, Cd, Cr and Fe which is highly toxic to the environment. The results reflect that the treated effluents of sugar industry are not highly polluted and they satisfy the BIS Indian standards values and therefore can be used for industrial purposes. Keeping in view the relevant policy scenario in India, various characteristics and results are discussed.

Keywords: Sugarcane effluent, anaerobic digestion, Enterobacterasburiae, Heavy metals.

I. INTRODUCTION

A. Sugarcane effluent

Milling of cane stalks for the extraction of raw sugar yields several by-products of various uses. These by-products Include waste water, molasses, and bagasse and mill mud. During this process a huge amount of water is used. As a result it also generates a huge amount of waste water. To be

Specific the waste water generated at mill house in sugar mill is of huge quantity. In this mill house it is mostly contaminated by oil and grease. The waste water which is produced from the process house mainly results from equipment washing is highly contaminated with the additive and other chemical used at the different stages. Boiler house mainly contributes in the air pollution and have a little share in water pollution. Based on the ratio, a sugar mill having a capacity to crush 4500 tonnes of cane a day requires 9000m^3/per day of water with the ratio 1:2 and hence the mill generates the waste water in the range of 180cm^3/day. The sugar mill waste water is characterized by its brown colour, unpleasant odour, high temperature, low, pH, high ash or solid residues and contain high% of dissolved organic and inorganic matter. Hence if they are normally discharged by water courses, it creates the odour nuisance, affect the aquatic life in water bodies and also not eligible for the irrigation purposes.

B. Method of treating industrial effluent

Industrial wastewater contains several chemical pollutants and toxic substances in too large proportion. It is generally necessary to isolate or remove the troubling pollutant from wastewater.

Depending upon the quantum, concentration, and toxicity, its treatment may consist of following processes:

- Equalisation;
- Neutralization;
- Physical treatment (sedimentation, floatatio);
- Chemical treatment (RO, Adsorption, Electro Dialysis, Chemical Precipitation);
- Biological treatment;

C. Biological treatment

Biological treatment arouse great interest because of their lower impact on environment then chemical treatment which produces large amount of secondary waste products due to various reagent added. Laboratory test on wastewater for determining its BOD/COD ratio, will helps in determining the type of treatment required. If the ratio is more than 0.6, then the wastewater is treatable without acclimatisation. If the ratio is less than 0.6 and up to 0.3, then acclimatisation is necessary for biological treatment; and if the ratio is less than 0.3, biological treatment may not require. Acclimatisation refers to exposure of wastewater with the seed or microbial population. In such cases, industrial wastewater do not contain sufficient nutrients, we need to add in to the reactor. In certain cases, special type of micro-organisms is found to cause better biological oxidation if commonly available micro-organism may fail to achieve oxidation. These micro-organism may produces their enzymes which on interact with chemical compound and oxidise it.

D. Continuous stirred anaerobic digester

Anaerobic digestion (AD) is a bioprocess that is commonly used to convert complex organic wastes into a useful biogas with methane as the energy carrier. Increasingly, AD is being used in industrial, agricultural, and municipal waste (water) treatment applications. The use of AD technology allows plant operators to reduce waste disposal costs and offset energy utility expenses. As the application of AD technology broadens for the treatment of new substrates and co-substrate mixtures, so does the demand for a reliable testing methodology at the pilot- and laboratory-scale. Anaerobic digestion systems have a variety of configurations; including the continuously stirred tank reactor (CSTR), plug flow (PF), and anaerobic sequencing batch reactor (ASBR) configurations. The CSTR is frequently used in research due to its simplicity in design and operation, but also for its advantages in experimentation. Compared to other configurations, the CSTR provides greater uniformity of system parameters, such as temperature, mixing, chemical concentration, and substrate concentration. Ultimately, when designing a full-scale reactor, the optimum reactor configuration will depend on the character of a given substrate among many other nontechnical considerations. However, all configurations share fundamental design features and operating parameters that render the CSTR appropriate for most preliminary assessments. If researchers and engineers use an influent stream with relatively high concentrations of solids, then lab-scale bioreactor configurations cannot be fed continuously due to plugging problems of lab-scale pumps with solids or settling of solids in tubing. For that scenario with continuous mixing requirements, lab-scale bioreactors are fed periodically and we refer to such configurations as continuously stirred anaerobic digesters (CSADs).At the same time the continuous stirring may also catalyze the microbes' reaction for the reduction of heavy metal and other toxins.

II. Related Work

Ali Asghar Mahessar [1] suggests that Sugar mill wastewater is acidic in nature and thus requires pH correction prior to anaerobic treatment. He had attempted the use of rotating biological contactor (RBC) for the treatment of synthetic sugar effluent. COD reduction was reported in the range of 90-97 %. The unit was operated at 34°C with a HRT of 5.5 h and an average COD loading rate of 13 $kg/m^3/d$. The average methane gas recovery was $0.22m^3$ CH^4 per kg COD removed.

Abdul LatifQuresh [2] has suggest the pollution level of effluents was evaluated against the National Environmental quality standard (NEQS) recommended level as well as with World Health Organization (WHO) level.

Bansodes.S [3] proposed that according to Indian industry standards, water consumption varies from 1.3 to 4.36 m^3. The mills generate the waste water in the ratio 5 of 1:2. The sugar industry wastewater is characterized by its colour, temperature of water, low pH, ash, dissolved organic inorganic matter of which 50% may present as reducing sugar.

M. Rais, A. Sheoran [4] proposed the treatment CSTR reduces the organic pollution load and brings down BOD to 80–95% of the original value; however, the biodigested effluent still contains BOD in the range of 5000–10,000 mg/l.

Baez-Smith [5] have proposed the enough data for subsequent evaluation of the technical feasibility of the process. The anaerobic digestion featured a complete mix reactor (digester) utilizing a two steps acid and methane-producing bacteria (thermophilic).

SatotoEndarNayono [6] suggests that the growth of microorganisms is very slow; the efficient operation of high rate anaerobic treatment is determined by the ability of to retain biomass concentration within the reactor by effective separation of the biomass from the liquid. This aspect can be reached by means of settling, attachment to support media or by recirculation.

Gregory K. Brown [7] proposed the method which was developed in response to increasing concern over the impact of endocrine disrupting chemicals in wastewater on aquatic organisms. Compounds were isolated by continuous liquid-liquid extraction with methylene chloride and determined by

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capillary column gas chromatography/mass spectrometry using selected-ion monitoring.

III. OBJECTIVES & OVERVIEW OF THE PROPOSED MECHANISM

A. Objectives

In this paper, we propose to design and fabricate a pilot scale continuous stirred anaerobic digester and in utilizing bacterial microbe for producing drastic reduction in pollutants and to digest the sugarcane effluent an aerobically which when exposed to the environment cause potential hazards as bear a high degree of pollution load.

- To effectively treat the untreated effluent as if it discharged without treatment may possess pollution problem in both aquatic and terrestrial ecosystems, will degrade the environment around us, affect the water we use, the air we breathe and the soil we live on.
- To digest the recommended sugar waste this may possess environmental problems.
- To utilize immobilized bacterial Enterobacter asburiae for bioremediating the effluent showed a drastic reduction in the levels of physical parameters and heavy metals after 45 days treatment.

B. Overview of the proposed Mechanism

We had fabricated a pilot scale cylindrical continuous stirred anaerobic reactor is designed and fabricated with overall volume = 6L, working volume = 4L, dimension diameter of 0.14m and 0.4m height. It consist of an airtight cylindrical glass container, and a stirrer to provide agitation, a rotor is fixed to provide continuous stirring, and a rpm fixer is placed to actuate the rotation, the influent tube is provided to admit the effluent, a separate gas collecting tube is connected to collect the biogas produced periodically. The feedstock required for the production of biogas is placed in a room temperature, and after certain hours it is inoculated into the digester and a constant stirring of 55 rpm is adjusted for proceedings of 6 hours a day, while the methane production is noticed once in couple of days. The production is measured through liquid displacement method, a measuring jar is utilized for the process, the gas yielding should be carried out for 45 days. The constant stirring leads to the production of methane and also catalyses the immobilized species to carry out their reaction faster for the drastic reduction of heavy metals and other hazardous pollutants.

IV. OPERATION & CULTURING MECHANISM

A.Pilot scale reactor fabrication and operation

The pilot scale or lab scale anaerobic digester is the miniature model of actual continuous stirred anaerobic digester. It is fabricated in smaller scale for laboratory operation. A pilot scale cylindrical continuous stirred anaerobic reactor is designed and fabricated with preferred dimensions. It consists of an airtight cylindrical glass container, and a stirrer to provide agitation, a rotor is fixed to provide continuous stirring. An rpm controller is fixed to actuate the rotation, the influent tube is provided to admit the effluent, and a separate gas collecting tube is connected to collect the biogas produced periodically.

B. Culturing of microbe

The main challenge is to remove organic matter and heavy metals with the aid of microbial species like Enterobacterasburiae which will be inoculated into the reactor. In order to decrease the toxic metal and polluted content from medium microbes were inoculated. Hence a “nutrient broth” is utilized for a microbial growth and for a provision of essential nutrient; it is prepared in a conical flask at correct proportion. A cotton plug is used to close the flask and it is covered by a paper. Then it is placed in an autoclave for 20 minutes at optimum pressure of 121Psi, and then the process is continued by inoculating the bacteria from the spread plate into the flask which takes place in laminar air flow chamber. Finally the flask is placed in the incubator at 26℃ for the microbial growth, later the cultured medium is inoculated into the effluent.

Requirements for the medium preparation

Nutrient broth [pH = 7.0]
Distilled water = 1000ml
Glass wares
Micro pipette

Constituents of nutrient broth

Peptone	=	5g
Sodium chloride	=	3g
Beef extract	=	3g

Fig 1.Culturing mechanism

V. Performance Evaluation

A. Methane gas production

Biogas formation is noted once for two days, and the collection principle follows liquid displacement method. For two days = 35ml (0.0035m^{3}) for 45 days =747ml (0.0747m^3).

Table.1 Biogas formation

S.NO.	DAYS	BIOGAS FORMATION(ml)
1.	2	6
2.	4	9
3.	6	16
4.	8	21
5.	10	26
6.	12	33
7.	14	41
8.	16	52
9.	18	73
10.	20	91
11.	22	108
12.	24	190
13.	26	275
14.	28	360
15.	30	489
16.	32	522
17.	34	554
18.	36	593
19.	38	625
20.	40	654
21.	42	702
22.	44	733
23.	45	747

B. Characterization results

Physical parameter

Table 2.characterization results

S.NO	Name Of The Parameter	Initial Characterization	Final characterization
1.	Colour	>1hue	>1hue
2.	Odour	Unpleasant	Agreeable
3.	Turbidity (NTU)	287	14
4.	Total dissolved solids(mg/l)	2022	1101
5.	Total solids(mg/l)	2345	1120
6.	pH	8.96	6.22
7.	Electrical conductivity	3.16	2.08
8.	BOD(mg/l)	2015	404
9.	COD(mg/l)	1265	115

Anions

S.NO	Name Of The Parameter	Initial Characterization	Final Characterization
1.	Chloride	1383	600
2.	Sulphate	189	12
3.	Phosphate	0.142	5.50

Cations

S.NO	Name Of The Parameter	Initial Characterization	Final Characterization
1.	Sodium	1048	600
2.	Oil & grease	0.216	Nil

Heavy metals

S.NO	Name Of The Parameter	Initial Characterization	Final Characterization
1.	Lead	0.26	0.09
2.	Copper	1.82	0.05
3.	Chromium	4.26	0.10
4.	Cobalt	0.46	0

Z. Gas chromatography results

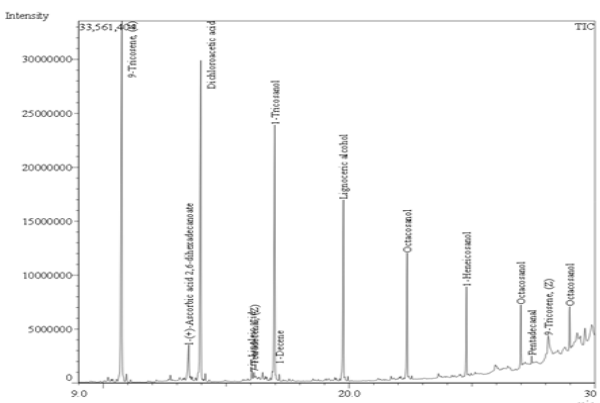
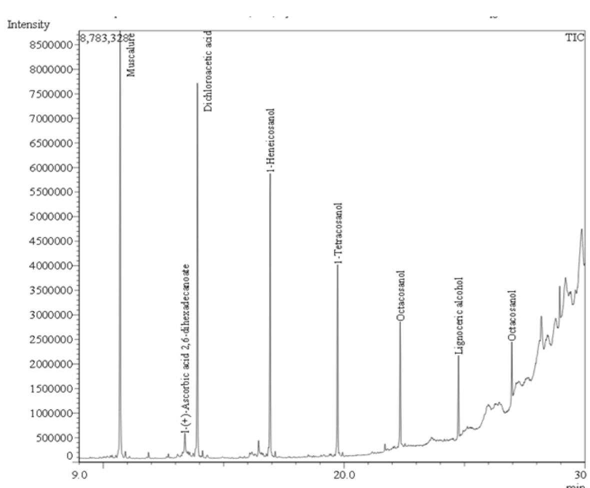


Figure2. Peaks of treated effluent



. Figure3. Peaks of untreated effluent

. VI. CONCLUSION

The organic waste generated during the sugar productions have different characteristics which taken into account during the design of the anaerobic digestion process. This study demonstrated the performance analysis of methane production and toxic metal reduction from sugarcane juice in a non-sterile CSTR augmented with Enterobacterasburiae.The characterization result could show off the rigid variation in the level of contaminants and the toxic bodies were largely reduced during the treatment. The biogas produced is about for 45 days 747 ml along with days; further treatment could increase the productivity of gas ,.The initial and final chromatography is discussed which shows clearly the reduction of heavy metals and other disagreeable compounds.

Thus the effluent treated may utilize for industrial purposes.

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