EFFECT OF THERMAL PRETREATMENT ON DAIRY SLUDGE FOR THE PRODUCTION OF BIOGAS BY ANAEROBIC BIODEGRADABILITY ASSAY METHOD

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ABSTRACT

Biogas is a renewable energy, which can be produced by sludge coming from different industrial waste water treatment plant. Particularly, dairy industry sludge does not contain any heavy metal. So biogas production is easier and it can be produced by anaerobic biodegradability assay method. Because of long retention time the sludge should be pretreated. One of the easiest, simplest and cost reduction methods is thermal pretreatment. The aim of this study is to explore the effect of thermal pretreatment of dairy sludge for the production of biogas by anaerobic biodegradability assay method. In this study first, the physical, chemical parameters of sludge were analyzed. After that sludge is pretreated at different temperature (100-220˚C) at different time interval (0-30 min) with the key parameters of TSS, SCOD the optimum temperature can be determined. The optimum temperature can be taken for anaerobic biodegradation depends based on the thermophilic range. In the optimum temperature range final physical, chemical parameters of sludge were analyzed. Finally anaerobic degradation of Dairy sludge will be conducted by active inoculums (cow dung). After by anaerobic decomposition, the generation of biogas can be measured. In the same way biogas production in the untreated sludge will be measured. The optimum temperature range for the TSS and SCOD are 180°C. The biogas production from the untreated, thermally pretreated sludge is 78mg/l, 123 mg/l .The maximum biogas production obtained in the optimum temperature range i.e., 180°C and also I hope that the thermal pretreatment of dairy sludge will enhance the biogas production. This gas can be used for any purpose

Keywords: Thermal pretreatment, Biodegradation, Biogas.

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INTRODUCTION

Nowadays water resources are polluted by city sewage and industrial waste discharge. The water pollution is caused by a few Industrial sub sectors Such as food processing industries, paper and pulp industries, textile, agro based industries and chemical industries, which release toxic wastes and organic pollutants[1]. Among all these industrial sub sectors, food-processing industries are the major role for wastewater generation. There are over 19,850 food processing industries in India, discharging large quantities of wastes in to the water bodies. The universal increasing environmental vigilance and its successive policies have led to the application of improved technologies in wastewater purification plants. This has resulted in higher wastewater and sludge productions. These wastes if uneconomically utilized or disposed of without treatment can cause serious pollution problems.The Aavindairyindustry in tiruchirappalli, per day 2 lakhs litter of water was used. About that 1 lakhslitter of waste water treated in each day. So the dairy industry need an efficient and cost-effective effluent treatment technology has to be developed. To this effect, anaerobic digestion offers a unique treatment option to the dairy industry.

Anaerobic digestion process is an efficient waste treatment technology that reduces waste volume and generates biogas.[2].Biogas typically contains 75% of methane and 24% of carbon dioxide and 1% of other gases[3].The process consists of four phases such as hydrolysis, acidogenesis, acetogenesis and methanogenesis[4]. Hydrolysis is a process of splitting up of one or more water molecules are split into hydrogen and hydroxide ions which may lead to participate in further reaction.Acidogenesis is a process of biological reaction in which simple monomers are converted into volatile fatty acids.Acetogenesis is a biological reaction in which volatile fatty acids are converted into acetic acids,carbon dioxide and hydrogen.Finally methanogenesis is a biological reaction in which acetates are converted into methane and carbon dioxide,while hydrogen is consumed in the reaction.A simplified chemical equation for the overall processes

$$C_6H_{12}0_6 \longrightarrow 3CO_2+3CH_4$$

Some of the microorganism has the capacity to produce methane under the anaerobic condition. Example Methanobacterium,Methanobrevibacter, Methanococcus, Methanomicrobium.

Biogas produced is done by anaerobic decomposition of biodegradable materials such as biomass, manure, sewage waste, municipal waste, green waste, plants material and energy crops. Sludge contains large amounts of organic and mineral components are created by municipal and industrial wastewater treatment plants. Sludge handling is a major criteria in all wastewater treatment plants of industries, due to the impact of sludge in environmental, economic, social and legal factors.

The treatment required to be done is dependent on the characteristics of the sludge. Subsequently, the pre-treatment with varied methods are Thermal, mechanical, biological and chemical pre-treatment is accomplished to enhance the dewater ability and digestibility of sludge. Among these pretreatments, thermal pretreatment is the most cost-effective method, due to the high energy recovery and its limited sludge treatment to increase biogas production. Biogas is a colorless, odorless gas. It does not release smoke while burning. It doesnot release kitchen refuse while burning. The biogas can be used for heating, lighting, water pumping, electricity generation. By this way the pollution problem can be controlled. The waste coming from the biogas plant can be used as the fertilizer.

Objectives

The objectives of the study are

1. To find out the optimum temperature of sludge for the reduction of TSS, SCOD by thermal pretreatment method

2. To find out the biogas production from the thermal pretreated sludge and untreated sludge

METHODOLOGY

The waste activated sludge was collected from Aavin dairy treatment plant in Tiruchirappalli district at Tamil Nadu. The Dairy treatment plant has a conventional aerobic activated sludge unit operated at an average SRT of 8h. From the collected sludge, the physical and chemical parameters were analyzed. Then the sludge was subjected to Thermal pretreatment at various temperatures (100-220^{0}C) for different time (0-30 min) duration mainly to increase COD solubilization (%) and to reduce the TSS. Optimum temperature was found by reduction of TSS, SCOD. Finally the physical and chemical parameters of sludge were analyzed in the optimum temperature range. A Biodegradability assay method was used to evaluate biogas recovery from sludge after thermal pretreatment. Biogas can be measured by water displacement method.

Physical, Chemical Parameters of Sludge

Physical parameters such as TS, TSS, VS, TCOD, SCOD, COD Solubilization %,pH, Turbidity and Conductivity were analyzed. TS, TSS, VS, TCOD, SCOD, COD Solubilization % were analyzed by APHA standard method. pH, Conductivity, Turbidity were analyzed by pH meter, conductivity meter, turbidity meter. Chemical parameters of sludge such as alkalinity was measured by titration against H_2SO_4,Total hardness and Ca were measured by titration against EDTA, Na and K by flame photometer, Fe by ammonium thiocyanate method, Mn by ammonium persulphate method,NH_3 by zinc sulphate method,NO_2 and NO_3 by brucine sulphate method, Cl by titration against Siliver nitrate,F by SPADNS method and Sulphate by Nephelometric method.

Thermal Pretreatment

A commercial domestic hot air oven and silicon crucible was used for thermal pretreatment. The thermal pretreatment for waste activated sludge is explained in Table1

Table 1 Experimental setup parameters of Thermal pretreatment

Sample	Parameters	Optimization
WAS (250ml)	Temperature(° C)	Control,100,120, 140,160,180,200, 220
	Time (min)	0,6,12,18,24,30

Anaerobic Biodegradability Assay

The biodegradability assay was used to evaluate biogas recovery from sludge after microwave pretreatment. The experimental setup of anaerobic biodegradability assay is shown in Fig. 1

Fig.1 Experimental setup of anaerobic biodegradability assay

A full quantity of water was taken in the 500mlmeasuring cylinder. A beaker is placed at the top of the cylinder. The whole setup is inverted. A Measuring cylinder is fixed with the help of pipette stand. A serum bottle having one hole at the center, insert one rubber tube, another end of rubber tube inserted into the measuring cylinder. A 60 ml sample of thermal pretreated sludge was seeded with 150 ml of active inoculum (cow dung) and was fed into a 250 ml serum bottle. A separate 60mL sample of untreated sludge was used as a control sample. The biodegradability assays were performed at room temperature (37°C). The cumulative gas production was measured using a water displacement method. The serum bottles were shaken every 12h to allow for sufficient blending.

RESULT AND DISCUSSION

Effect of Thermal Pretreatment on Dairy Sludgefor the Reduction of TSS

At different temperature 100-220˚C and time duration 0-30 min the reduction of TSS was recorded in the following Fig.2

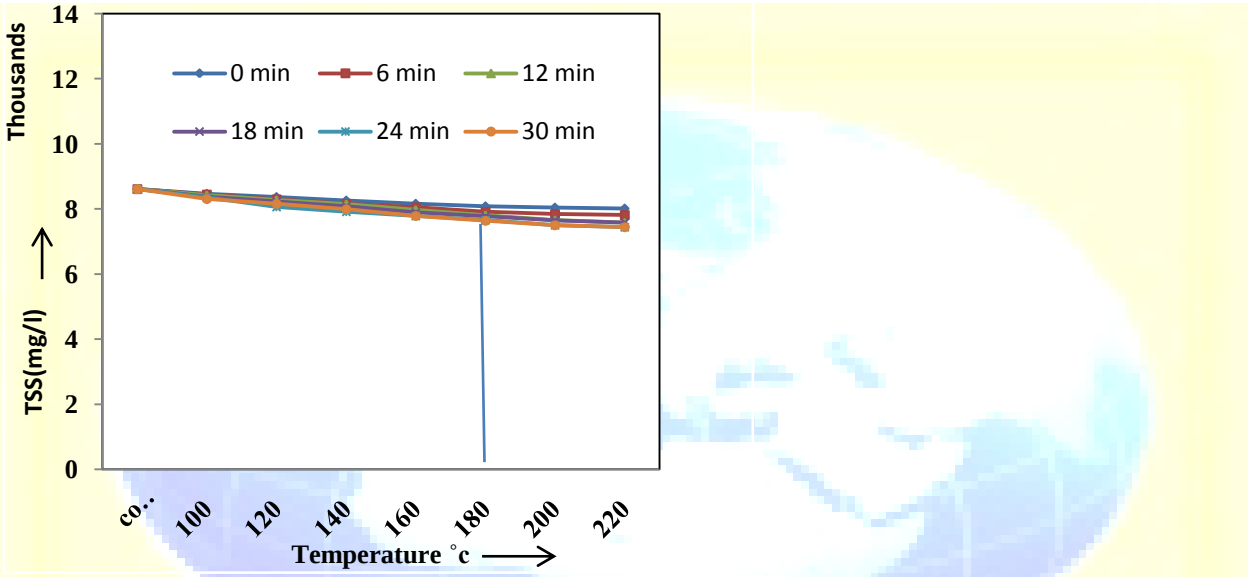

Fig. 2Optimum temperature range for the reduction of Total suspended solid

Fig. 2 shows that TSS reduced, when the temperature and time duration increases. At particular temperature (180˚C), the TSS cannot reduce and maintain at the constant level. All suspended solids present in the sludge decomposed at constant temperature. So optimum temperature range for the reduction of TSS is 180˚C sometimes vary from 180˚C-200˚C.Reduction of total TSS depend upon the characteristic of sludge.

From the thermal pretreatment process, sludge solid structure was destroyed and organic components dissolve into soluble parts[5]. So the solid content of the sludge decreased and the amount of sludge reduced. Part of solid components present in the sludge decomposed at high temperature. The volume of TS and SS were reduced in the thermal pretreatment. At particular temperature, sludge reduction maintain at the constant level. High temperature range would bring

high TS and SS dissolving ratio. Compared with TS, SS more usually was used to analysis the effect of sludge

Effect of Thermal Pretreatment on Dairy Sludge for the Reduction of SCOD

At different temperature 100-220˚C and time duration 0-30 min, the increment of SCOD was recorded in the following

Fig. 2

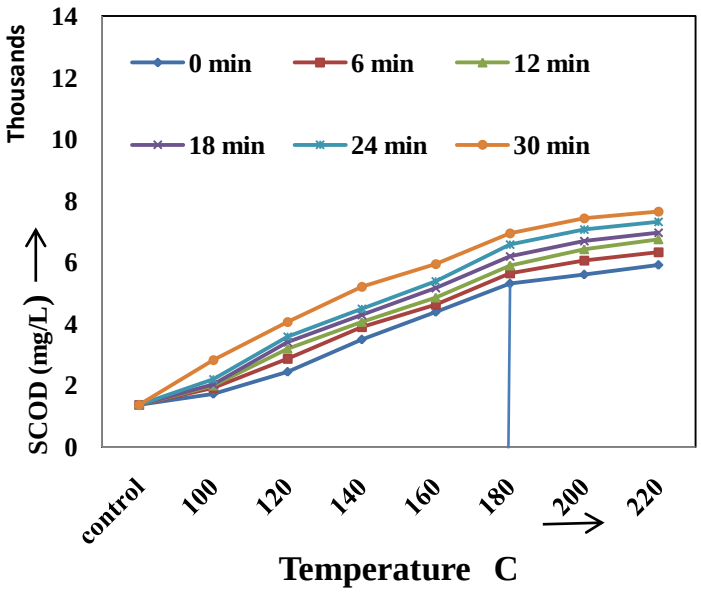

Fig. 3 Optimum temperature range for the increment of SCOD

The Fig. 3 shows that SCOD increased, when the temperature and time duration increases.At particular temperature (180°C) the SCOD cannot increase and maintain at the constant level. At 180°C all the complex material present in the sludge break down into simple material. The thermal pretreatment results in indicating a potential of damaging floc structure and releasing 4.4,4.5 fold higher soluble proteins and sugars. so the SCOD value increased[6].

Initial, Final Physical Parameters of Sludge

The initial physical parameters of sludge were analyzed by samples taken from the effluent treatment plant. The final physical parameters of sludge were analyzed by optimum temperature range(180°C).TS, TSS, VS, TCOD, SCOD, pH, COD solubilization %, Turbidity, Electrical conductivity were presented in the Table 2

Table 2 Initial, Final Physical parameters of sludge

Table 2 shows that changes of physical parameters of sludge. The raw thickened secondary sludge had the following characteristics as pH= 6.5, TS= 19,372± 713mg/l, VS=13,050 ± 704 mg/l, TCOD= 17,808 ± 1,206 mg/l, SCOD= 520± 140 mg/l and the COD solubilization was evaluated as 2.9 ± 0.8%[8]. .

Initial, Final Chemical Parameters of Sludge's

The initial chemical parameters of sludge were analyzed by samples taken from the effluent treatment plant. The final chemical parameters of sludge were analyzed by optimum temperature range. Chemical parameters such as alkalinity, Total hardness, Ca, Mg, Na, K, Mn, NH_3, NO_2, NO_3, F, PO_4 and Permissible limit were presented in Table3.This table shows that final value of total hardness only changed due to the thermal pretreatment process since the temporary hardness removed while doing pretreatment. NH_3, NO_2, NO_3, Cl, F, SO_4 are polluted test. The presence of these toxic, refractory compounds is a major drawback of biogas production[8].This table shows that these compounds are at permissible limits, shows that the sludge is not polluted. K is higher than the permissible limit, so it acts as a substrate of methanogenic bacteria which helps in the production of biogas.

Parameters	**Initial value**	**Final value**
TS(mg/l)	17,241	14,001
TSS(mg/l)	8610	7640
VS(mg/l)	14,007	11,207
TCOD(mg/l)	35,000	-
SCOD(mg/l)	1,370	6940
pH	6.3	7.2
COD solubilization %	3.92%	19.8 %
Turbidity(NTU)	16	14
EC(micS/cm)	1499	1499

Table 3 Initial, final Chemical parameters of sludge

Chemical parameters	Initial value	Permissible limit	Final value
Alkalinity(mg/l)	256	200-600	256
Hardness (mg/l)	280	200-600	201
Calcium(mg/l)	60	75-200	60
Mg(mg/l)	31	30-150	31
Sodium(mg/l)	168	200	168
Potassium(mg/l)	32	12	32
Iron(mg/l)	0.35	0.1-1	0.35
Mn(mg/l)	0.33	-	0.33
FreeNH_3(mg/l)	12.31	5-25	12.31
Nitrite(mg/l)	0.11	7	0.11
Nitrate(mg/l)	5	45	5
Chloride(mg/l)	305	200-1000	305
Fluoride(mg/l)	0.4	1-1.5	0.4
Sulphate (mg/l)	14	200-400	14
Phosphate(mg/l)	3.70	_	3.70
BOD	52	_	48

Anaerobic Biodegradability Assay

A biodegradability assay was used to evaluate biogas recovery from sludge after thermal pretreatment.The biogas production was monitored at two days interval. The sludge samples

were thermally pretreated at 20 minutes but the control sample cannot be pretreated. The biogas production from the four thermally pretreated (100°C,140°C,180°C,220°C)and untreated(Control) sample were presented in the Fig 4.

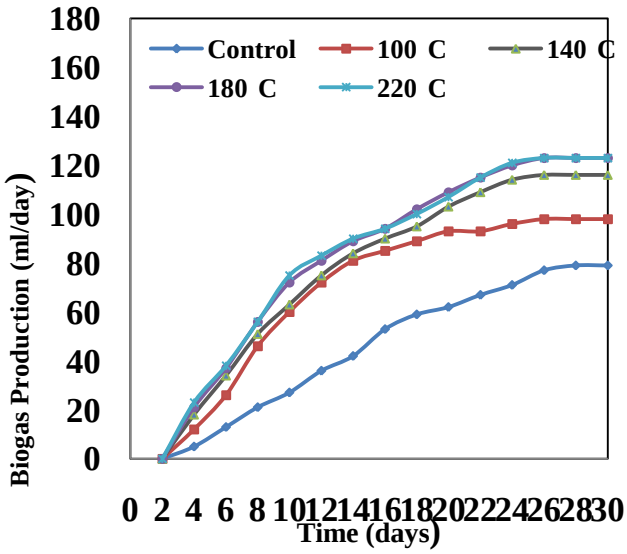

Fig.4 The cumulative biogas production

The Fig.4 shows that as a temperature increases, biogas production also increased. Biogas production is compared with pretreated and untreated (control) sludge. The higher biogas production is obtained in the thermal pretreated sludge. The maximum biogas production was found as 123ml/day for 180°C.So biogas production higher in the optimum temperature range. After 180°C,there is no change in biogas production since all the solid materials present in the sludge were biodegraded. After 25thday,the biogas production was progressively stagnant. The hydraulic retention time is 30 days. The biodegradation of sludge increases, biogas production is also increased. A possible explanation is that the soluble, easily degradable part of the organic matter in the sludge produces biogas easily[9].Thethermal pretreatment method enhances the degradation of sludge.

CONCLUSION

There are currently considerable in developing efficient and environmental friendly ways to convert waste sludge to biogas. It releases 22-28 MJm^{-3} energy during burning. The energy contents of 28m^3 of biogas are equal to 20.8 liters of petrol or 18.4 liters of diesel. So in this

biogas production physical, chemical parameters of sludge were analyzed. To enhance the biogas production, the Thermal pretreatment is needed. The thermal pretreatment was promising to enhance the anaerobic degradability of the sludge. The efficiency of sludge pretreatment was measured in terms of optimum temperature range for the reduction TSS, SCOD.The optimum temperature range for reduction of TSS, SCOD is 180°C.The biogas production is higher in the optimum temperature range.The thermal pretreatment method increases the degradation of sludge than the untreated sludge. The physical parameters such as TS, TSS, and VS can be reduced. SCOD, COD solubilization % value can be increased. No change in chemical parameter of sludge except total hardness. The maximumbiogas production in the untreated sludge is 81 ml/day.The maximum biogas production in thermal pretreated sludge is 123 ml/day at 180°C.It concluded that use of thermal pretreatment was promising to enhance the anaerobic degradability of sludge,and also decrease HRT of the anaerobic digestion.

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