

Enhancement of Methane Generation from the Sewage by the Addition of Fish Waste

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Research Article

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Abstract

Purpose-Fish waste affects the area surrounding and can change a broad oceanfront zone at unlike environment levels by its effluent. In order to reduce the environmental impacts of improper disposal of both fish waste and sewage in the vicinity of the fishing industry in the coastal zone, an attempt has been made to convert the mixture of fish waste and sewage into energy.

Findings-The by-product wastes mainly head, bones, skin, gut, tail and sometimes full whole fish waste. The main composition of fish waste is Protein 65%, fat 18% and minerals 17%. So fish waste having a large amount of biodegradable matter when compared to fresh sewage and also by adding higher amount of fish waste we can able to generate higher methane emissions.

Methodology-The ultimate aim of the project is to find the optimum methane gas emission from fish waste mixed with fresh sewage using the anaerobic digestion for the experimental part. And for the stoichiometry combustion equation for the theoretical part.

Value-Using stoichiometries equations methane gas generated has been calculated from the mixture of sewage and fish waste. Using the Orsat's apparatus methane gas generated has been measured from the mixture of sewage and fish waste. The correlation coefficient - R^2 value is 0.9906 indicating a strong correlation for the predicted values and the measured values.

1. Introduction

This paper presents a new combination of predicting methane generation from fresh sewage and fish waste collected from the Nagapattinam coastal area located in Tamilnadu(Chen Shi et al.,2012). From CPCB it is referred that the fresh sewage from first class and second class cities is forty thousand million litre per day(Yong-SungKim et al.,2012). Out of which only twelve thousand million litre per day is only disinfected and the balance is dumped into the aquatic bodies deprived of treatment(American Public Health Association and American Water Works Association 1998).In order to inhibit health difficulties, fresh sewage must be treated to create the water harmless to coming back into watercourses and to use again (Gitis V et al., 2018). The fresh sewage and fish waste effects on the environment are largely negative(Czepiel et al., 1995).These are needed to be properly managed before it can be disposed (Ghada A et al., 2020).The study was aimed to determine the current status of fish waste management strategies for the Nagapattinam coastal city (Mata-Alvarez J et al., 2000). In fish waste management fish waste by-product utilization, to produce methane from fish waste (Kythreotou. N et al., 2014)(Solli Let al.,2014).

On an average, Tamil Nadu's marine fish production is about 17.3% of that India's production(Food and Agriculture Organization of the United Nations2016). The main occupation of Nagapattinam people is fishing in the waters of the Bay of Bengal and selling the catch in the fish market (Shiplu Sarker et al., 2019). Thus, Nagapattinam coastal area is known to have rich resources of Anchovy, Barracuda, King Mackerel, Pomfret, Red Snapper, Salmon, Sardine, Shark and Tilapia fisheries (S. Ramu et al.,2015) and

(Palani kumar M1 et al., 2014). The waste disposal problem of sewage and fish waste in Nagapattinam facing a serious problem and creates a wide impact on the environment and Human health (Guven H et al., 2019). The ultimate dictum of this project proposal is to reduce the waste disposal and convert the Bio waste (sewage and fish waste) into energy instead of direct dumping on the land or water bodies (Hee-Jeong Choiet al., 2021). Fish waste consists of more nutrients for the microbial reactions, thereby we can enhance the methane(Pushparajan N et al.,2002)(Amon Tet al.,2006).

2. Literature Review

Sl.No.	Author's	Findings	Interpretation
1.	Afrah A.Maktoof1 et al., (2020)	The various nutritional components are identified in the fish waste, mainly in bones, scales and fins by proximate and statistical analysis of Cyprinus Carpio fish.	Small sized fish contain higher moisture content when compared with the large sized fish and the fish waste contain a high nutritive value mainly due the presence considerable amount of protein and lipids in the bones of fish.
2.	S.Cadavid-Rodríguez et al., (2019)	The production of Biogas potent from fish waste as a renewable energy under mesophilic condition for 28 days as an energetic and economic estimated production source.	Detail study of four different fish concentration and Biomethane potential.
3.	Kaspars ivanovus et al., (2018)	For designing the anaerobic digestion processes of fish waste modelling to reduce the high level of toxical ammonia release while fish processing.	Understanding of Biomethane potential of both thermophilic and mesophilic conditions with the development of mathematical equation.
4.	Mohamed Mahmoud ALI et al., (2018)	Prediction of Methanogen potential production by using three model groups and optimization of cumulative methane production.	The stoichiometry equation of the BMPthOFC model for the percentages of proteins, carbohydrate is directly taken.
5.	Palani kumar M1 et al., (2014)	Determination of the proximate and major mineral composition of 23 fin fishes landed in Thoothukudi were examined by proximate and mineral composition analysis of biochemical constituents.	The values of different fish species are analyzed and checked by comparing the values mentioned.
6.	LinnSolli et al., (2014)	Two parallel laboratory scale production of methane under anaerobic digestion by co-digestion of fish waste silage and cow manure when the effects of a gradually increased load.	Under 30 days of hydraulic retention time with a mesophilic temperature range of 37 °C methane production increased by 100% when fish waste silage feed stock was added.
7.	A.S. Ondo-Azi, et al., (2013)	To determine the proximate composition of 5 fish species under microbial spoilage by chemical and microbial analysis	Proximate composition of different fish species.
8.	Chen Shi et al., (2012)	The determination of methane potential optimal co-digestion under anaerobic mesophilic inoculum conditions to reduce the pollution on the marine environment.	Detailed study on Anaerobic mesophilic inoculum optimizing generation potential by BMP test for 13 days.
9.	Gopi Krishna Kafle et al., (2012)	The evaluation of productivity potential of Biogas under anaerobic conditions by comparing different models for biogas production and critical hydraulic retention time.	Study on batch trials and fish waste has the methane potential of 73% under 13 days mesophilic condition.

10.	Kamma Raunkjaer et al., (1994)	Optimizing pools of different chemical composition of carbohydrate, protein and lipid by the selected methods, optimization and analysis in domestic wastewater under suitable method Anthrone method with high precision.	The percentage of carbohydrates, protein and lipids for domestic waste water was taken directly.
Research gap: Based on the literature review this research is a combination of fish waste and fresh sewage to enhance methane generation by using bio-reactor.			

2.1 SCOPE OF WORK

The opportunity of the contemporary effort is to conduct an investigation in research laboratory measure. To produce methane from the anaerobic breakdown of fish waste and fresh sewage to make a waste into an efficient utilization of profitable energy. To reduce the pollution causing due to the disposal of fish waste and fresh sewage directly into the ocean dump and costal lands. In order to protect our environment to provide methane has the potential to replace fossil fuels.

2.2 OBJECTIVES

- To Enhance methane generation
- To promote the Conversion of Bio-waste (sewage and fish waste) into energy (methane)
- To develop a better and effective idea on the combination of fish waste and fresh sewage into a useful production
- To solve the waste management problem

3. Methodology

3.1 NUTRITIONAL COMPOSITION OF FRESH SEWAGE AND FISH WASTE TO PREDICT CH₄ GENERATION

To predict methane generation we used the stoichiometry equation separately for fresh sewage and fish waste. The stoichiometry equation used is given below.

$$\text{BMP}_{\text{thOFC}} = 415\% \text{ carbohydrates} + 496\% \text{ proteins} + 1014\% \text{ lipids} \quad (1)$$

Where BMP_{thOFC} is the Biochemical Methane Potential Theoretically from Organic Fraction Composition (Mohamed Mahmoud ALI et al.,2018). Eq. 1 is referred from the Theoretical models for prediction of methane production from anaerobic digestion a critical review on International Journal of Physical Sciences on that research Eq. 1 is mentioned as a more accurate model so we used that equation for predicting the Biomethane potential, theoretically by collecting fish waste and fresh sewage sample at Nagapattinam fish market and municipality (E.A. Obodai, et al., 2009).

3.2 NUTRITIONAL COMPOSITION FOR FISH WASTE

The various fish waste samples were collected from fish market where the fishes captured in the Nagapattinam coastal area dated on (26.01.2021) at namely Anchovy, Barracuda, King Mackerel, Pomfret, Red Snapper, Salmon, Sardine, Shark and Tilapia. The nutritional composition values of carbohydrates, protein and lipids of the individual fish waste sample were measured by conducting micro Kjeldahl method for protein and lipids and Anthrone method for carbohydrates. These measured values of carbohydrates, protein and lipids were checked against the standard limits(A.S. Ondo-Azi, et al., 2013) (A.O. Osibona, 2011). Then these values were used in the Stoichiometric equation to determine the methane in terms of ml/g (S.Cadavid-Rodríguez et al., 2019).

The nutritional values of various species of fish waste collected in Nagapattinam are shown in Table 1 (Afrah A.Maktoof1 et al., 2020) FAO(2016), (Nisa K et al., 2011).

Table 1
Nutritional composition of fish waste.

Sl.No.	Name of the fish waste sample collected in grams	Carbohydrates present in fish waste in grams	Proteins present in fish waste in grams	Lipids present in fish waste in grams
1.	Anchovy	0.1	24.7	9.2
2.	Barracuda	0.41	23.44	12.06
3.	King Mackerel	0.65	20	2
4.	Pomfret	1.6	20.3	2.6
5.	Red Snapper	0	21	1.3
6.	Salmon	0	20	6.3
7.	Sardine	0.81	24.62	11.45
8.	Shark	1.17	20.98	4.51
9.	Tilapia	0.39	20.08	1.7
Total		5.13	195.12	51.12
Average		0.57	21.68	5.68

Substituting the calculated average value of Table 1 in Carbohydrates, proteins and fats values in Eq. 1(R.Tomczate et al., 2013)(Buswell AMet al.,1952),.

$$\text{BMPthOFC} = 415 \times \% \text{carbohydrates} + 496 \times \% \text{proteins} + 1014 \times \% \text{lipids}$$

$$= 415 \times (0.57/100) + 496 \times (21.68/100) + 1014 \times (5.68/100)$$

$$= 2.3655 + 107.532 + 57.595$$

$$\text{BMPthOFC of fish waste} = 167.4925 \text{ ml/g.}$$

$$\text{Conversion of BMPthOFC of fish waste for 1kg} = 0.167 \text{ ml/g.}$$

$$\text{Conversion of BMPthOFC of fish waste for 0.25 kg} = 0.167 \times 0.25 = 0.041 \text{ ml/g}$$

$$\text{Conversion of BMPthOFC of fish waste for 0.50 kg} = 0.167 \times 0.50 = 0.0835 \text{ ml/g}$$

$$\text{Conversion of BMPthOFC of fish waste for 0.75 kg} = 0.167 \times 0.75 = 0.125 \text{ ml/g}$$

3.3 NUTRITIONAL COMPOSITION FOR FRESH SEWAGE

The fresh sewage sample was collected from Nagapattinam Municipality dated on (26.01.2021). The nutritional composition values of carbohydrates, protein and lipids of the fresh sewage sample were measured by conducting micro Kjeldahl method for protein and lipids and Anthrone method for carbohydrates. These measured values of carbohydrates, protein and lipids were checked against the standard limits (kamma Raunkjaer et al., 1994). Then these values were used in the Stiometric equation to determine the methane concentration of the fresh sewage sample in terms of ml/g.

The nutritional values of fresh sewage sample collected from Nagapattinam Municipality are shown in Table 2.

Table 2
Nutritional composition of fresh sewage.

Place name of fresh sewage sample collected	Carbohydrates present in a fresh sewage sample in %	Proteins present in a fresh sewage sample in %	Fats present in a fresh sewage sample in %
Nagapattinam	28	18	31

Substituting the standard average value of Table 2 in Carbohydrates, proteins and fats values in Eq. 1(Aiyuk S et al., 2004)

$$\text{BMPthOFC} = 415 \times \% \text{carbohydrates} + 496 \times \% \text{proteins} + 1014 \times \% \text{lipids}$$

$$= 415 \times (28/100) + 496 \times (18/100) + 1014 \times (31/100)$$

$$= 116.2 + 89.28 + 314.34$$

BMPthOFC of fresh sewage = 519.82ml/g.

Conversion of BMPthOFC of fish waste for 1L = 0.519ml/g.

Conversion of BMPthOFC of fish waste for 0.25 L = $0.519 \times 0.25 = 0.129$ ml/g

Conversion of BMPthOFC of fish waste for 0.50 L = $0.519 \times 0.50 = 0.259$ ml/g

Conversion of BMPthOFC of fish waste for 0.75 L = $0.519 \times 0.75 = 0.389$ ml/g

3.4 PREDICTION OF METHANE FROM FISH WASTE AND FRESH SEWAGE

By using the above three sets of combination converted values the predicted methane generation of fish waste of 1kg is 0.167 ml/g. .By considering the same fish waste value and addition with different combination of fresh sewage is shown in Table 3.

Table 3
Predicted methane from 1kg of fish waste mixed with different combination of fresh sewage

Sl.No.	Fish waste (ml/g)	Fresh sewage (ml/g)	CH ₄ (ml/g)
1.		0.129	0.296
2.	0.167	0.259	0.426
3.		0.389	0.556

3.5 PREDICTION OF METHANE FROM FRESH SEWAGE AND FISH WASTE

By using the above three sets of combination converted values we Predicted methane generation of fresh sewage of 1L is 0.519ml/g. By considering the same fresh sewage value and addition with different combination of fresh sewage Predicted methane from 1litre of fresh sewage mixed with different combination of fish waste is shown in Table 4.

Table 4
Predicted methane from 1litre of fresh sewage mixed with different combination of fish waste.

Sl.No.	Fresh sewage (ml/g.)	Fish waste (ml/g)	CH ₄ prediction (ml/g)
1.		0.125	0.644
2.	0.519	0.083	0.602
3.		0.041	0.560

3.6 MEASUREMENT OF METHANE GENERATION USING AUTOMATIC DIGITAL ORSAT APPARATUS UNDER ANAEROBIC DIGESTION

3.6.1 PART I: Experimental investigation of Methane generation from Fish waste mixed with Fresh Sewage (Milono P et al.,1981)

Combinations taken to measure Methane from Fish waste mixed with Fresh Sewage is shown in Table 5.

Table 5
Fish waste mixed with Fresh Sewage

Sl. No.	Fish waste (kg)	Fresh sewage (L)
1.	1kg	0.25
2.		0.50
3.		0.75

Measurement of methane generation using an Automatic Digital Orsat gas analyzer from fish waste mixed with fresh sewage in the anaerobic jar reactor (Kaspars ivanovus et al., 2018) (Md. Nurul Islam Siddique et al., (2018). By the 3 set of combinations like taking 3 kg of fish waste sample initially and the first step to adding 0.25 ml of fresh sewage in 1 kg of fish waste and second step to add 0.50 ml of fresh sewage in another 1 kg of fish waste and final step is to add 0.75 ml of fresh sewage in some another 1 kg of fish waste (Gopi Krishna Kafle et al., 2012). The experimental part is entirely based the presence and reaction of micronutrients by hydrolysis, acidogenesis, acetogenesis and methanogenesis processes (Kawarazuka N, et al., 2011) (Ravichandran S, et al., 2011) (M. Herout et al., 2010).

3.6.2 PART II: Experimental investigation of Methane generation from Fresh Sewage mixed with Fish waste (Svardal K et al., 2011)

Combinations taken to measure Methane from Fresh Sewage mixed with Fish waste is shown in Table 6.

Table 6
Fresh sewage mixed with Fish waste

Sl.No.	Fresh sewage (L)	Fish waste(kg)
1.	1litre	0.25
2.		0.50
3.		0.75

Measurement of methane generation by using an Automatic Digital Orsat gas analyzer from sewage mixed with fish waste in the anaerobic reactor (K. R. Venkatesh et al., 2009) (Damien John Batstone et al.,

2014). Taking 3 litres of fresh sewage sample initially and the first step to adding 0.25 kg of fish waste in 1 litre of fresh sewage and second steps to add 0.50 kg of fish waste in another 1 litres of fresh sewage and the final step is to add 0.75 kg of fish waste another 1 litre of fresh sewage (Theoretical study from gaseous emissions generated by fish scales 2020) (LinnSolliet al., 2014).

Measured values of methane under anaerobic digestion of fish waste with 3 different combination of fresh sewage for 5 days at 40°C – 55°C using Automatic Digital Orsat gas analysis shown in Table 7.

Table 7
Measured values of methane

Sl.No.	Fish waste (kg)	Fresh sewage (L)	CH ₄ Measured value (ml/g)
1.		0.25	0.274
2.	1kg	0.50	0.410
3.		0.75	0.565

Measured values of methane under anaerobic digestion of fish waste with 3 different combination of fresh sewage for 5 days at 40°C – 55°C using Automatic Digital Orsat gas analyser shown in table 8.

Table 8
Measured values of methane

	Fresh sewage (L)	Fish waste(kg)	CH ₄ Measured value (ml/g)
1.		0.25	0.653
2.	1L	0.50	0.598
3.		0.75	0.530

4. Validation Of Data

4.1 Determination of Correlation Coefficient

Correlation Coefficient is calculated Using Pearson Correlation Coefficient Calculator for calculated and measured values are tabulated in the Table 9.

Table 9
Correlation Coefficient for calculated and measured values of methane generated

Sl.No.	CH ₄ Prediction value (ml/g) x values	CH ₄ Measured value (ml/g) y values	R	R ²
1.	0.296	0.274	0.9953	0.9907
2.	0.426	0.410		
3.	0.556	0.565		
	CH ₄ prediction (ml/g) x values	CH ₄ Measured value (ml/g) y values		
1.	0.644	0.653		
2.	0.602	0.598		
3.	0.560	0.530		

5. Conclusion

Using stoichiometries equation methane gas generation was calculated from the mixture of fresh sewage and fish waste. Using the automatic digital Orsat apparatus methane generated is automatically measured under anaerobic conditions from the fresh sewage and fish waste. The predictions and measurements are validated by finding the correlation coefficient - R² value as 0.9907.

By the addition of fish waste to the fresh sewage methane gas generation is enhanced. A higher quantity of sewage and lower combinations of fish waste can give better results.

5.1 SCOPE FOR FUTURE WORK

For future proceeding will be possible by collecting the fish waste sample from the whole coastal area means ultimately the value of the per day generation exceeds to the profitable utilization of renewable energy instead of affecting the environment by direct dumping.

Declarations

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Ethical approval-

This content is fully prepared by our own.

Consent to participate-

We are consenting to participate.

Consent to publish-

We are consenting to publish.

Author's Contribution –

Anand Kumar Varma S. conducted the research work for the full experimental recordings and completion of the full work with the entire correction.

Suvalakshmi A. works for the entire manuscript preparation.

Parthiban P revised the entire manuscript and verified the data.

Funding-

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Competing interests-

Completed by each author.

Availability of data and materials-

We collect our fish waste from Nagapattinam fish market and Automatic digital orsat apparatus available in our environmental engineering laboratory.

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Figures

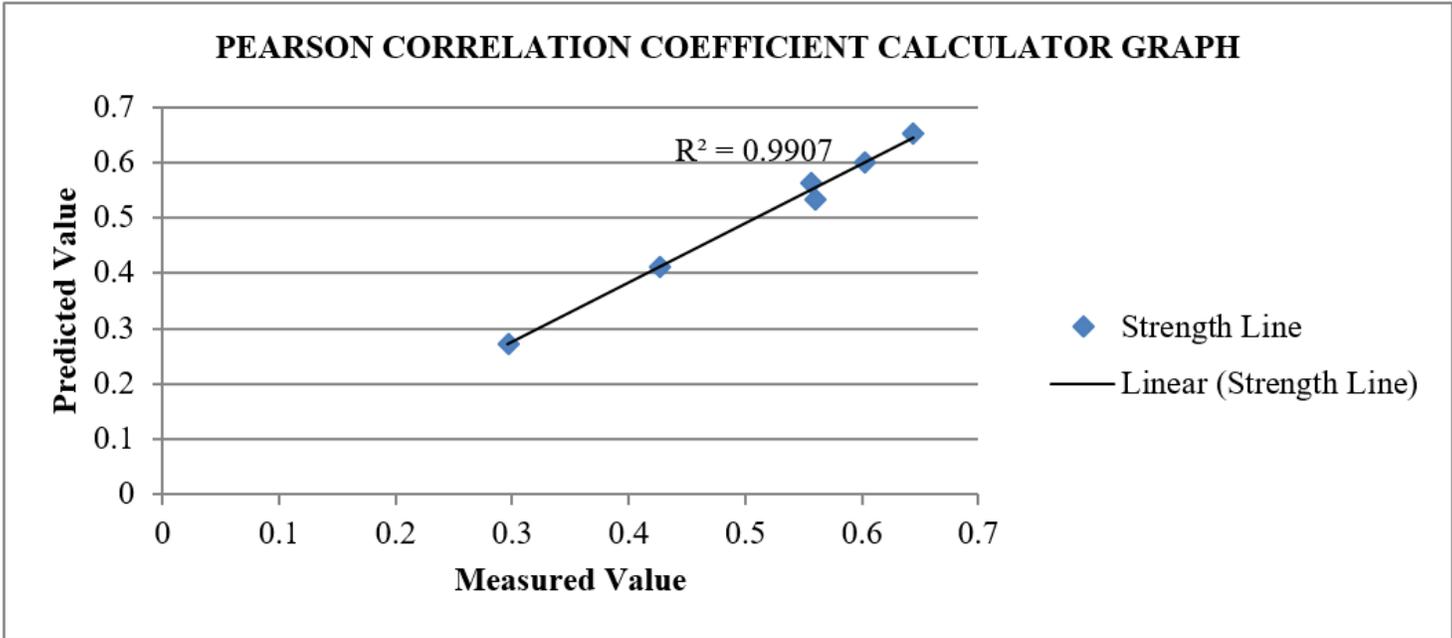


Figure 1

Correlation Coefficient for calculated and measured values of methane generated graph