Comparative Study of Bio-Hydrogen Production from Dairy Waste Water and Ayurvedic Waste Water

Rijimol.P.M[1], Lubna.C.H[2]

[1]P.G Student, Department Of Civil Engineering, Malabar College Of Engineering and Technology, Desamangalam, Thrissur, Kerala, India
[2]Assistant Professor, Department Of Civil Engineering, Malabar College Of Engineering and Technology, Desamangalam, Thrissur, Kerala, India

---***---

Abstract - *Hydrogen has been recognized globally as an energy carrier that fulfills all the environmental quality, energy security and economic competitive demands. The utilization of biohydrogen as an energy source could be able to provide environmental safety as it does not liberate green house gases during combustion. The present study investigate the bio-hydrogen production from dairy waste water and ayurvedic waste water using zinc metal powder, pumpkin seed powder and pistachio shell powder as micronutrient.*

Key Words: Bio-Hydrogen, Sludge, Dairy waste water, Ayurvedic waste water, Hydrogenase

1. INTRODUCTION

Hydrogen is considered as a viable alternative fuel and energy carrier of future. Hydrogen gas is clean fuel with no CO_2 emissions and can easily be used in fuel cells for generation of electricity. Besides, hydrogen has a high energy yield of 122 kJ/g, which is 2.75 times greater than hydrocarbon fuels. Demand on hydrogen is not limited to utilization as a source of energy. Hydrogen gas is a widely used feedstock for the production of chemicals, hydrogenation of fats and oils in food industry, production of electronic devices, processing steel and also for desulfurization and reformulation of gasoline in refineries.

Bio-hydrogen production demand is increasing in recent days. Our major energy requirements are depends on fossil fuels. But these resources are limited in nature. Biohydrogen can substitute these fossil fuels.

Upadhyay et. al (2015) conducted a study about the Production of bio-hydrogen gas from wastewater by anaerobic fermentation process. The major criteria for the selection of waste materials to be used in biohydrogen production are the availability, cost, carbohydrate content and biodegradability.

R Mullai et. al (2015) conducted a study based on the role of iron concentration in confectionery waste water. Compared to other metal ions, iron has the benefits of high protection during handling as it scarcely reacts with water at low temperature, is easily recoverable, and is efficiently excavated. Iron concentration plays an essential role in the hydrogen production by anaerobic bacteria as it facilitates activation of hydrogenase, bacterial enzyme cofactors and hydrogen evolution.

Maleek et. al (2010) conducted a study based on the Influence of Metal ions on hydrogen production by photosynthetic bacteria grown in Escherichia coli pre-fermented cheese whey. Addition of N_2 gas at intervals activates H_2 production. The addition of Molybdenum, Manganese and iron plays a crucial role in accelerating the rate of hydrogen production.

1.1 Objectives of the Study

The main objectives of the study is to determine the maximum amount of bio-hydrogen produced by dark fermentation using effluents of dairy waste water and ayurvedic waste water. Then determines the optimum concentration of micro nutrient needed for the biohydrogen production.

1.2 Scope of the Study

The technologies for production of hydrogen from new and renewable sources of energy are in the process of development and demonstration. In order to meet the future energy demands in sustainable and environment friendly manner, technologies are required to be developed for the production, storage and applications of hydrogen in transportation sector as well as for portable & stationary power generation. Greener technologies for hydrogen production will be a blessing for the future generation as it produces less impact on the environment.

2. MATERIALS AND METHODS

2.1 Materials

Zinc metal powder, pumpkin seed powder, and pistachio shell powder are used as micronutrients. Zinc metal is readily available from shop. Pumpkin seed powder and pistachio shell powder are collected locally. The collected

Fig -1: Zinc powder

materials were thoroughly washed using distilled water and dried for 48 hours in hot air oven. Then the seeds were grained to fine powder. The powder was sieved using 0.45 mm mesh and was stored in an airtight container to prevent the entry of moisture into it and to avoid loss of its activity. This fine powder was used as micronutrient for this analysis.

Fig -2: Pumpkin seed powder and pistachio shell powder

2.2 Effluent collection

Waste water samples were collected from Milma dairy unit, Ramavarmapuram and Amala Ayurvedic Hospital, Amala Nagar, Thrissur. The samples were collected in sterilised bottles and were preserved in the refrigerator during storage.

Fig -3: Ayurvedic waste water and dairy waste water

2.3 Methods

A batch reactor is a vessel used to mix chemicals under tightly controlled conditions. 250 ml of Erlenmeyer flask which acted as batch reactor. Sample volume was considered as 100ml. The flask was tightly closed using a rubber cork with two outlets, one for sample collection and the other for hydrogen gas. The sample collection outlet was tightly closed using a clamp in order to prevent the entry of air from outside.

The water displacement method is used to measuring the volume of an irregularly shaped object by immersing it in water. This is known as Archimedes principle. The principle states that a body immersed in a fluid is buoyed up by a force equal to the weight of the displaced fluid.

2.4 Experimental procedure

1. Before and after conducting the experiment, test for pH were done
2. The pH of the sample should be within the range of 6-7 and test temperature should be 25 ^{0}C- 35 ^{0}C
3. Heated the sample for 2 minutes at 110 ^{0} C for inactivate the methanogens and enhancing hydrogen producing bacteria.
4. Mix waste water and sludge in different proportions of 50:50, 30:70, and 10:90
5. Micronutrient is added at various concentrations of 0, 0.10, 0.15, 0.20, 0.25, and 0.30
6. Observe the evolution of hydrogen for 24 hours

Fig -4: Experimental setup

3. RESULTS AND DISCUSSIONS

3.1 Ayurvedic waste water

Waste water and sludge are mixed at various ratios of 50:50, 30:70, and 10:90. Then micronutrients are added to the waste water sludge mix at various concentrations of 0, 0.10, 0.15, 0.20, 0.25, and 0.30. Evolution of biohydrogen is depends on the concentration of micronutrients.

Table -1: Hydrogen production of various mix proportions without micronutrient

Mix proportion	Hydrogen production(ml)
50% waste water and 50% sludge	3.1
30% waste water and 70% sludge	4.5
10% waste water and 90% sludge	7

Maximum biohydrogen production is 7ml and it is obtained for 10% of waste water and 90% of sludge mix.

Table -2: Bio- hydrogen production of various mix proportions with zinc powder

Zn concentration	Bio-hydrogen production(ml)		
	50% waste water and 50% sludge	30% waste water and 70% sludge	10% waste water and 90% sludge
0.10	4	5.2	8.3
0.15	6.1	6.1	11.3
0.20	8.2	9.3	14.6
0.25	6.9	10.1	12.7
0.30	5.3	8.7	9.4

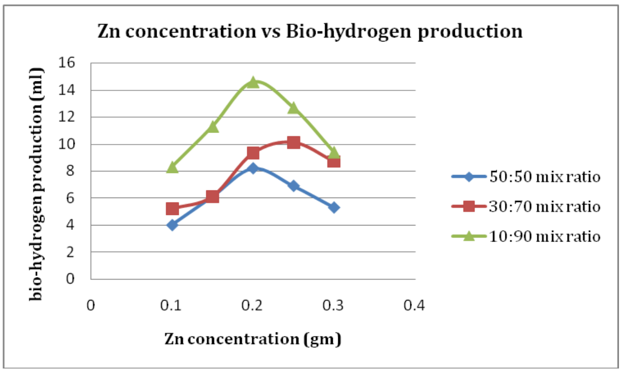

Chart -1: Zn concentration vs bio-hydrogen production

Maximum bio-hydrogen production is 14.6 ml with 10: 90 mix ratio. Optimum micronutrient concentration is 0.20 gm.

Table -3: Bio- hydrogen production of various mix proportions with pumpkin seed powder

Pumpkin seed powder concentration	Bio-hydrogen production(ml)		
	50% waste water and 50% sludge	30% waste water and 70% sludge	10% waste water and 90% sludge
0.10	5	6.4	7
0.15	6	7.6	8.4
0.20	6.4	8	10.3
0.25	8	8.9	11.1
0.30	7.1	7	9.5

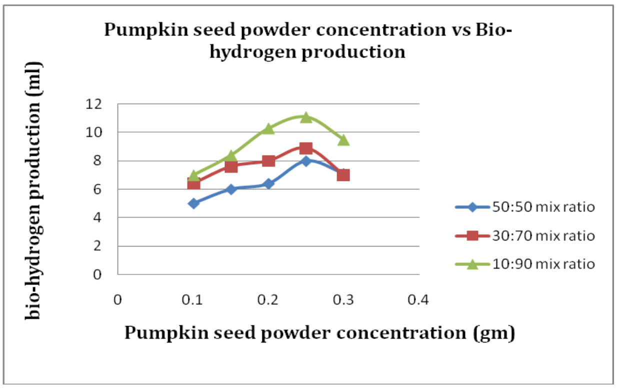

Chart -2: Pumpkin seed powder concentration vs bio-hydrogen production

Maximum bio-hydrogen production is 11.1 ml with 10: 90 mix ratio. Optimum micronutrient concentration is 0.25 gm.

Table -4: Bio- hydrogen production of various mix proportions with pistachio shell powder

pistachio shell powder concentration	Bio-hydrogen production(ml)		
	50% waste water and 50% sludge	30% waste water and 70% sludge	10% waste water and 90% sludge
0.10	3.1	5.1	8.4
0.15	4.5	6.4	9.5
0.20	6.4	7	10.4
0.25	7.3	7.4	10
0.30	5.5	6.9	8.1

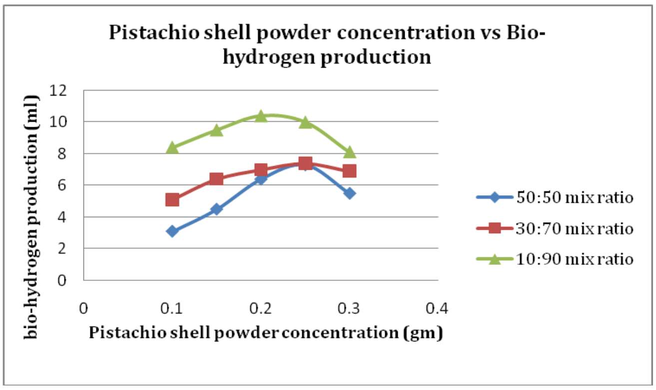

Chart -3: Pistachio shell powder concentration vs bio-hydrogen production

Maximum bio-hydrogen production is 10.4 ml with 10: 90 mix ratio. Optimum micronutrient concentration is 0.20 gm.

3.2 Dairy waste water

Waste water and sludge are mixed at various ratios of 50:50, 30:70, and 10:90. Then micronutrients are added to the waste water sludge mix at various concentrations of 0, 0.10, 0.15, 0.20, 0.25, and 0.30. Evolution of biohydrogen is depends on the concentration of micronutrients.

Table -5: Hydrogen production of various mix proportions without micronutrient

Mix proportion	Hydrogen production(ml)
50% waste water and 50% sludge	6.7
30% waste water and 70% sludge	7.9
10% waste water and 90% sludge	8.1

Maximum biohydrogen production is 8.1ml and it is obtained for 10% of waste water and 90% of sludge mix.

Table -6: Bio- hydrogen production of various mix proportions with zinc powder

Zn concentration	Bio-hydrogen production(ml)		
	50% waste water and 50% sludge	30% waste water and 70% sludge	10% waste water and 90% sludge
0.10	10.1	12.4	16.3
0.15	12.4	17.1	18.4
0.20	14.7	19.4	22
0.25	11.3	20.5	21.3
0.30	9	15.1	17.9

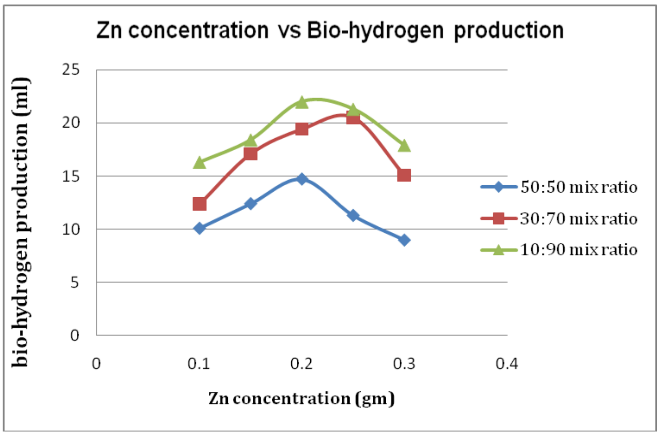

Chart -4: Zn concentration vs bio-hydrogen production

Maximum bio-hydrogen production is 22 ml with 10: 90 mix ratio. Optimum micronutrient concentration is 0.20 gm.

Table -7: Bio- hydrogen production of various mix proportions with pumpkin seed powder

Pumpkin seed powder concentration	Bio-hydrogen production(ml)		
	50% waste water and 50% sludge	30% waste water and 70% sludge	10% waste water and 90% sludge
0.10	9.9	8.9	16.5
0.15	10.5	10.2	19.7
0.20	12	11.9	18.3
0.25	10.1	14.1	15.9
0.30	8.4	12.8	13.1

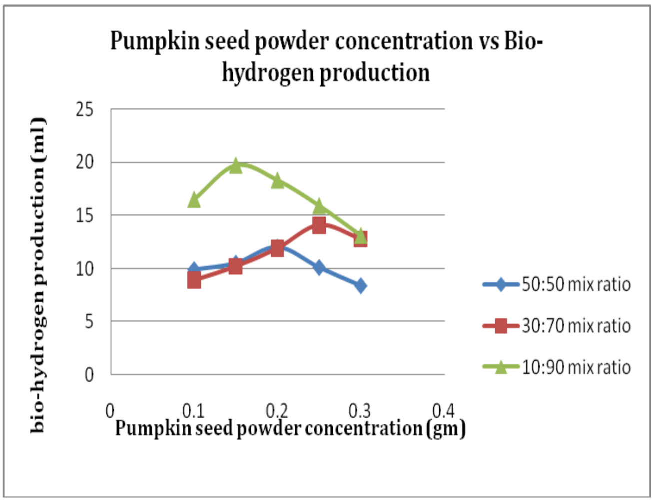

Chart -5: Pumpkin seed powder concentration vs bio-hydrogen production

Maximum bio-hydrogen production is 19.7ml with 10: 90 mix ratio. Optimum micronutrient concentration is 0.15 gm.

Table -8: Bio- hydrogen production of various mix proportions with pistachio shell powder

pistachio shell powder concentration	Bio-hydrogen production(ml)		
	50% waste water and 50% sludge	30% waste water and 70% sludge	10% waste water and 90% sludge
0.10	9.1	12.1	10.9
0.15	10.4	13.2	11.4
0.20	11.2	11.4	14.9
0.25	9.8	9.9	15.2
0.30	8.4	8.3	13.3

Maximum bio-hydrogen production is 15.2 ml with 10: 90 mix ratio. Optimum micronutrient concentration is 0.25gm.

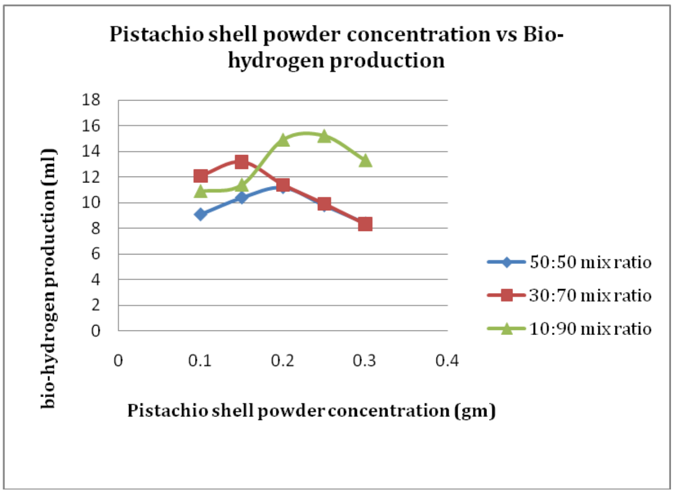

Chart -6: Pistachio shell powder concentration vs bio-hydrogen production

4. CONCLUSION

In this project experiments are conducted to produce bio-hydrogen with the use of zinc metal powder, pumpkin seed powder and pistachio shell powder as micronutrient. It is evident that micronutrients help in increasing the rate of hydrogen production. The maximum hydrogen production occurs in dairy waste water and the quantity is 22 ml with mix ratio of 10:90. Optimum micronutrient concentration is 0.20 gm of zinc. Dairy waste water is more effective than ayurvedic waste water for biohydrogen production. From this study, it is evident that Zinc is more effective than pumpkin seed powder and pistachio shell powder for the production of biohydrogen.

REFERENCES

[1] Mullai et al. "Role of iron concentration in confectionery waste water" Journal of Environmental Engineering, ASCE 2015
[2] Upadhyay et al. "Production of Bio-Hydrogen Gas from Wastewater by Anaerobic Fermentation Process" International Journal of Chemical Studies 2015
[3] SikShin et al. "Feasibility of biohydrogen production by anaerobic co-digestion of food waste and sewage sludge" International Journal of Hydrogen Energy 2015
[4] Ana Raquel Ribas Cordeiro (2013) : "Biological hydrogen production using organic waste and specific bacterial species" International Journal of Chemical Studies 2013
[5] Dhanasekar et al (2014) : "Effect of aeration on microbial production of hydrogen from maize stalk hydrolysate" International Journal of Chemical Studies 2014

[6] Maleek et al. "Influence of Metal ions on hydrogen production by photosynthetic bacteria grown in Escherichia coli pre-fermented cheese whey" Journal of Environmental Protection 2010
[7] Wan et al. "Factors influencing fermentative hydrogen production" International Journal of Hydrogen Energy 2009