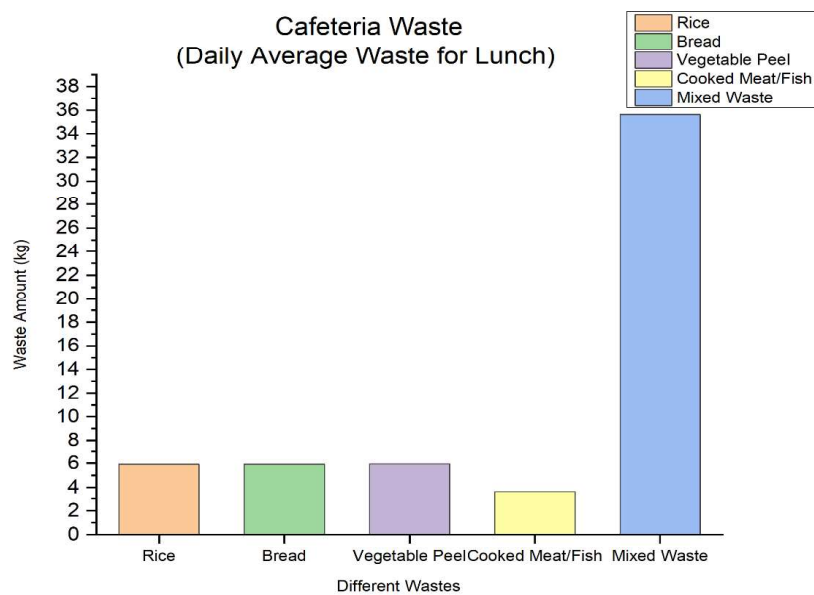


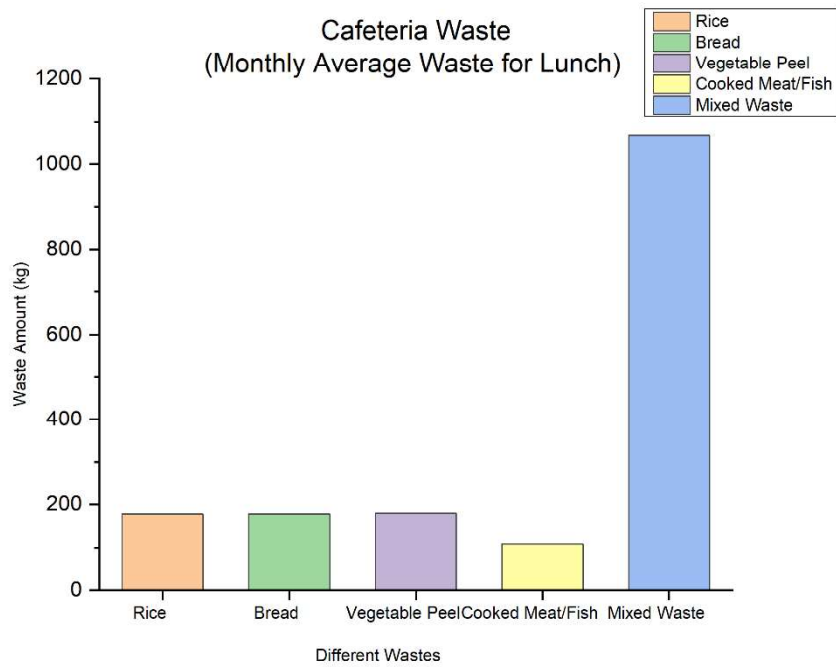
CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Waste Measurement Analysis

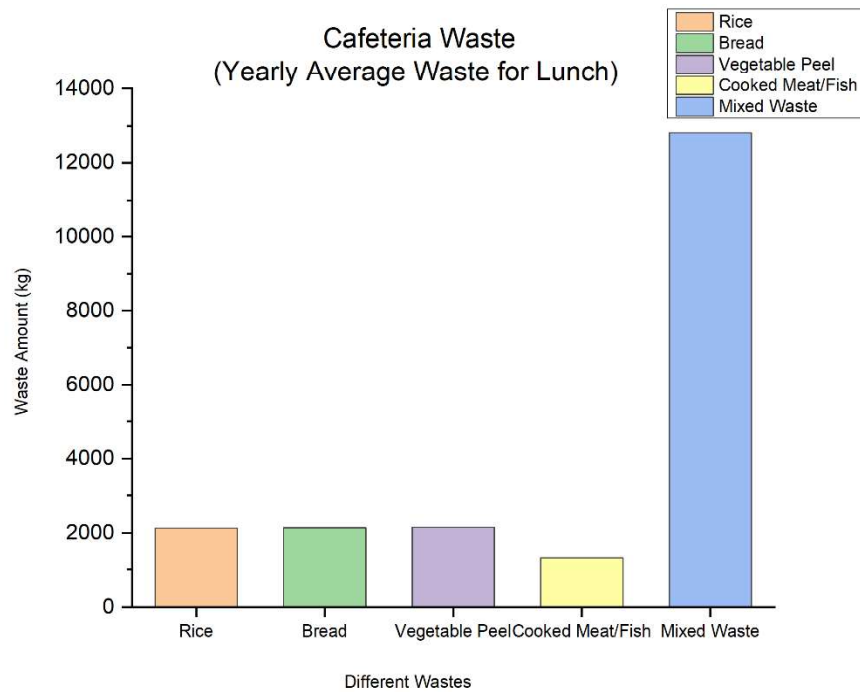
For assessing the potential of a biogas plant from cafeteria waste, we needed to know the amount of waste generated in IUT cafeteria. The findings are presented in bar charts below.



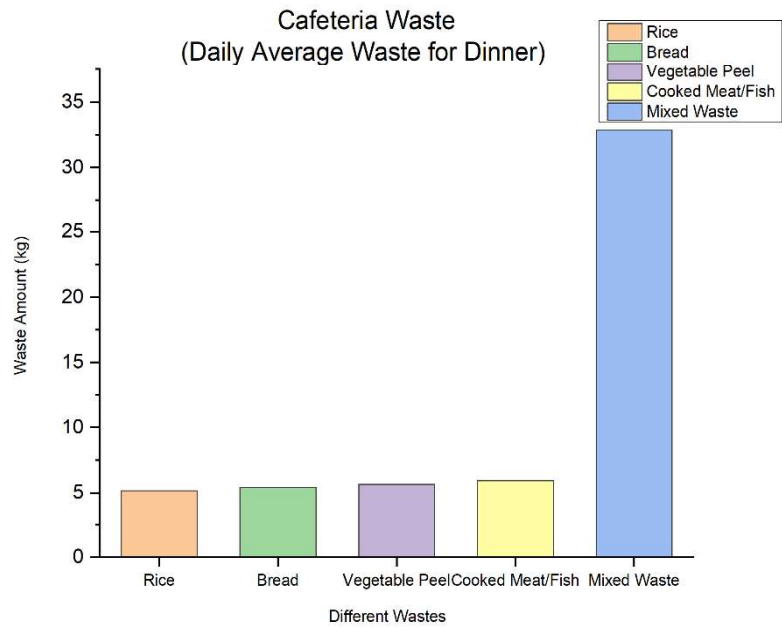
Graph 1 Demonstrating Daily Average Waste for Lunch



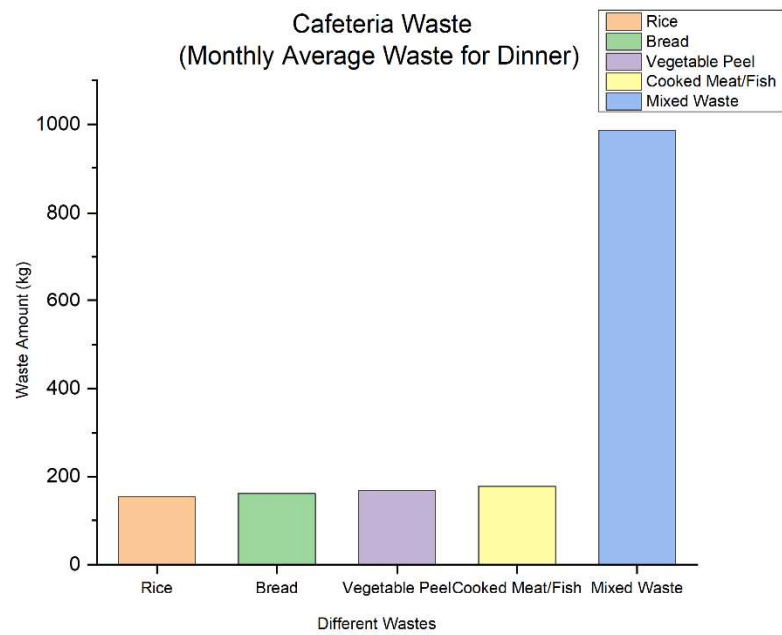
Graph 2 Demonstrating Monthly Average Waste for Lunch



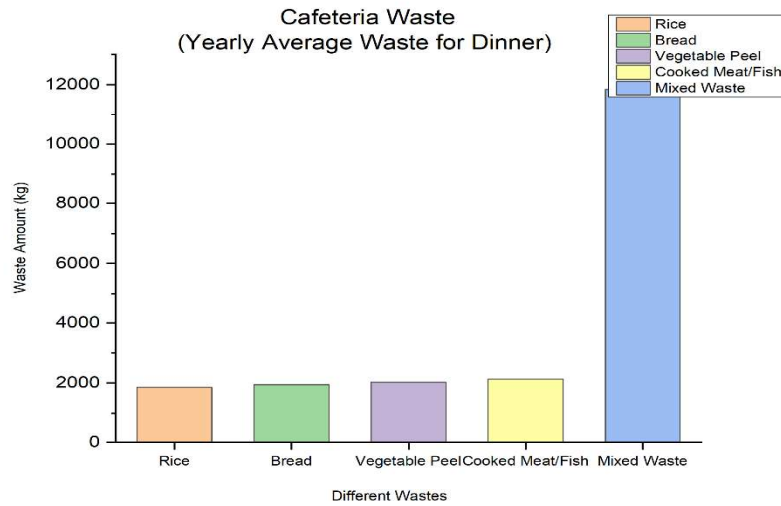
Graph 3 Demonstrating Yearly Average Waste For Lunch



Graph 4 Demonstrating Daily Average Waste for Dinner



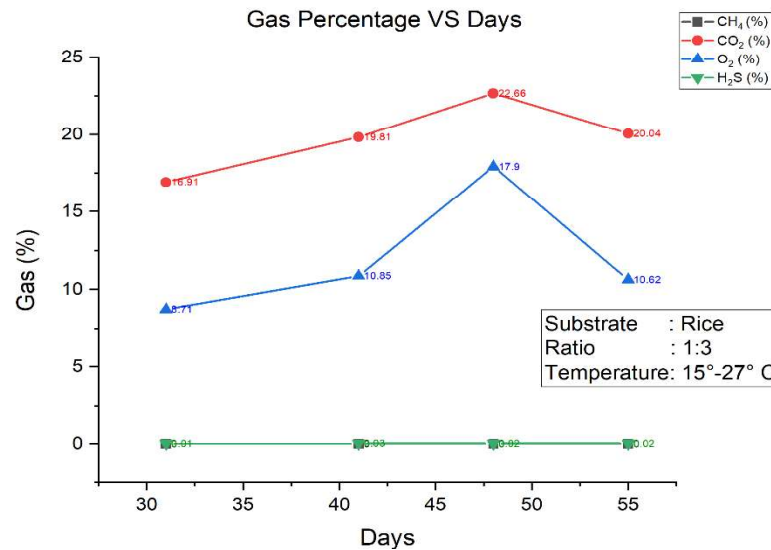
Graph 5 Demonstrating Monthly Average Waste for Dinner



Graph 6 Demonstrating Yearly Average Waste for Dinner

From these graphs, it can be seen that the highest waste produced are the mixed waste. There is also significant amount of rice waste, vegetable peel, cooked meat/fish. In experiments we tried to find out the potential of biogas production from these wastes. The findings are discussed in the next section.

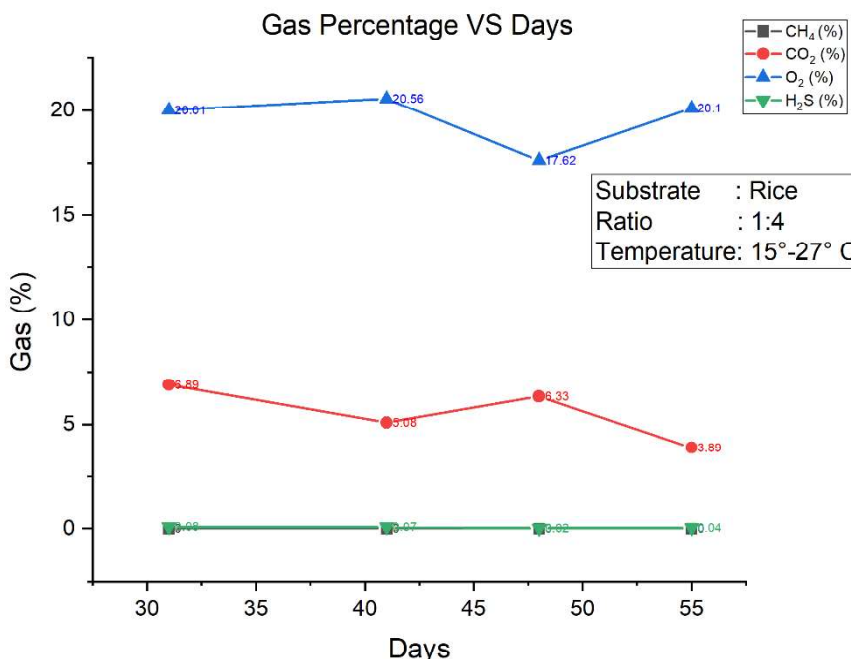
4.2 Rice Waste: Gas Analyzing Results



Graph 7 Gas Percentage Vs Days for Rice Waste (1:3)

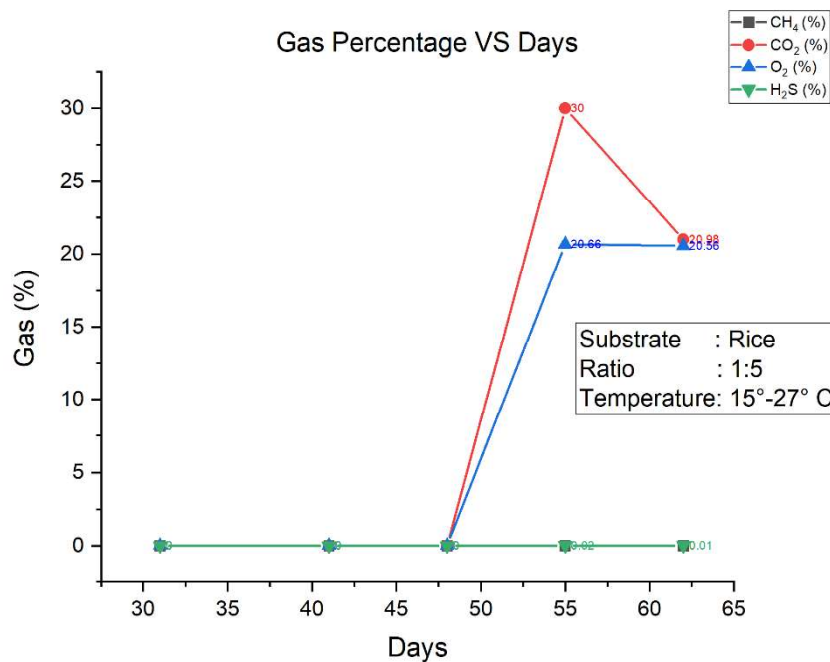
From the Graph 7 Gas percentage Vs Days for Rice waste (1:3), it can be seen that CH₄ production is very insignificant. From the plot, it is also evident that production of CO₂ is the highest, O₂ is also produced, but lesser than CO₂, and a trace

amount of H₂S is produced. The highest CO₂ percentage is 22.66%, and the highest O₂ rate is 17.9% which occurred on the 48th day.



Graph 8 Gas Percentage Vs Days for Rice Waste (1:4)

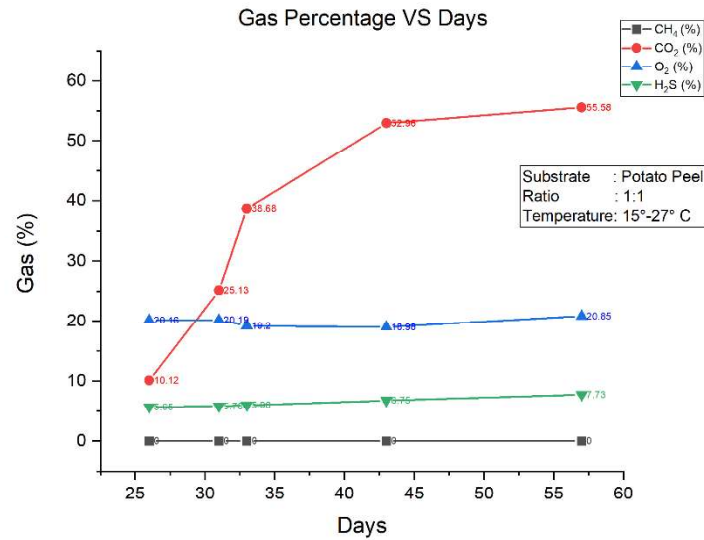
The ratio of 1:4 for rice waste did not result in methane production. Only CO₂, O₂, and a trace amount of H₂S were produced, which is evident from the Graph 8 Gas percentage Vs Days for Rice waste (1:4). Here the O₂ production rate was higher than anything else. The highest CO₂ percentage is 6.33% which occurred on the 49th day, and the highest O₂ rate is 20.56% which appeared on the 41st day.



Graph 9 Gas Percentage Vs Days for Rice Waste (1:5)

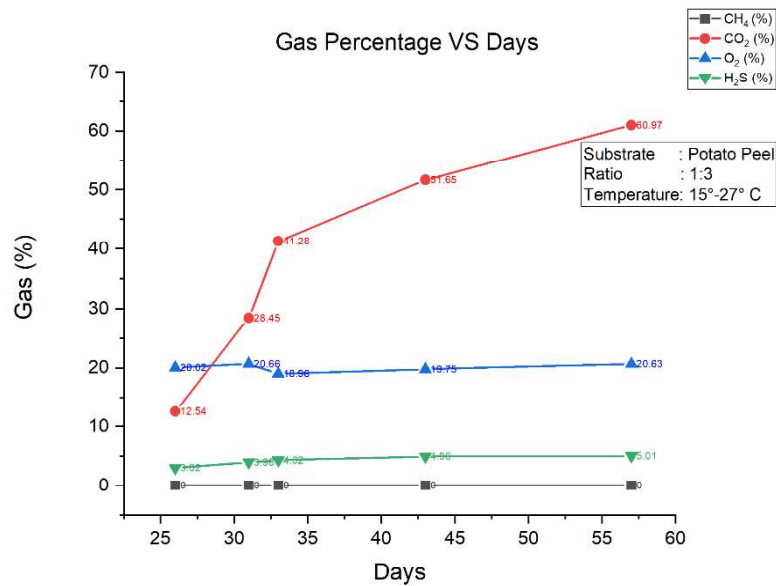
For the ratio of 1:5, it can be seen in Graph 9 Gas percentage Vs Days for Rice waste (1:5) that there is no methane. Only CO₂, O₂, and a trace amount of H₂S were produced. Among these, CO₂ production is the highest, and the amount is 30% which occurred on the 55th day.

4.3 Potato Peel: Gas Analyzing Results



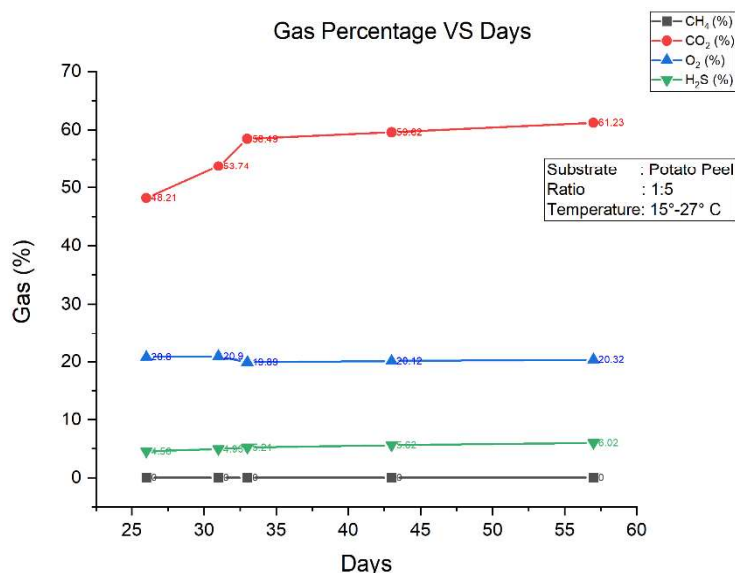
Graph 10 Gas Percentage Vs Days for Potato Peel (1:1)

From the Graph 10 Gas percentage Vs Days for Potato Peel (1:1) for the ratio of 1:1 between potato peel and water, it can be seen that there is no methane production. The highest percentage of gas produced is CO₂, and the amount is 55.58%. Some O₂ and H₂S are also produced.



Graph 11 Gas Percentage Vs Days for Potato Peel (1:3)

From the Graph 11 Gas percentage Vs Days for Potato Peel (1:3) of the ratio of 1:3, similar conclusions can be drawn. Methane cannot be found. A significant amount of CO₂ (~61%) is produced with small amounts of O₂ and H₂S.



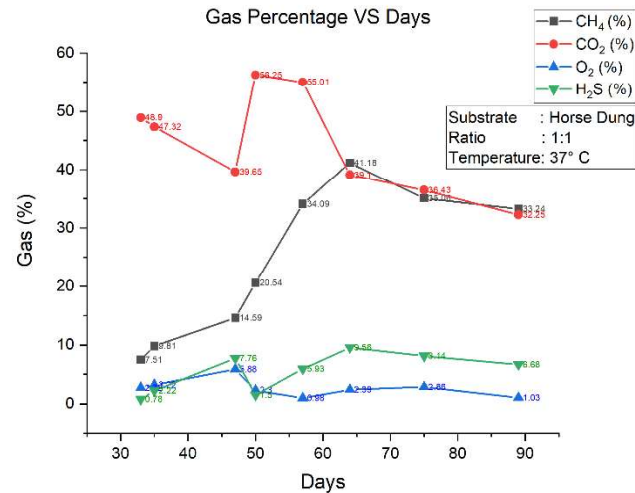
Graph 12 Gas Percentage Vs Days for Potato Peel (1:5)

The ‘Gas Percentage VS Days’ Graph 12 Gas percentage Vs Days for Potato Peel (1:5) for potato peel ratio 1:5 looks quite similar to others. No methane is produced. A large amount of carbon dioxide is produced with small amounts of oxygen and hydrogen sulfide. The highest CO₂ percentage is 61.23%.

For rice waste and potato peel experiments, the temperature was not controlled. These experiments were conducted during the winter season, and the temperature varies between 15°-27 °C, which falls under the psychrophilic conditions. As a result, methane was not produced; only CO₂, O₂, and H₂S. In most cases, CO₂ percentages were highest only except for the ratio of 1:4 for rice waste, where O₂ production was the highest.

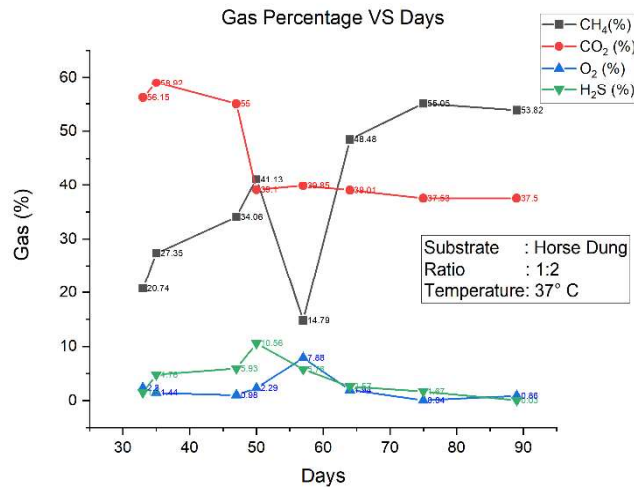
When we could not get any methane from our experiments, we tried to add inoculum to the mixtures. For preparing the inoculum/biological seed, horse dung was used. We tested ratios of 1:1 to 1:5. The findings are presented below.

4.4 Horse Dung: Gas Analyzing Results



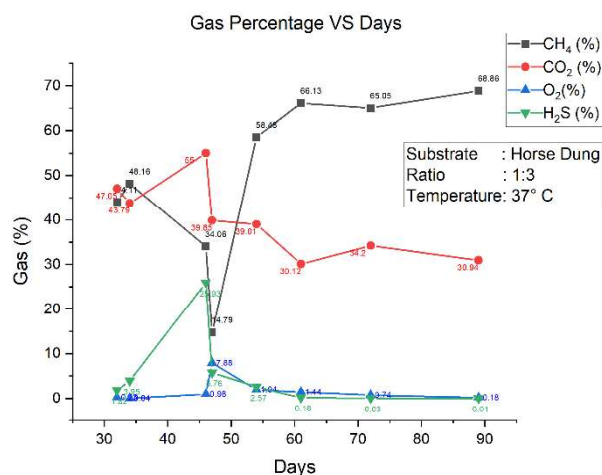
Graph 13 Gas Percentage Vs Days for Horse Dung (1:1)

Horse dung mixed with water in a ratio of 1:1 was contained in the digester bottle for 89 days. The temperature was controlled at 37 °C using the incubator we made. From the Graph 13, we can see that, as the day increases, methane production increases till the 65th day and starts to drop again. The highest methane percentage for 1:1 was 41.18%. CO₂, O₂, and H₂S are also produced.



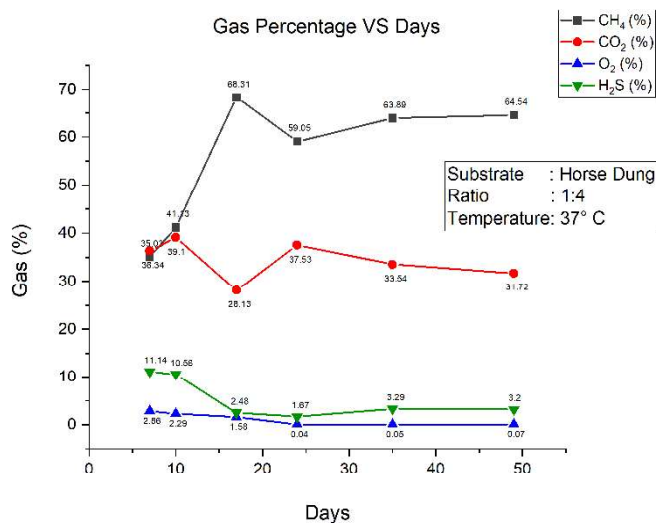
Graph 14 Gas Percentage Vs Days for Horse Dung (1:2)

For the ratio of 1:2, methane production increased till the 50th day, then decreased sharply and started to rise again from the 56th day. The highest methane percentage is 56.05% which occurred on the 75th day. CO₂, O₂, and H₂S are also produced shown in Graph 14.



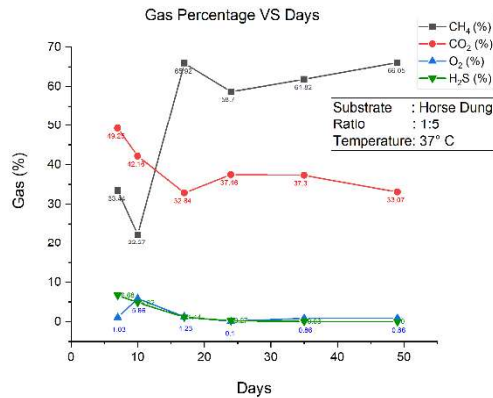
Graph 15 Gas Percentage Vs Days for Horse Dung (1:3)

For the ratio of 1:3, the highest methane percentage was 68.86% which occurred on the 89th day. CO₂, O₂, and H₂S are also produced shown in Graph 15.



Graph 16 Gas Percentage Vs Days For Horse Dung (1:4)

For the ratio of 1:4, the highest methane percentage was 68.31% which occurred on the 18th day. CO₂, O₂, and H₂S are also produced shown in Graph 16.

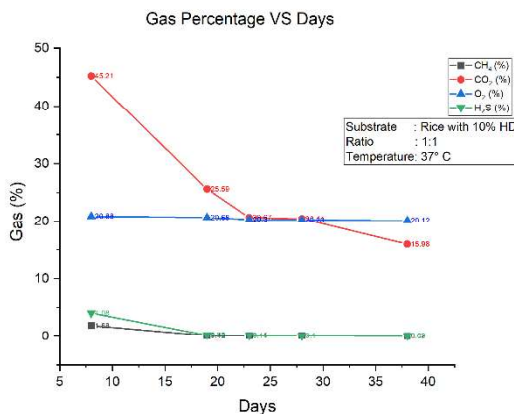


Graph 17 Gas Percentage Vs Days for Horse Dung (1:5)

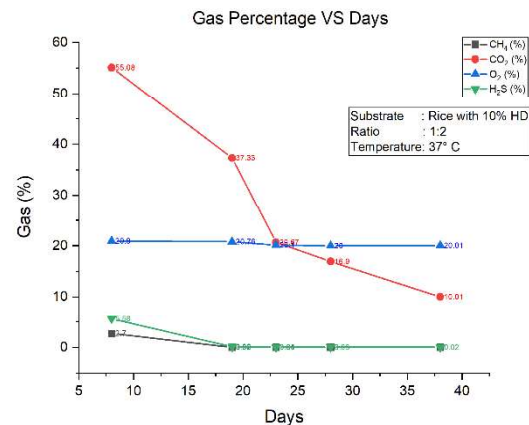
For the ratio of 1:5, the highest methane percentage was 66.05% which occurred on the 49th day. CO₂, O₂, and H₂S are also produced shown in Graph 17.

Among all these ratios for horse dung, the best result came from 1:3. It produced the highest methane percentage, which was ~69%. Thus, it can be concluded that if biogas was to produce from horse dung, the horse dung and water should be mixed at 1:3 proportions.

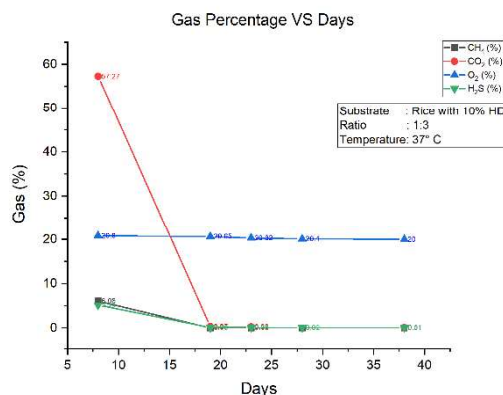
4.5 Rice with 10% Horse Dung: Gas Analyzing Results



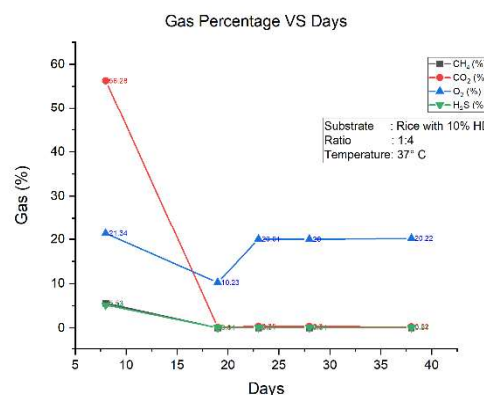
Graph 18 Gas Percentage Vs Days for Rice With 10% H.D(1:1)



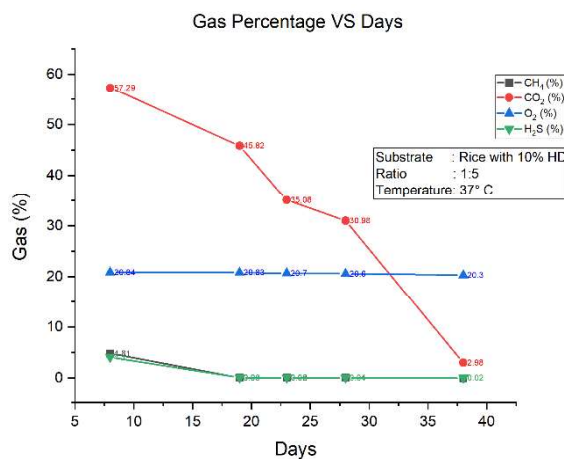
Graph 19 Gas Percentage Vs Days for Rice With 10% H.D(1:2)



Graph 20 Gas Percentage Vs Days for Rice With 10% H.D(1:3)



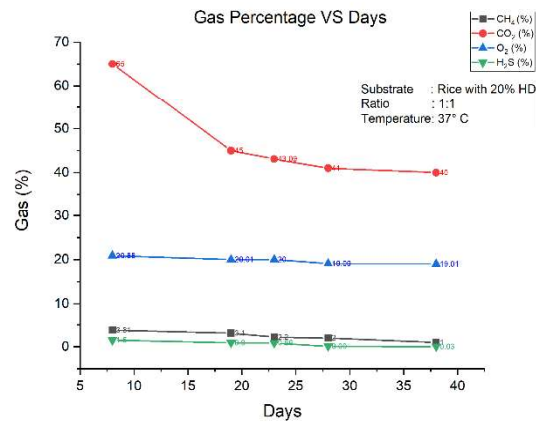
Graph 21 Gas Percentage Vs Days for Rice With 10% H.D(1:4)



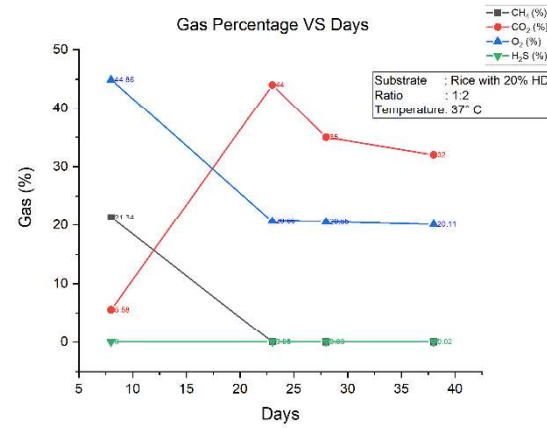
Graph 22 Gas Percentage Vs Days for Rice With 10% H.D(1:5)

Rice with 10% horse dung did not produce any significant percentage of methane. Only CO₂, O₂, and H₂S were produced. Among these gases, in all cases, the CO₂ portion was more significant than any other gases. For these experiments, temperatures were maintained at 37 °C using the incubator.

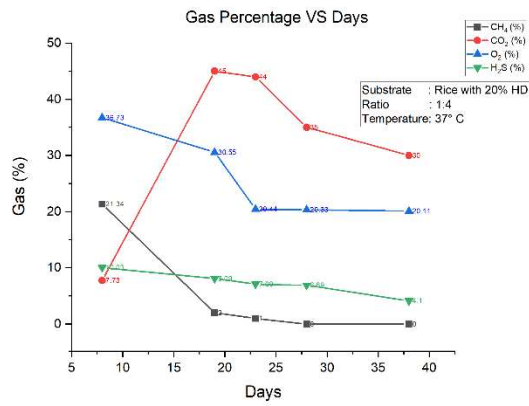
4.6 Rice with 20% Horse Dung: Gas Analyzing Results



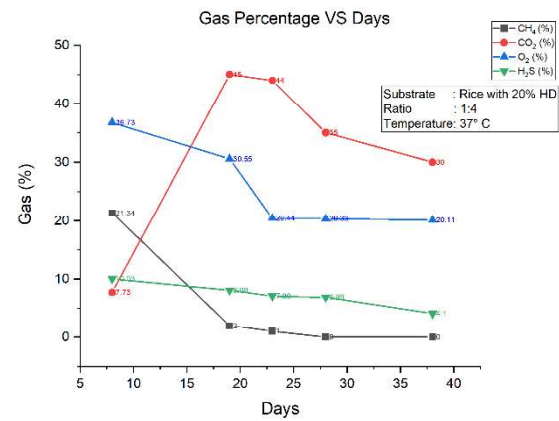
Graph 23 Gas Percentage Vs Days for Rice With 20% H.D(1:1)



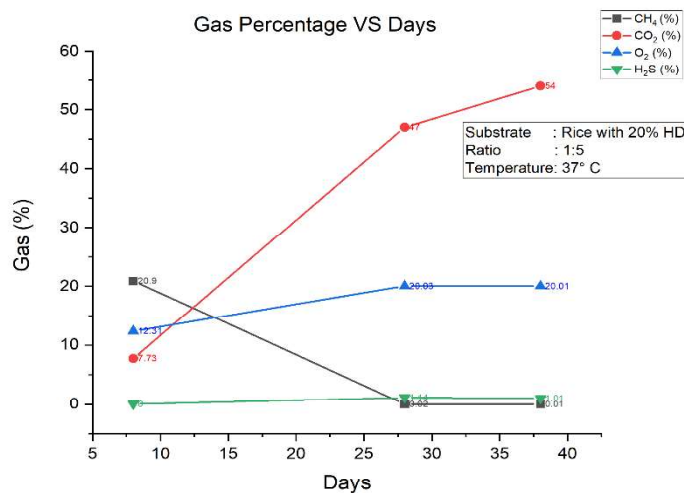
Graph 24 Gas Percentage Vs Days for Rice With 20% H.D(1:2)



Graph 25 Gas Percentage Vs Days for Rice With 20% H.D(1:3)



Graph 26 Gas Percentage Vs Days for Rice With 20% H.D(1:4)



Graph 27 Gas Percentage Vs Days for Rice With 20% H.D(1:5)

The results of rice with 20% horse dung are pretty similar to rice with 10% horse dung. The only difference is that in the case of rice with 20% horse dung, the amount of methane produced was a bit higher than that of rice with 10% horse dung.

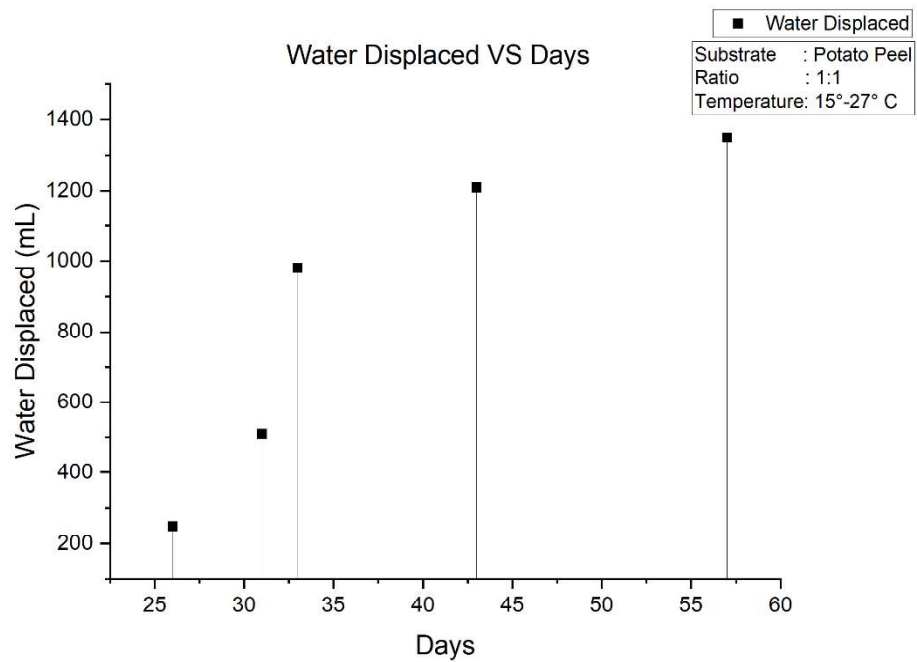
The results of CH₄ production from different wastes are summarized in the following table.

Waste	Ratio	CH ₄	CO ₂	O ₂	H ₂ S	Days needed to produce the CH ₄
Rice with 10% Horse Dung	1:1	1.88	45.21	20.88	4.08	8
	1:2	2.7	55.08	20.9	5.58	8
	1:3	6.08	57.27	20.8	5.14	8
	1:4	5.53	56.28	21.34	5.04	8
	1:5	4.81	57.29	20.84	4.1	8
Rice with 20% Horse Dung	1:1	3.81	65	20.88	1.5	8
	1:2	21.34	5.58	44.86	0	8
	1:3	21.34	5.14	25.68	0	8
	1:4	21.34	7.73	36.73	10.03	8
	1:5	20.9	7.73	12.31	0	8
Horse Dung	1:1	41.13	39.10	2.29	10.56	64
	1:2	59.05	37.53	0.04	1.67	75
	1:3	68.86	30.94	0.18	0.01	89
	1:4	64.54	31.72	0.07	3.2	49
	1:5	66.05	33.07	0.86	0	49

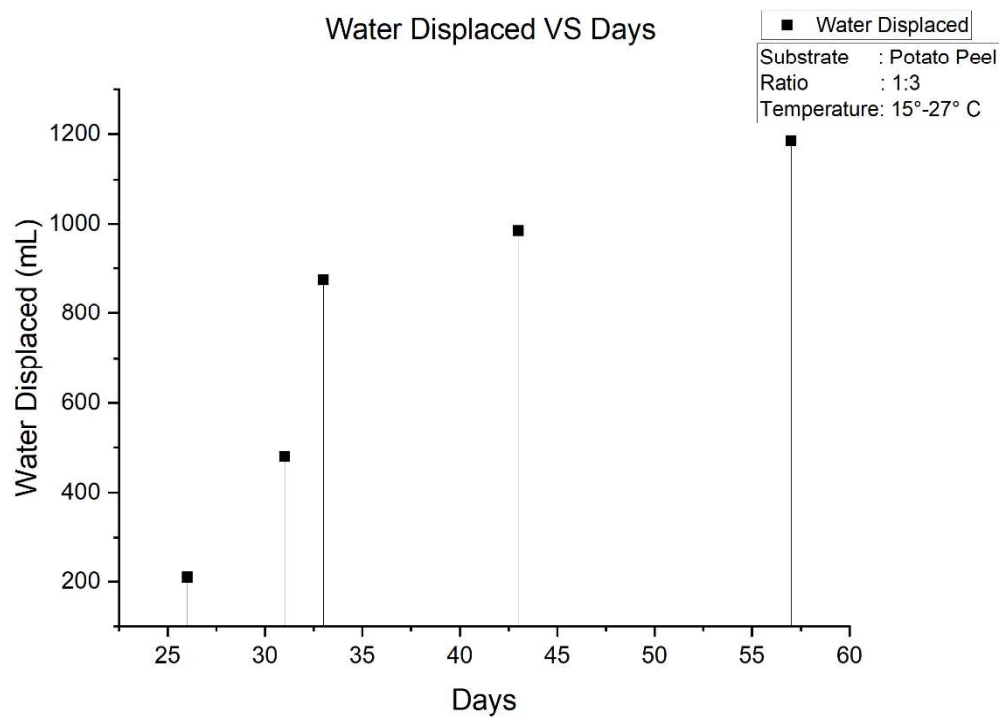
Table 7 The Results of CH₄ Production from Different Wastes

4.7 Gas Volume Measurement: Water Displacement Method

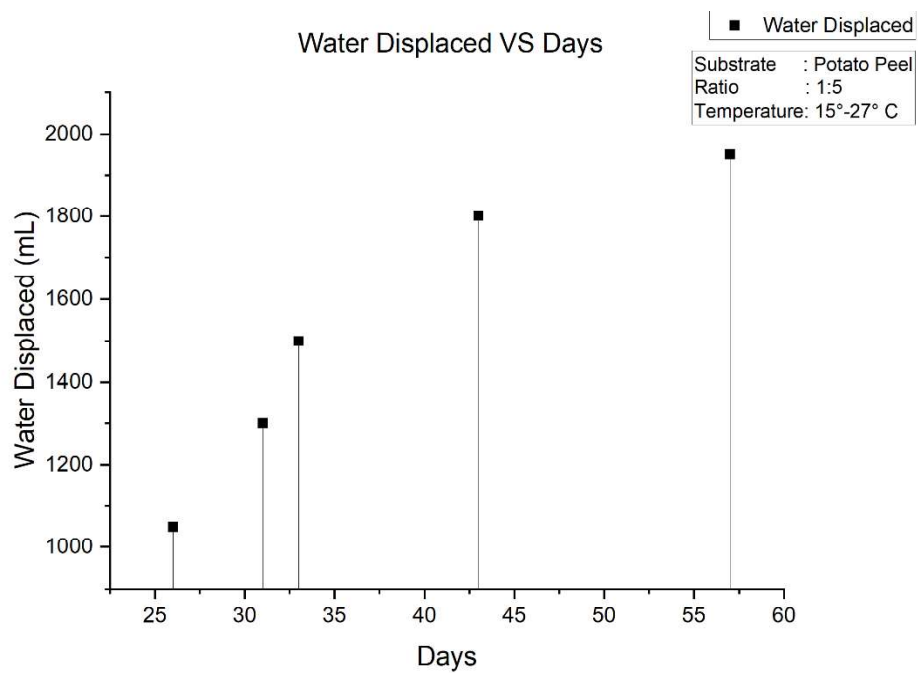
For measuring the volume of the biogas, the water displacement method was tested. The gas pressurizes the second bottle's water and is displaced in this method. The displaced water is then collected in a third bottle. After that, the collected water is measured. We tested this for potato peel experiments. The results are presented here.



Graph 28 Water Displaced Vs Days for Potato Peel (1:1)



Graph 29 Water Displaced Vs Days for Potato Peel (1:3)



Graph 30 Water Displaced Vs Days for Potato Peel (1:5)

The amount of water displaced represents the amount of gas produced on a corresponding day in these graphs.